Abstracts

Contributed Papers (Oral and Poster)
Colloquia
Workshops

92nd Annual Meeting of the American Society for Horticultural Science

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The Abstracts that follow are arranged by type of session (Colloquia first, then Orals, Posters, Workshops). The Poster abstract numbers correspond to the Poster Board number at which the Poster will be presented.

To determine when a paper is to be presented, check the session number in the Program Schedule or the Conference at a Glance charts. The Author presenting the paper is indicated by an asterisk.

8 COLLOQUIUM 1 (Abstr. 001–005)
Genome Mapping of Horticultural Crops

001

Progress in *Prunus* Mapping and Application of Molecular Markers to Germplasm Improvement

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Prunus, which includes peach/nectarine, almond, apricot, cherry, and plum, is a large and economically important genus in the family Rosaceae. The size and long generation time of these tree crops have hampered improvement through classical breeding and long-term selection programs. With the advent of DNA-based molecular diagnostics, an exciting era in germplasm improvement has dawned. Efforts are underway, notably in the United States (e.g., California, Michigan, North Carolina, and South Carolina) and the European Community (e.g., England, France, Italy, and Spain), to apply the tools of molecular mapping and marker-assisted selection to this important genus. The objective of these projects is to develop molecular linkage maps of sufficient marker density to tag phenotypic trait loci of agronomic importance. These include traits controlled by single genes (e.g., flower color, compatibility, flesh color, pest resistance), as well as more-complex, quantitative traits (e.g., cold hardiness, tree architecture, sugar content). An immediate outcome of these mapping efforts has been the development of DNA "fingerprints," allowing for the discrimination of cultivars—both

scion and rootstock. The maps will be used by breeders and molecular biologists to monitor gene introgression from wild species into elite lines, for marker-assisted selection of desired trait combinations, and for map-based cloning of specific genes. The molecular markers used in these mapping projects include RFLPs, RAPDs, and microsatellites. Each has their appropriate applications and advantages depending upon the resources at hand and the project's specific goals.

002

The Application of Genetic Diagnostics to Plant Genome Analysis and Plant Breeding

J.M. Vogel[*1], *A. Rafalski*[1], *M. Morgante*[2], *G. Taramino*[1], *W. Powell*[3], *M. Hanafey*[1], *and S.V. Tingey*[1], [1]Agricultural Products, E.I. Dupont de Nemours, P.O. Box 80402, Wilmington, DE 19880-0402; [2]Universita Di Udine, Dip Di ProduzioneVegetale, Via Delle Scienze 208, Udine, I-33100, Italy; [3]Scottish Crop Research Ins., Invergowrie, Dundee, DD2 5DA Scotland, United Kingdom.

DNA-based diagnostics are now well-established as a means to assay diversity at the locus, chromosome, and whole-genome levels. As technology has advanced, DNA sequence-based assays have become easier to use, more efficient at screening for nucleotide sequence-based polymorphisms, and available to a wider cross-section of the research community. A review of the use of molecular markers in several different areas of genetics and plant breeding will be presented, as well as a discussion about their advantages and limitations. Recent advances in several areas of technology development and laboratory automation will also be presented, including a summary of direct comparison of different DNA marker systems against a common set of soybean cultivars.

003

Progress of Apple Genetic Mapping in Europe

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The progress of the European Apple Genome Mapping Project will be described. Five populations segregating for a range of agronomic genes have been established in six European countries. Isozyme systems, RFLPs, RAPDs, and other PCR-based markers are being used to construct a unified genetic linkage map. Genotypic and phenotypic measurements have been precisely defined and standardized among participants. Phenotypic measurements for many agronomic traits are being replicated in different geographical locations over several years. Statistical and genetic analyses are aimed at defining components of genetic variation that account for "genes" manipulated by apple breeders. The segregation of fungal and insect resistance genes, tree habit, juvenility, budbreak, and many fruit characters has been scored. Markers have been identified linked to and flanking scab and mildew resistance genes. RAPD markers have been converted to codominant PCR-based markers for selection purposes. The JoinMap program has been extended for linkage analysis of crosses between heterozygous parents. A method for mapping QTLs in outcrossing species has been developed, together with software that is able to contend with dominant markers and missing data. Associated research is being carried out on the genetics and diversity of fungal resistance genes, fruit quality, and the socioeconomic aspects of apple production. The relational database, APPLE-STORE, has been designed and implemented for combined management of agronomic and genetic information. Synteny of linkage groups between *Malus* and *Prunus* has been established.

004

Genetic Studies in Pea and Apple: The Yin and Yang of Mapping in Plants

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Linkage maps consisting primarily of molecular markers have been constructed in pea and apple. Different approaches have been taken to generate these maps. For pea, F_2 and recombinant inbred populations have been used to study segregating loci, and a critical factor has been the selection of sufficiently divergent inbred parents for the crosses. In contrast, a double pseudotestcross format has been used in apple, and virutally every variety possesses sufficient heterozygosity to permit the development of a map by examination of the F_1. Markers have been identified for many genes in each crop.

005

Molecular Markers and Mapping in Bulb Onion, A Forgotten Monocot

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Although always among the top five vegetables in value, little genetic information has been published on the bulb onion. Genetic and molecular analyses are hampered by the plant's biennial nature, severe inbreeding depression, and huge genome. Research is underway to construct a low-density genetic map of onion based on RFLPs, AFLPs, and RAPDs. Among open-pollinated populations (OPPs), levels on DNA polymorphisms were in agreement with those of other outcrossing diploid species. However, we identified little putative-allelic diversity among the OPPs (1.9 polymorphic bands per polymorphic probe–enzyme combination) supporting a bottleneck during the domestication of onion. Our segregating family is from the cross of two diverse inbreds and will be used to map quantitative trait loci conditioning phenotypically correlated production (maturity, storability, and firmness), consumer-preference (pungency, flavor, and bulb shape), and health-enhancing (anti-platelet aggregation) attributes of onion. We are also attempting to tag chromosome regions controlling relatively simply inherited traits that are difficult or expensive to characterize classically.

49 COLLOQUIUM 2 (Abstr. 006–011) Biological Control Approaches for Successful Stand Establishment

006

Biological Seed Treatments

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Biological seed treatment offers a safe, environmentally responsible option for protection of seeds and seedlings from attack by soilborne pathogens. Most effective biological seed treatments have used either bacterial or fungal agents. The efficacy of a biological seed treatment depends upon the ability of the biocontrol agent to compete and function on the seed and in the rhizosphere under diverse conditions of soil pH, nutrient level, moisture, temperature, and disease pressure. Seed treatment performance may be improved through application and formulation technology. An example of this is the bio-priming seed treatment, a combination of seed priming and inoculation with *Pseudomonas aureofaciens* AB254, which was originally developed for protection of *sh-2* sweet corn from *Pythium ultimum* seed decay. Bio-priming has been evaluated for protection of seed of sweet corn and other crops under a range of soil environmental conditions.

007

Factors Affecting Suppressiveness of Composts to Plant Diseases

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Many factors affect the potential for composts to provide biological control of diseases caused by soilborne plant pathogens. Heat exposure during composting kills or inactivates pathogens and weed seeds if the process is monitored properly. Unfortunately, most beneficial microorganisms also are killed by this heat treatment. Conditions must be provided after peak heating that enhance natural recolonization of composts by biocontrol agents. The raw feedstock, the environment in which the compost is produced, as well as conditions during curing and utilization, determine the potential for recolonization by this microflora and the induction of disease suppression. Controlled inoculation of compost with biocontrol agents has proved necessary to induce consistent levels of suppression on a commercial scale. Compost stability is another important factor. Immature composts serve as food for pathogens and increase disease even when biocontrol agents are present. On the other hand, excessively stabilized organic amendments, such as highly decomposed peats, do not support the activity of biocontrol agents and disease therefore develops. Finally, salinity, C to N ratio, and other factors affect suppressiveness. Each of these factors will be discussed.

008

Application of Growth-promoting Rhizobacteria to Transplant Plug and Seed

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Plant growth-promoting rhizobacteria (PGPR) enhance plant development by many mechanisms. Indirect growth effects result from PGPR activities that displace soilborne pathogens and thereby reduce disease. Direct effects include improved nutrition, reduced disease due to activation of host defenses, and bacterial production of phytohormones. An understanding of the mode of action is essential for exploitation of PGPR for field use. For instance, bacteria that act as biological control agents can only be of benefit at locations where disease occurs. PGPR that stimulate plant growth directly will likely have more universal uses and greater impacts. Thus, we have been developing model systems for identifying PGPR with such traits. In this presentation, the effects of bacterization of tissue culture-grown plants, plug transplants, and seed with a growth-promoting *Pseudomonas* sp. (PsJN) will be described. Potential uses for this and other PGPR will also be identified. The talk will consider the advantages and limitations of: a) screening methods used for selection of PGPR, b) model systems available for studying the mechanisms of action, and c) why transplants offer an ideal delivery system for rhizobacteria. Results from field trials with PGPR with different modes of action will be presented and their future role in agriculture considered.

009

Biological Control of Root Pathogens in Rockwool and Other Hydroponic Systems

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One of the main difficulties in controlling root diseases biologically has been the inability of biocontrol agents to establish and persist in the rhizosphere. The inability of biocontrol agents to establish and persist is often attributed to competition from indigenous microorganisms for space and nutrients and to fluctuations in environmental conditions. The use of biocontrol agents over the entire geographic range of a crop also has been limited by differences in environmental and edaphic conditions from field to field and region to region. An advantage of hydroponic crop production in greenhouses is that environmental conditions such as temperature, moisture, pH, and growth medium can be consistently controlled in a house and from site to site. An additional advantage of many hydroponic systems is that they are virtually sterile upon planting. This initial period of virtual sterility greatly reduces competition for an introduced biocontrol agent. In addition, these systems are usually pathogen-free upon planting allowing the establishment of a biocontrol agent prior to pathogen introduction. Last, the temperatures, high moisture levels, and pH ranges of hydroponic systems can be ideal for the proliferation of many biocontrol agents. With all of these advantages for the use of biocontrol agents in hydroponic systems, our company, and many labs around the world, have focused their attention on developing biological control agents for these systems. I will provide a review of research focused on controlling root diseases of vegetables grown in rockwool and other hydroponic systems.

010

Using Entopathogenic Nematodes for the Control of Insect Pests

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Recent advances in the development of large-scale, in vitro rearing techniques and formulation technology have prompted the commercialization of entomopathogenic nematodes. The potential for these nematodes as biological control agents is very promising, with proven efficacy against a wide variety of soil-inhabiting insects including root weevils, white grubs, mole crickets, and fungus gnats. Entomopathogenic nematodes are currently marketed in many countries for a variety of horticultural crops, including turfgrass, vegetables, berries, ornamentals, and citrus. Specific examples of successful application of nematodes for the control of insect pests during stand establishment will be discussed.

011

Principles of Biological Weed Control

*Susan M. Boyetchko**, Agriculture and Agri-Food Canada, Research Station, Box 440, Regina, Saskatchewan, Canada S4P 3A2.

Weeds continue to have a tremendous impact on crop yield losses in Canada and the United States, despite efforts to control them with chemicals. Biological control offers an additional means for reducing weed populations while reducing the reliance of the agri-food industry on chemical pesticides. Effective biological strategies that are compatible with good soil conservation practices would benefit farmers while maintaining environmental quality and a sustained production for the future. Inundative biological control of weeds with microbial agents involves the mass production and application of high concentrations of a plant pathogen to a target weed. Historically, biocontrol agents used on weeds have been foliar fungal pathogens. More recently, the soil has become a source for microorganisms, such as rhizobacteria, for development as biological control agents. Several naturally occurring rhizobacteria have weed suppressive properties, where growth and development of weeds such as downy brome, wild oats, leafy spurge, and green foxtail are significantly inhibited. Although the focus in weed biocontrol has been on the eradication of weeds, rhizobacteria may be used to improve seedling establishment of the crop by reducing the weed competition. This can be achieved through a reduction in weed growth, vigor, and reproductive capacity and improvement in the ability of the crop to compete with the weed. Current research in weed biocontrol with microorganisms and its application to weed management systems will be discussed.

137 COLLOQUIUM 3 (Abstr. 012–017) Effect of Preharvest Factors on Postharvest Quality

012

Effects of Temperature, Light, and Rainfall on Superficial Scald Development in Apples

*William J. Bramlage** and *Sarah A. Weis*, Dept.of Plant & Soil Sciences, Univ. of Massachusetts, Amherst, MA. 01003-0910.

Preharvest environmental conditions apparently determine susceptibility of apples to postharvest scald development. Cool temperature, as hours below 10C, can greatly reduce susceptibility, but greater than 30C appears to enhance it. These effects appear to interact, because a high-temperature episode can cause loss of some low-temperature benefit. Shading of fruit increases their scald susceptibility and preharvest light conditions, along with preharvest rainfall, appear to be factors in scald susceptibility in New England. Fruit maturation reduces scald susceptibility. We are constructing models of contributions of these variables to scald susceptibility of fruit grown under different environmental conditions, and in this the relative importance of these variables is being evaluated.

013

Preharvest Factors Affecting Postharvest Quality of Vegetables

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Vegetables provide a major source of essential vitamins such as ascorbic acid and beta carotene and other quality components in the human diet. Postharvest yield and quality of vegetables depend upon genetic, biotic, edaphic, chemic and other factors, as well as combinations of these factors. Successful production, quality and nutritional value of vegetables are related to both primary and secondary metabolic processes occurring during vegetable growth and development. Related research has focused upon cultivar selection, cultural practices used during production, interaction of light and temperature, and use of chemicals for growth regulation, and pest control. We will discuss the effects of genetic, pest, and soil management; crop maturity at harvest; environmental modification; and climatic conditions. Postharvest vegetable quality will be characterized in terms of vitamin content, appearance, yield, and flavor.

014

Production Factors Affecting the Longevity and Quality of Flowering Plants

*Terril A. Nell**, Dept. of Environmental Horticulture, Univ. of Florida, Gainesville, FL 32611.

The quality and longevity of flowering potted plants and cut flowers are affected by the cultivar grown and cultural practices used during production. Preharvest factors may account for 70% of the life of flowering plants. Longevity

is directly related to the cultivar grown. In potted chrysanthemums, longevity has been increased by 100% by carefully selecting a long-lasting variety. Cultural factors, such as fertilization practices, may increase longevity by 40% to 50%. Chrysanthemums grown without fertilizer during the final 3 weeks of production lasted 10 to 14 days longer than plants receiving fertilizer for the entire crop. Flower and plant quality is influenced by cultivar and cultural practices. Poinsettia bract edge burn, a marginal burn or spotting on the bracts, appears to be caused by a calcium deficiency that may be triggered by use of cool day temperatures or warm night temperatures and use of cultivars sensitive to this disorder. Light compensation point and carbohydrate status of the plant at flowering have not been related to differences observed in flower longevity and quality.

015

Preharvest Factors Affecting Postharvest Stone Fruit Quality

Carlos H. Crisosto, R. Scott Johnson, Kevin Day,* and *Ted DeJong*, Dept. of Pomology, Univ. of California, Davis, CA 95616.

Studies on the influences of "orchard factors" such as cultivar, harvest time, crop load, fruit canopy position, irrigation, and nitrogen regimes were investigated for plums, nectarines, and peaches at the Kearney Agricultural Center (San Joaquin Valley, Calif.a). These preharvest factors affected internal browning and mealiness incidence differently. More-reliable benefits of treatments to eliminate or reduce internal breakdown may be accomplished by using outer canopy fruit. Optimum quality expression and subsequent consumer satisfaction for each cultivar can be achieved by understanding the role of preharvest factors and harvest time on fruit quality and potential postharvest life.

016

Preharvest Factors Affecting Postharvest Quality of Berry Crops

*Robert K. Prange** and *Jennifer R. DeEll*, Agriculture & Agri-food Canada, Kentville Research Centre, 32 Main St., Kentville, NS, Canada B4N 1J5.

Berry crops can include a wide variety of plant species, with the most important temperate North American species in the genera *Fragaria*, *Rubus*, and *Vaccinium*. The preharvest factors affecting the postharvest quality of berry crops can be divided into abiotic and biotic factors. Amongst the abiotic factors, mineral nutrition, especially calcium and nitrogen, water, temperature, and light play important roles in postharvest quality attributes such as size, color, firmness, acidity, and sweetness. Amongst the biotic factors, several postharvest pathogens, which are also present as preharvest pathogens, can cause very significant reductions in postharvest quality. Grey mold (*Botrytis cinera*) is considered to be the most important pre- and postharvest pathogen in berry crops, but other preharvest pathogens (e.g., *Alternaria*, *Colletotrichum*, and *Rhizopus*) can become major problems, depending on other preharvest factors. In some growing areas, the presence of fruit fly larvae in the fresh fruit reduces the postharvest quality. Other biotic factors can be more subtle in their effects on postharvest quality, such as cultivar, pruning, and pollination.

017

The Role of Calcium and Nitrogen in Postharvest Quality and Disease Resistance of Apples

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In several experiments, strong negative correlations were found between fruit and leaf N vs. fruit color and fruit N vs. firmness, but a positive correlation existed between fruit Ca vs. firmness in apples. Based on these relationships, several models were developed to predict postharvest quality using preharvest nutrient status. Quantity and timing of N application to produce optimum-quality fruit in 'Delicious', 'Fuji', and 'Gala' apples have also been investigated. High levels of nitrogen adversely affected fruit quality and increased endogenous ethylene and respiration. In separate experiments, the effects of seven post-bloom $CaCl_2$ applications on various postharvest pathogens were studied in four apple cultivars. Calcium applications did not increase fruit Ca sufficiently enough to reduce colonization or maintain firmness after 4 months of 0C storage, but did slightly reduce infection by these pathogens during the growing season.

167 COLLOQUIUM 4 (Abstr. 018–021) The Professional Career: Issues and Concerns

018

Faculty Scholarship and Productivity Expectations—An Administrator's Perspective

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An organization can be effective only when its value system is congruent with and complementary to its central mission(s). The value system of a university is most clearly described by its promotion and tenure policies, processes, and the criteria it uses in evaluating a faculty member's performance. Professorial-rank faculty members at universities are required to perform assigned duties in teaching, research, extension, advising, administration, etc., that are unique to their position. *All faculty members are required to make scholarly contributions* and are encouraged to perform service that is relevant to their assignment and of value to their institution and profession. The balance of emphasis between assigned duties and scholarship varies from one faculty position to another—ranging from faculty with few assigned duties who engage predominantly in scholarship, to faculty with extensive assigned duties who devote a small, but significant, effort to scholarly achievement. A university's effectiveness can be compromised, and its faculty inappropriately evaluated, if this reality is not recognized; if scholarship is too narrowly interpreted; or if undue weight is given to individual achievement rather than to the achievements of individuals—*including those that resulted from team efforts.* Changes that are evolving at Oregon State Univ. to address these three issues will be described, including: adoption of a broader definition of *scholarship as intellectual work that is validated by peers and communicated*; a description of four fundamental forms of scholarship: *discovery, development, integration, and creation*; incorporation of a dynamic *description of position responsibilities* for each faculty member into annual and promotion and tenure evaluations; and addition of a category entitled, *Results of team efforts* into the format for faculty documentation of achievements.

019

Junior Faculty: Their Needs and Professional Development

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This presentation will summarize research on the characteristics and needs of junior faculty in North America. Following this will be a description of practices that various institutions, department chairs, and new faculty themselves are using to assist new faculty. The general perspective is that this is a critical time in the careers of faculty members, one that will have a major influence on their research and teaching activities for a long period of time.

020

Mid-career and Senior Faculty: Maintaining Vitality and Productivity

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Over the past 25 years, faculty and their work have been studied on an intensive level. In 1977, Sarason defined a "one life—one career" model, in which faculty are "called" to a profession. Numerous studies, beginning with Hodgekinson (1974) and Baldwin and Blackburn (1981), indicate that faculty as adult learners continue to explore new interests and redefine careers, particularly as age and experience increase. Although the institutional context is a mediating factor, a number of researchers, including Baldwin (1985), Creswell, et. al. (1990), Schuster and Wheeler (1990), Simpson (1990), and Sorcinelli and Austin (1992) have identified a range of faculty needs and strategies which can aid in meeting these needs. Department chairs and faculty colleagues are identified as crucial in encouraging changes to maintain faculty vitality, and to encourage preventative action rather than remediation. Such investments in human capital have both short-term and long-term payoffs [Simpson (1990) and Schuster and Wheeler (1990)].

021

Approaching Retirement

*Bruno C. Moser**, Dept. of Horticulture, Purdue Univ., West Lafayette, IN 47907-1165.

Society sends numerous signals to those of us who reach official senior citizen status at age 55. Both personal and professional decisions and goals begin to adapt to that inevitable retirement date, which may no longer be age 65. Our institutions send mixed signals of early retirement incentives to individuals on the one hand, but loss of position threats to departments on the other. Elimination of a required retirement age allows individuals to plan past 65, with a number of options available. This forces departments to consider the final career years more closely than in the past. Maintaining viability and aggressiveness of faculty members during this phase of an individual's career is a challenge. Issues of deadwood on the one hand, vs. aggressive productivity up to retirement, can affect a department's capabilities. Discussion of this phase in faculty careers will center around both the individual and his/her department head who, hopefully, are on the same track regarding career direction, but often have different plans for the final years, e.g. semi-retirement and disengagement versus productivity to the last day. Faculty in departments with competitive peers and strong professional development programs throughout the career path lead to the latter as individuals approach retirement.

12 ORAL SESSION 1 (Abstr. 022–027) Cell and Tissue Culture/Vegetable Crops

022

A Simple Method for Estimating Ploidy of in Vitro Watermelon Plantlets

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Ploidy of in vitro watermelon plantlets was estimated by painting the lower epidermis of leaves with fluorescein diacetate (FDA) and observing fluorescence of guard cell chloroplasts with a microscope and UV light. Leaves from shoot-tip cultures of known diploid and tetraploid cultivars were used to establish the mean number of chloroplasts per guard cell pair for in vitro plantlets. Leaves from diploid and tetraploid plantlets had 9.7 and 17.8 chloroplasts per guard cell pair, respectively. This method was used to estimate ploidy of shoots regenerated from cotyledon explants of the diploid cultivar Minilee. Approximately 10.6% of regenerated shoots were classified as tetraploid while still in vitro. Putative tetraploids were transplanted to the field and self-pollinated. A majority of polyploids identified in vitro were true breeding, nonchimeric tetraploids. This study demonstrate that FDA can be used to estimate ploidy of in vitro shoots of watermelon prior to acclimatization and transfer of plants to the greenhouse or field.

023

The Effects of Different Concentrations of Gibberellic Acid (GA_3) and Kinetin on in Vitro Tuberization of Potato (*Solanum tuberosum* L.)

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To determine the influence of gibberellic acid (GA_3) and 6-furfuryl aminopurine (kinetin) concentrations alone and in combinations on in vitro tuberization of potato, nine treatments consisting of combinations of gibberellic acid and kinetin at three levels of concentration (0, 2, and 5 mg·liter^{-1}) were included in Murashige and Skoog medium supplemented with 6% sucrose. Four single nodes of in vitro plantlets from *Solanum tuberosum* L. cultivar Atlantic were placed into each magenta box. All magenta boxes were arranged in a randomized complete box design with five replications and cultured under a short photoperiod condition (8 h light/16 h dark). Gibberellic acid strongly inhibited tuberization when used alone or with kinetin, whereas kinetin induced tuberization at both 2 and 5 mg·liter^{-1}. Although tuberization was initiated in the absence of kinetin because of the high concentration of sucrose and short photoperiod, the presence of kinetin accelerated the in vitro tuberization process of potato.

024

Monitoring Nutrient Levels during the in Vitro Tuberization of Potato

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Macro- and micronutrient levels were monitored during the in vitro tuberization of potato (cv. Alpha) in liquid medium of MS salts and vitamins supplemented with 8% sucrose and 5 mg·liter^{-1} kinetin under complete darkness at 18C. Microtubers were formed in 50% of the cultured jars at day 20 and reached their full size at day 60 of culture initiation. By this time, medium N, P, and K levels had dropped by 89%, 84%, and 41%, respectively. The major drop in medium N occurred during the pre-tuberization stage, when it was taken up mostly by shoots. During tuber enlargement, the rate of Zn, Fe, and Mn removal from medium was slower than their rate of uptake by tubers. The changes in shoot and tuber Ca were very small where most of the Ca removed from medium was diverted into the roots.

025

A Modified Nodal Cutting Bioassay for Assessing Salinity Tolerance in Potato (*Solanum* sp.)

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The potato (*Solanum tuberosum* L.) is considered moderately sensitive to salinity stress. Yields can be adversely affected by salinity at EC levels of 2 to 3 dS·m^{-1}. In vitro screening and selection for salinity tolerance may be faster and more reliable than traditional field assessment. A modified nodal cutting bioassay was developed based on that of Morpurgo (1991) and used to rank the salinity tolerance of several potato cultivars, wild *Solanum* species, and their hybrids. Nodal cuttings were cultured in Murashige and Skoog (1962) basal medium which included NaCl at 0, 40, 80, and 120 mM. After 4 weeks at 25C and 16/8 h day/night period, vegetative growth parameters were assessed. Hybrids derived from *S. chacoense* outperformed hybrids of other wild species, their wild parents, and *S. tuberosum* cultivars. 'Russet Burbank' and 'Kennebec' were more salinity-tolerant than the three other cultivars tested.

026

In Vitro Ranking of Salinity Tolerance in Potato (*Solanum* sp.)

*T. Khrais** and *D. Donnelly*, Dept. of Plant Science, Macdonald Campus of McGill Univ., 21,111 Lakeshore Road, Ste. Anne de Bellevue, QC, Canada H9X 3V9.

Globally, salinization of agricultural soils is an increasing problem. At least 25% of the world's cultivated land area is now salt-affected. Although the potato (*Solanum tuberosum* L.) is among the most important of crops plants, little is known of the range of salt tolerance among cultivars of *S. tuberosum*, wild *Solanum* sp., or their hybrids. The objective of this work was to rank the salinity (NaCl) tolerance of 200 North American and European cultivars, 13 hybrids of *S. chacoense*, *S. tuberosum*, and primitive cultivated diploids (*S. phureja* and/or *S. stenotomum*) and their progenies, and 14 accessions of *S. chacoense* from different collection sites. This was done in vitro, using a modified nodal cutting bioassay. The parameters evaluated included shoot and root lengths, and fresh and dry weights. Extreme variation for salinity tolerance was noted among the cultivars, the hybrids, and the wild species.

027

Photoautotrophic Micropropagation of Triploid Melon. I: Sucrose, Light, and CO_2 Affect Growth and Net Photosynthetic Rates of Shoot Buds

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Growth and net photosynthetic rates of shoots of a triploid melon clone, '(L-14 x B) x L-14', were observed over 21 days following transfer from a multiplication MS medium containing 3% sucrose and 10 μM BA to a shoot development medium containing 1 μM BA at varying levels of sucrose in the medium (0%, 1%, and 3%), and light (50, 100, and 150 PPF) and CO_2 (500, 1000, and 1500 ppm) in the headspace. Largest numbers of shoot buds were observed in media with 3% sucrose. Increased light and CO_2 had a positive interactive effect. Fresh and dry weights were greatest at highest levels of sucrose, light, and CO_2. Although there was less growth in the absence of sucrose, fresh or dry weight of

shoot buds grown without sucrose in the media still doubled over the 21 days of culture. Net photosynthetic rates of buds were negative 4 days after initiation of culture and approximately zero after 20 days of treatment. When transferring buds to fresh, sugar-free media, net photosynthetic rates became highly positive. Buds that had been cultured in the absence of sucrose and at highest light levels had the highest net photosynthesis rates upon transfer to fresh, sugar-free media.

13 ORAL SESSION 2 (Abstr. 028–034) Education/Cross-commodity

028

Advancing From Learning to Action Through Writing

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Teaching is a process that incorporates active participation from both teacher and student. As the students' development progresses, they should formulate questions themselves that provoke thought and compel them to seeks answers and should become adept at identifying problems and seeking solutions. Have students write "Persuasive Letters to get Action" provides opportunities for students to achieve these learning goals while refining communication skills. Students select and research a landscape issue or problem in depth; but instead of writing a paper for only the teacher to read, they determine whom they could write to with solutions to the problem. Letters are peer-reviewed and revised before being mailed to the government officials, CEOs, and others in a position to follow through on the proposed actions. Students experience a sense of empowerment when they take action on an issue. They are motivated by a larger audience that goes beyond the teacher. They receive feedback from individuals outside the classroom as well as within the classroom, and they are being recognized and asked to serve on committees as a result of their letter writing. They are being heard nationwide and are experiencing the power of the written word as a means of both identifying and solving problems.

029

Experimental Evaluation of an Environmental Education Program and Its Impact on Knowledge and Attitudes of Texas Secondary School Students

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The objectives of this research project were to: 1) Develop an environmental science curriculum that was heavily activity-based, 2) evaluate the curriculum for usefulness as a teaching tool, and 3) test student knowledge and attitude changes towards the environment resulting from exposure to this 10-day curriculum unit. The curriculum developed entitled Environmental Technology—"Natural State of the Environment" was designed to provide an introduction to biological processes and basic principles of ecology, and to set the foundation for additional environmental studies. The curriculum was sent to 31 high schools in Texas and tested on 1500 students. Students participating in this study were administered a pretest prior to participation in the environmental science curriculum and an identical post-test after its completion. The questionnaire included an attitude inventory and knowledge section in addition to a biographical information section. Results examine the relationship between environmental knowledge and environmental attitudes, determine the attitude and knowledge changes from before until after the instructional unit, and focus on the importance and need for environmental education programs.

030

The H.O.R.T Project: A Hands-on Educational Experience

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The Farm Management and Technology Program (FMT) is a 3-year postsecondary vocational agriculture program. FMT students may choose to specialize in horticulture. Since January 1995, all horticulture students have been involved in a hands-on, practical educational experience called "H.O.R.T." (Horticultural Opportunities for Real Training). The students operate a small horticultural "business." They must plant, maintain, harvest, and sell several horticultural crops, including greenhouse and field-grown vegetables, apples, berries, and potted flowers. H.O.R.T. lasts two semesters: January through April and September through December. Students may choose to do H.O.R.T. for 2 years to broaden and deepen their horticultural learning. Through active participation in H.O.R.T., students will achieve the technical competencies required by the FMT program and specified by Quebec's ministries of education and agriculture. Each year of H.O.R.T. counts for 5-2/3 credits out of a program total of 90-1/3 credits. The goals of H.O.R.T. are not so much the acquisition of "book knowledge" (lower part of the cognitive domain) as the development of technical skills, planning and decisionmaking abilities, business sense, and proper communication (higher-order cognitive skills as well as psycho-motor and affective skills).

031

Need for Systemic Change in Undergraduate Education

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Changes in the environment, in technology, and in societal needs will result in a change in the expectations from our graduates. Meeting these expectations will require a systemic change in undergraduate education in horticulture. While we do an excellent job in training students, we are not as effective in educating them. Our students must develop critical thinking skills and become adept at solving problems utilizing a multidisciplinary integrated approach rather than in a reductive manner. Achieving these skills is essential if our graduates are to be successful in the rapidly changing job market. Implementing curricular change requires faculty ownership as well as administrative support and an appropriate rewards and recognition system. These and other principles from the USDA-funded project on Theoretical Bases for Systemic Change in Higher Education in Agriculture will be discussed.

032

The Effectiveness of a Workshop Model in Conveying Information on Xeriscaping

Cynthia McKenney[1]* and *Robert Terry, Jr.[2]*, [1]Dept. of Plant and Soil Science, Texas Tech Univ., Lubbock, TX 79409-2122; [2]Dept. of Agricultural Education, Texas A&M Univ., College Station, TX 77843.

Workshops are one of the primary tools utilized to convey information to audiences with diverse backgrounds. Frequently, the results obtained are of mixed success or unmeasurable. In this project, the Environmental Protection Agency sponsored the development of a model workshop to promote the concept of water conservation through xeriscaping. Two workshops were conducted in Spring 1994. Slide presentations, audience discussion sessions, tours of an existing xeriscape, and the administration of pre- and post-workshop surveys were included in the model. Statistical analysis comparing the surveys determined the effectiveness of the model. The results indicated both the perception and the general knowledge about water conservation were significantly improved. Promotion by newspaper was the most-effective method of reaching the audience, while TV spots were the least effective method used. The model was successful in reaching a new audience which was characterized as being 45 years old, having less than 1 year of gardening experience, and possessing some college education.

033

Development of Multimedia Software for Plant Materials Courses and the Landscape Industry—A Developer's Perspective

Gary Kling, Christopher Lindsey,* and *Mark Zampardo*, Dept. of Horticulture, Univ. of Illinois, Urbana, IL 61801.

The authors present a case study of the progress and development of UIPLANTS from its inception to marketing. Topics such as determining the objectives of the software program, choosing equipment, authoring software, hardware, personnel, and funding will be addressed. The authors will lead the audience through the path of development and show how the product being produced evolves as each of the above factors change in time. Included in the presentation will be issues relating to copyrights, patents, publishers, and royalties. The effects of continuous evaluation and testing of software development will be demonstrated. Also discussed will be changes in software development as influenced by each of these factors. The presentation will include future development of UIPLANTS as it is being modified to meet industry needs.

034

Canadian Peat Harvesting and Its Effects on the Environment

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Canadian sphagnum peat moss has long been the preferred base for growing media of horticulturists in North America and Europe. Growers, horticultural scientists, and soil media producers have been using peat moss for several decades with excellent results. In the past 5 years, there has been some concern raised, especially in the U.K., that harvesting peat is harmful to the environment. The situation in Canada is far different from that in Europe. The Canadian peat industry is a world leader in restoration research because of its efforts to find the best ways to return harvested bogs to functioning wetlands. The first stage of research just completed by Laval Univ. shows that peat bogs can be effectively, economically, and easily restored. Additional research findings will be described in this paper. But, the conclusion is clear: Peat moss is a safe, environmentally friendly growing medium. This paper also will describe the state of resource in Canada as outlined by an independent environmental group, the steps taken by the Canadian Sphagnum Peat Moss Assn. to ensure that resource development is sustainable, as well as the process of how peat is harvest and how bogs are restored to functioning wetlands.

14 ORAL SESSION 3 (Abstr. 035–042) Culture and Management/Vegetables (temperate)

035

Mechanical Harvesting of Peppers

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For nearly 30 years, more than 75 different groups: producers, entrepreneurs, engineers, processors, consultants, state or federal researchers, or manufacturers have constructed over 195 harvesters attempting to mechanize the harvest of *Capsicum* peppers. Countries testing experimental harvesters include: Bulgaria, Hungary, Israel, Italy, Spain, the United States, and the former Soviet Union. Over 25 principles have been tested. In 1980, there were 10 different university, state, or federal research agencies experimenting with pepper harvest mechanization. However, in 1990, there were no active mechanization projects. At least 13 patents have been identified that have been issued on pepper harvesters and 65 patents on harvesting elements or principles for other crops that have been tested or might be used to harvest peppers. Interest in mechanization has resumed in the United States and a number of commercial harvesters are available. Harvester usage is expected to increase significantly by the year 2000.

036

Watermelon Yield as Affected by Plant Density and Spatial Arrangement

*Warren Roberts** and *Jim Duthie*, Wes Watkins Agricultural Research and Extension Center, Oklahoma State Univ., Box 128, Lane, OK 74555.

Watermelons are grown at many different row widths and in-row spacings, but an ideal plant density has not been established. Experiments were conducted at one location in 1993 and at two locations in 1994 in southeastern Oklahoma. Effects of plant density and spatial arrangement on 'Allsweet' and 'Sangria', two standard-sized watermelons, were evaluated. Beds 0.3 m wide were formed on 0.91-, 1.83-, 2.74-, and 3.66-m centers. Various in-row spacings that ranged from 0.30 to 2.44 m were established at each row width. This resulted in various spatial arrangements of plants with densities of 1500, 3000, 6000, and 12,000 plants/ha. With 1500 and 3000 plants/ha, about one melon was harvested from each plant, and less than one melon was harvested from each plant when the density reached 12,000 plants/ha. Yield (weight/ha) increased with plant density and reached a maximum at 12,000 plants/ha. Isometric spatial arrangements did not produce greater yields than did the more-rectangular arrangement. Weight per melon decreased with increasing plant densities in two experiments, but the decrease was small relative to the increased number of melons/ha.

037

Effects of Transplanting Depth of Pepper on Flowering and Fruit Characteristics

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Bell pepper (*Capsicum annuum*) is traditionally transplanted either to the top of the root ball or to the cotyledons of the transplant. Recent evidence has shown that increased and earlier yields may be obtained by deeper transplanting of pepper. Thus, a study was undertaken to investigate the effects of pepper transplanting depth on flowering and the fruit characteristics of harvest fruit. Pepper was transplanted to the top of the rootball, the cotyledons, and the first true leaf at two locations in 1994. Both 'Camelot' Hybrid and 'Jupiter' (open-pollinated) cultivars were planted into bareground on Mar. 24 at Tifton, Ga. Only 'Camelot' was transplanted into a plastic mulch with drip irrigation on Mar. 28 at Cool Springs. Plots consisted of a single row of seven plants with the internal five plants used for data collection. Treatments were replicated three times. Normal cultural and pest control practices were used at both locations. Data on flowering were collected 5 weeks after transplanting. Data on fruit characteristics were collected at harvest. Number of bloom clusters per plant, number of blooms per cluster, number of open blooms, and number of set blooms were significantly greater in the deeper-planted pepper at Cool Springs. The same was true for bloom clusters and blooms per cluster at Tifton. Number of blooms open and set were greater in deeper-planted 'Camelot' at Tifton as well. There were virtually no differences among characteristics of harvest fruit. Earlier bloom set appears to occur in deeper-planted pepper on both bareground and mulched beds.

038

Changes in Broccoli Head Quality during Spring, Summer, and Fall, in Coastal South Carolina

*Robert J. Dufault** and *Mark Farnham*, Clemson Univ. and USDA Vegetable Lab., Charleston, SC 29414.

The objectives of this study were 1) to identify high-quality broccoli cultivars for field production in spring, summer, and fall seasons; and 2) to illustrate dynamic changes in head quality of promising cultivars for a particular growing season compared to head quality over all seasons evaluated. Twenty-four hybrid cultivars were grown in spring, summer, and fall growing seasons 1993 to 1995 included 'Arcadia', 'Baccus', 'Bonanza', 'Citation', 'Claudia', 'Early Dawn', 'Embassy', 'Emerald City', 'Everest', 'Exselsior', 'Galaxy', 'Galleon', 'Goliath', 'Green Comet', 'Green Duke', 'Leprechaun', 'Packman', 'Paragon', 'Skiff', 'Southern Comet', 'Sprinter', 'Sultan', 'Symphony', and 'Viking'. Head density, color, leafiness, and shape, bead size, and consumer use were documented. 'Symphony' performed best in Spring 1993 and 1994, and only 'Paragon' tolerated heat in Summer 1993 and 1994. Fall climate in coastal South Carolina is most conducive to high-quality production versus spring and summer seasons, with the following cultivars producing superior heads in both years: 'Symphony', 'Embassy', 'Galleon', 'Galaxy', 'Sultan', and 'Emerald City'. Quality defects for each cultivar in each inappropriate growing season will be illustrated.

039

Interplanted Small Grain Management in Cucumbers

*Bernard H. Zandstra** and *William R. Chase*, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824.

Small grains are interseeded with several vegetable crops in Michigan to protect them from wind and water erosion. When the vegetable crop is well-established, the small grain is killed with a graminicide. Research was conducted to determine the optimum combination of small grain species, age of kill, and nitrogen application rate for acceptable pickling cucumber yield in a single harvest. In several experiments, barley, oats, rye, and wheat were seeded at 130 seeds/m^2 in the field. Cucumbers were seeded 1 week later. The cover crops were treated with sethoxydim at 0.21 or 0.31 kg·ha^{-1} plus 1.25% COC when they were 7 to 10 or 13 to 16 cm tall. Small grain size at application had no effect on their kill with sethoxydim or on cucumber yields. Barley and rye were the most vigorous small grains up to 3 weeks after seeding, but oats were similar in size by 4 weeks. Wheat was slower to develop, and more difficult to kill with sethoxydim. The optimum nitrogen treatment was 34 kg·ha^{-1} before planting the cover crop, followed by 45 kg·ha^{-1} at the two- to three-leaf stage of cucumber.

040

Maximum Improvement of Cucumber Yield is Expected if Planted Shortly Following Nematode-resistant Tomatoes in Soils Susceptible to Nematode Buildup

H.Y. Hanna, T.L. Kirkpatrick,* and *P.D. Colyer*, Louisiana State Univ. Agricultural Center, Bossier City, LA 71113, and Univ. of Arkansas, Hope, AR 71801.

Our previous studies have indicated that improving cucumber yield in nematode-infested soil is feasible without chemical control if planted after nematode-resistant tomatoes. The current study was conducted to determine the length of time this beneficial effect might last. Results indicate that planting cucumbers shortly after the last harvest of nematode-resistant tomatoes (July) significantly increased the premium and marketable yields. Nematode injury to the cucumber root system was extremely low. Cucumbers planted 1 month later (August) also produced higher premium and marketable yields and sustained less injury to the root system. However, yield improvements and root injury reduction of cucumbers planted 1 month later were not of the same magnitude noticed of cucumber planted shortly after the termination of the tomato crop. These results may indicate a tendency of a gradual nematode buildup in the soil previously planted with the nematode-resistant tomatoes.

041

Evaluation of Color Mulches and Oil Sprays for Yield and Silverleaf Whitefly Control on Tomatoes

A.A. Csizinszky, D.J. Schuster,* and *J.B. Kring*, Univ. of Florida, Gulf Coast Research and Education Center, 5007 60th St. E., Bradenton, FL 34203.

In Fall 1990 and Spring 1991, the effects of four mulch colors, orange, yellow, aluminum, and white or black (fall or spring) were evaluated in the field on yields of 'Sunny' tomato and numbers of insect vectors. In additional treatments, plants on the orange mulch were sprayed weekly with 2% mineral oil, and the yellow mulch was sprayed with soybean oil as needed during the season. In fall, plants were tallest ($P \leq 0.05$) on the aluminum and yellow + oil treatments. The largest number of whiteflys (*Bemisia argentifolii*, Bellows and Perring) and the largest proportion of plants with virus symptoms were found on the white and yellow mulches. Fruit size and marketable yields were best with the yellow + oil treatment. In the spring, insect populations were low and only a few plants had virus symptoms. Plant heights, fruit size, and marketable yields were similar with all treatments.

042

The Effect of Staking vs. Ground Culture on Tomato Postharvest Losses

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Freshly harvested and graded tomatoes were held for 7 days at 21C in 1993 and 15.5C in 1994. After the holding period, the fruit were examined for decay development. In 1993, decay losses were not significantly different between cultural treatments, possibly due to a very warm and dry growing season. However, decay losses were significantly different during a wet 1994 growing season. Stake-grown fruit decay loss was 10.1% vs. 34.1% loss for ground culture. Losses due to anthracnose (*Colletotrichum coccodes*) was significantly higher on the ground culture fruit (8.7%) than on the stake culture fruit (0.5%). Sour/watery rot (*Geotrichum candidum*), Rhizopus soft rot (*Rhizopus stolonifer*), bacterial soft rot (*Erwinia carotovora*) and the black mold rot complex (*Alternaria*, *Stemphylium*, *Pleospora*) were the other predominant postharvest decays.

15 ORAL SESSION 4 (Abstr. 043–049) Nutrition/Fruit & Nuts (temperate)

Changes of Orchard Soil Property and Fruit Quality of 'Fuji' Apples Treated with Energized "Bio-green Water"

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The energized water, Bio-Green Water (B.G. Water) was manufactured through a series of processes: water purification → adding catalysts → exposure with special energy spectra → filtering, by Kyungwon Enterprise Co. B.G. Water was treated with irrigation of 4 liters/tree at 30 Apr. 1994 and 8 liters/tree at 20 June 1994 in the 'Fuji' apple orchard soil, and a pasting to the trunk of apple trees at 20 Apr. 1994. In terms of orchard soil property, Ca and Mg contents were outstandingly increased; however, P_2O_5 was decreased and K_2O was not influenced by irrigation of B.G. Water. The B.G. Water treatment changed soil pH from 4.71 to 5.81 of surface soil level (0 to 20 cm) and from 4.82 to 6.45 of deeper soil level (30 to 50 cm). B.G. Water treatment showed higher soluble solids in apple fruit juice, and lower flesh browning after peeling than that of control. Of mineral contents in fruit skin, Ca was increased; however, N was decreased by the B.G. Water treatment. Of the four solvents fraction for Ca extraction, water-soluble Ca content was increased in the fruit skin treated with B.G. Water, whereas the contents of N, P, Ca, Zn, and B were decreased in the leaves and stem bark of apple trees treated with B.G. Water.

044

Irrigation Management Affects Soil Solution NO_3-N Concentration

Denise Neilsen, Gerry H. Neilsen, Peter Parchomchuk,* and *Eugene J. Hogue,* Agriculture and Agri-Food Canada, Research Station, Summerland, BC, Canada V0H 1Z0.

Direct application of fertilizers in irrigation water (fertigation) has been advocated as an efficient method of fertilizing fruit trees. However, more information is needed on the relationship between irrigation and N inputs in order to target fertigation to meet plant demands. Soil solution NO_3-N concentration was measured at three sites in response to the method of fertilizer application in which 25 g N/tree per year was either spring-broadcast with sprinkler irrigation or fertigated at 8 weekly intervals through drip irrigation; the amount of irrigation water in which 50 g N/tree per year was given in 63 daily fertigations with either 4 or 8 liters of water/day for two soil types and the concentration of fertigated N in which either 75 or 150 ppm NO_3-N was given in 63 daily fertigations. Soil solution NO_3-N concentration decreased rapidly for broadcast fertilizer with sprinkler irrigation and was lower than for weekly fertigation with drip irrigation. Doubling the amount of irrigation water effectively halved the soil solution NO_3-N concentration in both the silt loam and loamy sand soils, although concentrations were higher in the silt loam soil. Movement of applied N below the root zone was halted for the silt loam soil by mid-summer with the lower amount of irrigation water, but was only delayed in the loamy sand soil. Doubling the average concentration of N in the irrigation water resulted in a doubling of the concentration of NO_3-N in the root zone. A simple model was devised to predict the soil solution NO_3-N concentration based on N and water inputs and fitted to measured values for daily and weekly fertigation.

045

Effect of Differential Rates of Nitrogen Fertilization on Subsequent Recovery of Isotopically Labeled Fertilizer Nitrogen by Mature Almond Trees

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There is legitimate concern that excessive fertilizer nitrogen (N) application rates adversely affect groundwater quality in the San Joaquin Valley of California. A 5-year study was conducted to assess the interrelationships between N fertilization rates, tree productivity, leaf [N], soil [NO_3^-], tree recovery of isotopically labeled fertilizer N, and NO_3^-leaching. High N trees recovered <50% as much labeled fertilizer N in the crop as did trees previously receiving low to moderate fertilizer application rates. Our data suggest that the dilution of labeled N in the soil by high residual levels of NO_3^-in the soil had a greater effect than tree N status (as expressed by leaf N concentration) on the relative recovery of fertilizer N.

046

Nitrogen Partitioning in the Hazelnut Tree

Jeff Olsen, Timothy Righetti,* and *Enrique Sanchez*, Dept. of Horticulture, Oregon State Univ., Corvallis, OR 97331.

Isotopically labeled ^{15}N was applied to 'Barcelona' hazelnut trees planted in 1982. The trees were given the following treatments: 120 g N applied to the ground in spring (SG), 120 g N applied to the ground after harvest (PHG), 40 g N applied foliarly after harvest (PHF). The percent of nitrogen from the labeled fertilizer was

measured in all of the tree tissues. The uptake of ^{15}N in the leaves was measured monthly for two seasons. The utilization of stored nitrogen reserves was quantified for each treatment. There was a 28% rate of recovery for the applied N. The hazelnut tree showed a strong reliance on stored N reserves in all of the tissues. The fruiting structures were a strong sink for N in the year of application, and for reserve N. Dry matter (DM) partitioning showed that the nuts accounted for 9.1% of the total DW of 11-year-old trees. The SG showed 10.63% of N from ^{15}N in the buds, and 7.40% in the nuts. The PHG treatment was absorbed into the tree, and used the next season in amounts similar to the SG treatments. The PHF was absorbed and used in smaller amounts consistent with the reduced amount of N applied to the foliage.

047

Bark storage Protein in Peach, Plum, and Cherry Trees

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The main form of nitrogen reserves during overwintering are amino acids and proteins. Specific proteins called bark storage proteins (BSP) have been characterized in many tree species. To identify BSPs in 'O'Henry' peach, 'Angeleno' plum, and 'Early Burlat' cherry trees, samples of bark were collected from January through December 1993 from trees growing under field conditions in Santiago, Chile. SDS-PAGE analyses were used to characterize the seasonal variation on the protein pattern on the bark of those *Prunus* species. A 60 kDa BSP was identified in the bark of all three species, which corresponds to the main protein present in the bark during the winter. This protein may play an important role as a nitrogen reserve in these fruit trees.

048

Response to Iron-deficiency Stress of Pear Genotypes

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Pear rootstocks differ in tolerance to calcareous and alkaline soils. Roots of Fe-efficient dicots react to Fe-deficiency stress by strongly enhancing the Fe^{3+}-reductase system, termed turbo-reductase, and by lowering the rhizosphere pH. In this study, we tested whether such adaptation mechanisms characterize pear and quince genotypes. Two trials were performed using micropropagated plants of three quince rootstocks (BA29, CTS212, and MC), three *Pyrus communis* rootstocks (OH x F51 and two selections obtained at Bologna Univ.: A28 and B21) and of two pear cultivars (Abbé Fétel and Bartlett, own-rooted). In the first trial, plants were grown in a nutrient solution with [Fe(+)] and without iron [Fe(–)] for 50 days. Their root iron-reducing capacity (IRC) was determined colorimetrically, using ferrozine and Fe-EDTA, and Fe uptake of Fe(+) plants was estimated. In the second trial, the rhizosphere pH of plants grown in an alkaline soil (pH in water = 8.3) was measured by a microelectrode. With the only exception of pears OH x F51 and A28, whose IRC was similar in Fe(+) and Fe(–) plants, the Fe-deficiency stress caused a significant decrease of the IRC. Among the Fe(–) plants, the two pear OH x F51 and A28 had higher IRC than the quince rootstocks and the cultivar Abbé F. When plants were pretreated with Fe, IRC was highest in the *P. communis* rootstocks (more than 50 nmol Fe^{2+}/g fresh weight per h), intermediate in the own-rooted cultivars, and lowest in the quinces (<15 nmol Fe^{2+}/g fresh weight per h). Fe uptake proved to be linearly and positively correlated with root Fe-reducing capacity ($r = 0.91$***). Rhizosphere pH, averaged over the first 2 cm from root tips, was highest in quince MC (7.2), intermediate in the other two quinces and in the cultivar Abbé F. (6.2–6.6) and lowest in the pear rootstocks and in the cultivar Bartlett (5.2–5.5). The results indicate that roots of pear and quinces do not increase their ability to reduce the iron under Fe-deficiency stress. The genotypical differential tolerance to iron chlorosis likely reflects differences in the standard reductase system and in the capacity of lowering the pH at soil/root interface. The determination of the root IRC appears very promising as a screening technique for selecting efficient Fe-uptake rootstocks.

049

Copper Sprays—Effects on Apple Fruit Typiness and Market Color Grades

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Late dormant copper (Cu) sprays and mid-summer foliar Cu sprays are being promoted within the Washington apple industry as a means to enhance fruit typiness and red skin color, respectively. While there appears to be theoretical bases for these practices, they have not been tested for horticultural significance. Differential late dormant spray treatments of Cu hydroxide (the Cu source most commonly recommended by agricultural consultants) were imposed in two 'Delicious' orchards. Flower cluster Cu was positively related to Cu rate, but the sprays had no effect on leaf Cu or on six fruit typiness variables. Differential mid-summer spray treatments of water, Cu sulfate, and Cu oxysulfate solutions were imposed in three 'Delicious' orchards and one 'Fuji' orchard. The Cu sprays increased leaf Cu, but had no effect on market color grade measured using a commercial color sorter. The results appear to reflect Cu physicochemistry and timing of application. These preliminary results call into question the utility of the Cu sprays for improving apple fruit quality characteristics when trees show no visual signs of Cu deficiency. They do suggest some alternative ways to manage Cu nutrition in deciduous tree fruit orchards.

20 ORAL SESSION 5 (Abstr. 50–57) Cell & Tissue Culture/Cross-commodity

050

Changes in Storage Reserves of Pecan Somatic Embryos during Maturation and Maturation Enhancement Treatments

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Changes in lipid and total protein content of somatic embryos of pecan (*Carya illinoinensis*) were estimated during maturation, cold treatment alone (3, 5, or 8 weeks) or cold followed by dessication (3, 5, or 7 days). Triglyceride was estimated colorimetrically and methyl esters of fatty acids were analyzed by GC-MS. Total protein was extracted from the same tissue with 2% SDS in Tris·HCL buffer. Triglyceride content of enlarged somatic embryos was significantly lower than zygotic embryos and further declined after 5 weeks cold treatment. An even greater decline was observed during the desiccation treatment. The most abundant fatty acids in small and enlarged somatic embryos are linolenic > palmitic > oleic > stearic acid. However, the molar ratio of linolenic to oleic reached 1:1 after 5 weeks of cold treatment. During enlargement, protein content increased to levels found in zygotic embryos, with desiccation resulting in further elevation.

051

Development of a Nutrient Medium for the Growth of Date Palm (*Phoenix dactylifera* L.) Roots by tTissue Culture

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Several experiments were conducted in this investigation with the objective of determining the chemical components and the physical state of an optimal medium for the growth and elongation of excised date palm, cv Sukkari, roots. The chemical tests carried out included: Comparison of (MS)-salts with "White's"-salts mixture and different concentrations of (MS)-salts and its chelated iron; sugars; Modified White's Organics; inositol; adenine sulfate; growth regulators; and some antioxidants. The physical tests, on the other hand, included comparison of the growth and elongation of cultured roots in a liquid or on solidified nutrient media. The effects of various pH values were also tested. Roots were cultured in basal nutrient media composed of: (MS)-salts mixture, and (in mg·liter^{-1}): $NaH_2PO_4 \cdot H_2O$, 170; sucrose, 30,000; inositol, 200; Modified White's Organics; adenine sulfate, 120; activated charcoal, 1500; (2,4-D), 1; kinetin, 2. pH was adjusted at 5.7 ±01. (MS)-salts mixture was found to be superior to "White's"-salts. No significant difference was observed between (1/2MS) and full-strength (MS)-salts. However, twice the concentration was found to be inhibitory. The normal concentration of (MS)-Fe was found to be optimum for root growth and elongation. The optimal concentration most suitable for the growth and elongation of excised date palm roots has been determined for each of: sugars; Modified White's Organics; inositol; and adenine sulfate. The only growth regulator that needs to be added to the nutrient medium is 2,4-D at 0.1–1.0 mg·liter^{-1}. The study showed the importance of the inclusion of activated charcoal to the nutrient medium. The growth and elongation of roots were both stimulated at all concentrations tested. (PVP), on the other hand, was inhibitory at all concentrations tested. Shaken liquid media was recommended for better root growth and elon-

gation at pH 7.0–8.0. Incidentally, the medium developed was found to support the growth and elongation of roots excised from two other cultivars, namely 'Khudri' and 'Khaias'.

052

Use of Forcing Solution Techniques to Improve Chestnut Micropropagation

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Chestnut (*Castanea* spp.) is considered difficult to micropropagate. The timing for harvesting explant materials from forced stems is critical, although many factors need to be considered for successful micropropagation. Previous research with spirea and five-leaf aralia demonstrated that forcing solution techniques extended the availability of high-quality explant material, thus expediting micropropagation. However, preliminary research illustrated that chestnut is very difficult to force and the new forced softwood growth is very short-lived, which made micropropagation difficult. It was found that, at about 7 days from budbreak, the forced chestnut softwood growth (about 2 cm long) served as the best explant material. If longer than this timing window, the new growth would die. If shorter, the explants had a high contamination rate, exudation of purported phenolic compounds, and explants would not regenerate. Shoot proliferation and callus regeneration were achieved by culturing good-quality explants on Woody Plant Medium supplemented with 0.1 mg BA/liter. The new shoots grew vigorously in vitro with apparent normal morphology.

053

Commercial Plant Tissue Culture in India—Current Status

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In recent years, there has been an explosion in the number of commercial plant tissue culture (TC) units in India. More than 25 such companies have production capacity of two to five million plants per annum. Almost all units are export oriented, but the target crops are the same. Indoor foliage plants dominate the export market. Micropropagation industry in India is providing major support to Indian agriculture in four crop groups: Fruits, ornamentals, spices, forestry/plantation crops. Banana is the largest selling TC fruit crop. TC papaya plants are now marketed for extraction and processing of papain. TC anthuriums, orchids, and gerberas have attained commercial importance. TC rose plants are used as pot plants. Nearly 500 ha are under TC cardamom cultivation in southern India recording 20% to 30% increase in yield. Vanilla cultivation is expected to increase from the existing 50 ha to more than 400 ha in the coming years using TC plants. Sugar companies have in-house units for micropropagation of sugarcane. There is demand for bamboo and eucalyptus for selective reforestation. The TC Industry is constrained by the non-availability of international varieties, high infrastructure and electricity costs, and lack of managers with commercial experience. A shake-up is imperative, during which many of the existing TC units may not survive the year 2000.

054

The Plant Tissue Culture Information Exchange: A Web Site for Teachers, Researchers, Practitioners, and Students

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The World Wide Web is the most rapidly growing communication tool in use today. The Web links networked computers of all sizes and types through use of a hypermedia application known as a "browser." Hypermedia technology allows research-based information related to plant tissue culture to be disseminated worldwide rapidly and cheaply, and to audiences that previously had difficulty accessing the information through scholarly journals (practitioners, secondary school students, consumers). The Plant Tissue Culture Information Exchange resides on the Aggie Horticulture homepage (http://aggie-horticulture.tamu.edu). Present contents include information on suppliers of tissue culture equipment and media, research reports on micropropagation of several ornamental species, and links to tissue culture related material at other universities. Hardware, software, and network requirements to access the Information Exchange and the construction of hypertext documents for inclusion in the Information Exchange will be presented.

055

Micropropagation of *Achimenes* Hybrids for Winter Production

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Achimenes is a summer-flowering pot plant commonly propagated by shoot tip cuttings taken from rhizomes released from dormancy. Micropropagation was used in this study in order to establish a protocol for producing plants in winter when *Achimenes* are not usually available. Leaf segments, taken in August 1993, from hybrids 'Flamenco', 'Rosenelfe', 'Bella', and 'Sandra' grown in a greenhouse, were cultured on a modified Murashige and Skoog (MS) medium supplemented with 0.1 mg·liter^{-1} BA and 0.5 mg·liter^{-1}; shoots proliferated without callus formation. Leaf explants taken from the proliferated shoots were placed on MS medium with 0.5 mg·liter^{-1} BA and 0.1 mg·liter^{-1} NAA for 8 weeks for further shoots proliferation. 'Bella' showed vigorous growth and produced the most shoots (82) with no rhizomes, whereas 'Flamenco' had the least shoots (28) along with rhizomes. Shoot tips were then transferred on MS medium supplemented with 0.5 mg·liter^{-1} NAA for 6 weeks where more vigorous shoots developed along with roots. Microcuttings were directly stuck ex vitro under moisture and rooted well in 4 weeks before planting in individual culture and flowered normally. These results provide the basis for a successful production of *Achimenes* hybrids for growth and flowering in winter months provided optimal temperature and irradiance levels are given.

056

Internal Disinfection for in Vitro Culture of Chrysanthemum

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Asymptomatic contaminated cuttings were used in two trials to test 1) the effects of antibiotica (streptomycin and penicillin) included in MS culture medium and 2) the internal disinfection employing germicide pulsing solutions, used for cut flowers, as a pretreatment. Before the regular disinfestation, cuttings were immersed to 3 h in the preservative solutions (treatments): 1) 818 mg·liter^{-1} silver thiosulfate; 2) 1000 mg·liter^{-1} NaOCl; 3) 800 mg·liter^{-1} 8-hydroxyquinolin sulfate; 4) 600 mg·liter^{-1} potassium sulfate. The addition of penicillin to MS medium reduced bacterial contamination by 50% on chrysanthemum nodal explants. Streptomycin showed similar results, but not promoted undesirable morphological alternations such as chlorotic, deformed leaves and shoots. All treatments except silver thiosulfate solution reduced the contamination by more than 50%. The highest efficiency (87%) was obtained with aluminum sulfate, without negative side effects.

057

Shoot Micropropagation in *Vitis* as a Source of Leaf-derived Embryogenic Cultures

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Micropropagation of *Vitis bourquiniana* Lenoir 'Black Spanish', *V. champini* Planchon 'Dog Ridge', *Vitis* hybrids ('Blanc du Bois', 'Himrod', and 'Niagara Seedless'), *V. rotundifolia* Michx. ('Carlos' and 'Dixie'), and *V. vinifera* L. ('Autumn Seedless', 'Cabernet Sauvignon', 'Carignane', 'French Colombard', 'Ruby Cabernet', and 'Tokay') was accomplished. Shoot tips taken from micropropagated plants in long-term culture were inoculated onto solidified C_2D medium containing 5 μM benzyladenine. Culture times consisting of either one or two 4-week cycles were compared for effect on shoot number. A range of response among cultivars tested was noted. The best-responding variety was *V. champini* 'Dog Ridge', with 5.8 shoots per apex. All other varieties were less prolific. When shoot micropropagation from nodal explants and apices was compared, so significant difference was noted. In vitro micropropagation offers rapid clonal production of grape and is a source of sterile leaf explant material for embryogenic cultures, which, in turn, are useful target for genetic transformation.

21 ORAL SESSION 6 (Abstr. 059–062) Extension/Cross-commodity

059

A Computer-based Diagnostic System for Diseases, Disorders, and Pests of Subtropical and Tropical Fruits

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A computer-based diagnostic system that can assist commercial producers, extension agents, and homeowners in the diagnosis of diseases, disorders, and pest damage for citrus, avocado, 'Tahiti' lime, mango, carambola, lychee, and papaya was developed. The program was written in C++ and runs under MS-DOS. The system design was based on the diagnostic reasoning process of experts by identifying the location of symptoms, tree vigor, and occurrence within a grove. Full-screen color images link symptoms to possible diseases, disorders, and/or pest damage. Users can also refer to expert knowledge, graphic displays, pop-up menus, dialogue boxes, and retrieve information via hypertext from extension publications as well as current control methods. The program is available on CD-ROM, contains over 800 digital color images, and includes a glossary of terms.

060

Using Fax-on-demand to Disseminate Agricultural Production Information

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Fax-on-demand is a new system of communications that combines computer, fax, and telephone technologies. Corporate use of fax-on-demand has shown it to be a rapid, user-friendly, economical way to disseminate technical support information. A project was initiated to evaluate the usefulness of fax-on-demand for disseminating "time-sensitive" crop management information to growers. The system, named the "RCE FaxInfo Line," has made extension newsletters, pesticide label updates, market price summaries, IPM insect counts and treatment thresholds, etc. available to callers 24 hours a day. While most of the producers surveyed felt the system fit their needs, there has not been widespread use. A limiting factor has been the lack of producers with fax machines. A recent survey revealed that only 8% of New Jersey farmers own fax machines. If this technology is to be effective for extension, the percentage of growers utilizing fax machines must increase.

061

Factors Essential for the Success of a Master Gardener Demonstration Garden

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Penobscot Co. (ME) Master Gardeners initiated a highly successful demonstration garden in 1994, on the university's sustainable agriculture farm. Five factors for the garden's success are suggested for consideration by groups planning similar projects: 1) The garden has a permanent site with excellent road visibility, on a public farm that supports public service; 2) The farm manager tills the plot and manages cover crops; 3) 10 to 12 Master Gardeners and two extension educators commit significant ongoing labor to the project; 4) Local businesses supply plants and other materials; 5) A vital statewide Master Gardener Program assures an ongoing supply of volunteers, ideas and enthusiasm.

062

Effects of the Worker Protection Standard on Vegetable and Fruit Production—A Trainer/Extension Agent's Perspective

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The Dade County Extension Service has conducted three types of training classes related to the new Federal Worker Protection Standard (WPS): Train-the-Trainer sessions, WPS Worker Training, and WPS Handler Training. All of these must follow rigid course outlines to comply with requirements of the U.S. Environmental Protection Agency. At the end of training classes, growers and other audience members are often confused as to how this Standard actually affects their operation. The discussion will describe: a) materials and supplemental training classes developed by extension agents to help growers comply; b) operational changes that local growers have made as a result of this new law; c) the effects of this Standard on field visits and demonstration-research projects; and d) interactions between agents and non-traditional clientele groups.

22 ORAL SESSION 7 (Abstr. 063–070) Culture and Management (Nutrition/ Photosynthesis)/Vegetables (Temperate)

063

Utilization of Municipal Solid Waste Compost for Vegetable Crop Production

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Vegetable culture with Municipal Solid Waste Compost (MSWC) amended soils was evaluated with the emphasis on crop and soil responses. There were three treatments of 0, 20, and 40 $t \cdot ha^{-1}$ of MSWC applied in the fall of 1993 to a Matapeake Silt Loam on the Eastern Shore of Maryland. The following spring the soil was prepared for planting tomatoes and green beans. All crop management practices were in accordance with the standard procedures followed in Maryland for each crop, except for the addition of the MSWC. Both crop yields were significantly increased with the addition of the MSWC. Following the bean crop, broccoli transplants were established in the fall of 1994. Again, the yields obtained with the MSWC plots as compared to the control were significantly greater. Soil properties were also favorably affected by the addition of the compost. Analysis of soil samples indicated significant increases with MSWC, such as cation exchange capacity, soil pH, percent organic matter, and water-holding capacity.

064

Phasic Control of Photosynthetic Photon Flux for Lettuce Production in CELSS

*C. Chun** and *C.A. Mitchell*, NASA Specialized Center of Research and Training, Purdue Univ., West Lafayette, IN 47907-1165.

For biomass production in a space-deployed Controlled Ecological Life-Support System (CELSS), efficient usage of limited resources such as light, CO_2, growth area, and labor is more consequential than for biomass production on Earth. Light will be one of the most energy-consuming environmental factors to provide in CELSS. Therefore, development of an energy-efficient lighting-control strategy would make a great contribution to the sustainability of CELSS. Lettuce (*Latuca sativa* L.) was used as a model salad crop for the development of new control methods due to its rapid growth rate and high harvest index (≥80%). Lettuce seeds were sown and plants were cultured hydroponically in the Minitron II plant growth/canopy gas-exchange system. Canopy net photosynthetic rates (μmol CO_2/m^2 per s) were measured under a specific photosynthetic photon flux (PPF) and analyzed to decide the PPF of the next 1-h interval. Appropriate PPFs were provided on the initial day and during the first 1-h interval of each 20-h photoperiod. Plant-growth indices, crop yield rates (g/m^2 per day), and power consumption rates were determined for different lighting strategies to identify the best compromise between energy cost and yield. Day/night temperature and CO_2 concentration were maintained at 25/25C and 1100/400 $\mu l \cdot liter^{-1}$, respectively. This research is supported by NASA grant NAGW-2329.

065

The Influence of Nitrogen Rate and Timing on 'Beauregard' Sweetpotato Yield and Quality

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Sweetpotato yield and quality are influenced by a N fertilization program. These studies were conducted to evaluate the effect that different N rates and application

times had on the yield and quality of Beauregard roots. Three experiments were conducted in separate locations in North Carolina: One in 1992 to evaluate N rates of 28 to 56 kg·ha^{-1}; and two in 1994 that evaluated nitrogen rate and time of N application. In 1994, N timing using single applications (21, 28, and 35 days after planting) were compared with split applications (10–21 and 21–35 days after planting). Also, in 1994, N rates for the season was varied from 0 to 42 kg·ha^{-1} comparing single and split applications. No yield differences were detected when N rate was varied from 14 to 56 kg·ha^{-1}. However, the application of at least 14 kg N/ha increased yield when compared with the control (0 kg N/ha). The highest yield of US #1 marketable roots was obtained when all N was applied at 21, 28, or 35 days compared with split applications made at 10 and 21 days after planting. Roots tended to be shorter with single vs. split N applications.

066

Enhancing Potato Tuber Calcium Concentration Through Calcium Application May Reduce the Incidence of Internal Brown Spot and Hollow Heart

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A direct comparison was made of several commercially available calcium sources applied on two different schedules for their effectiveness in increasing tuber medullary and periderm tissue calcium concentrations in 170–284-g tubers of the cultivar Atlantic grown on a Plainfield sandy loam. Plots (6 x 3 m) were arranged in a CR design in 1993 and a RCBD in 1994 (eight replications). Paired measurements of tuber Ca concentration and internal quality (±hollow heart, ±internal brown spot) were made on individual tubers produced in plots with no additional or additional Ca (168 kg Ca/ha) supplied from either gypsum, liquid calcium nitrate, or NHIB. Two Ca and N application schedules were compared: 1) application at emergence and hilling (non-split), 2) application at emergence, hilling, and 4 and 8 weeks after hilling (split). All plots received 224 kg H/ha balanced with ammonium nitrate. In general, tuber yield and grade were unaffected by treatments in 1993 and 1994, but overall percent A-grade was lowest and percent B-grade highest in 1993 compared with 1994 data. In 1993, all treatments receiving Ca had greater mean tuber medullary and periderm tissue Ca concentration values and a greater percentage of tubers with an elevated Ca concentration compared with non-Ca-supplemented controls. The overall incidence of tuber internal defects was 5% in 1993. All split schedule treatments receiving Ca showed 0% internal defects. In contrast, nearly 8% of the tubers from control plots showed some defect. The medullary tissue Ca concentration of 65% of the tubers having either defect was below the median value of Ca concentration for the entire experiment in 1993. Similar evaluations are underway for the 1994 crop. These data suggest that tuber calcium concentration may be related to the incidence of these internal defects.

067

Using Spoke Wheel Injectors for Improved N Use Efficiency in Dry Bulb Onions

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Recent adoption of a raised bed production system for improved drainage on muck soils prompted experimentation to improve N use efficiency. The established methods of N fertilization was to simply broadcast 908 kg·ha^{-1} of 10–26–27 prior to planting in single rows. The raised bed production system results in a concentrated rooting zone directly underneath the raised bed. A system that places the N fertilizer within the root zone of influence at a peak time of crop utilization would increase N use efficiency, reduce fertilizer costs, and promote appropriate environmental stewardship. The use of a spoke wheel injector to sidedress N fertilizer effectively reduced total fertilizer costs by half,while producing onion yields equal to or greater than the established broadcast method under the raised bed production system. In addition, the use of the spoke wheel injector was not intrusive to the integrity of the raised bed, which allowed realization of benefits from using raised beds for the entire growing season.

068

Nitrogen and Potassium Application Scheduling for Drip-irrigated Tomatoes

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Tomato (*Lycopersicon esculentum* Mill.) was grown with drip irrigation on a fine sand and on a fine sandy loam to evaluate the effect of N and K time of application on yield. On the sandy soil, 196–112 kg of N–K/ha was applied with 0%, 40%, or 100% preplant with 100% or 60% applied in six or 12 equal or in 12-week variable applications. Marketable fruit yields were lowest with 100% preplant, intermediate with 100% drip-applied, and highest with 40% preplant with 60% drip-applied. With 100% drip-applied, yields were highest with 12 even than with six even weekly applications or with 12 variable N and K applications. With the 40% preplant, timing of application had little effect on yield. On the sandy loam soil in 1993, where only N was applied (196 kg·ha^{-1}), yields were highest with 100% preplant, intermediate with 40% preplant and 60% drip-applied, and lowest with all N drip-applied. In 1994, when excessive rains occurred, yields were similar with all preplant and with split-N applications.

069

Tomato Petiole Sap Nitrogen and Potassium Seasonal Trends with Various Fertilization Programs

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Tomato (*Lycopersicon esculentum* Mill.) was grown on fine sand and fine sandy loam soils at two sites to evaluate effects of N and K fertilization practices on petiole fresh sap N and K concentrations and to determine N and K sufficiency ranges. Treatments included applying N (196 kg·ha^{-1}) and K (112 kg·ha^{-1}) either 0%, 40%, or 100% preplant. With 0% or 40% preplant treatments, the remaining N and K was injected through the drip irrigation system in six or 12 equal weekly amounts or by a variable injection rate with most of the N and K injected between weeks 5 and 10 of the season. Petiole sap K concentration declined during the season, but was not greatly affected by treatment. Petiole N decreased over the season from 1100 to 200 mg NO_3-N/liter and decrease was greater for preplant N treatments. Petiole N was correlated with tomato yield, especially for petiole N measured in the period of 5 to 10 weeks after transplanting.

070

Comparison of Specific Electrode Techniques for Measuring Bell Pepper Petiole Sap Nitrate Concentration

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Sap nitrate was determined with the ion-selective electrodes, HACH combination nitrate electrode, and the CARDY nitrate meter on pepper petioles over five sample dates (n = 160). The electrode values were compared to the Cd reduction method performed on a Lachat automated ion analyzer with flow injection analysis. Thirty petioles were collected from plots of each of several N rate studies and the sap expressed by a hand-held garlic press. Correlation among the techniques were similar (r > 0.9), but the CARDY meter constantly read 100 to 175 ppm higher than the HACH. Across all dates the standard deviation of the difference, compared with the Cd reduction, for the HACH = 16 ppm, while for the CARDY it was 50. While the CARDY meter is easier to use and has fewer steps, the HACH electrode values were closer to the true readings and less erratic. One must use care when interpreting nitrate sufficiency value ranges with different quick-test techniques.

23 ORAL SESSION 8 (Abstr. 071–077) Growth & Development/Floriculture–Foliage

071

Evaluation of Non-climacteric Senescence of *Gladiolus* sp. Flowers

G.H. Pemberton, Terril A. Nell,* and *James E. Barrett*, Dept. of Environmental Horticulture, Univ. of Florida, Gainesville, FL 32611.

Senescence of gladiolus flowers, like many geophytes, does not involve a climacteric burst of ethylene. Eleven gladiolus cultivars were screened and all were non-climacteric (NC) for both respiration and ethylene production. Average ethylene levels for individual flowers were 0.5 μl C_2H_4/kg per h or less. As in other NC flowers, protein synthesis may be linked to senescence. Our goal was to identify specific proteins that were involved in the senescence process that could be used as indicators of postharvest longevity. SDS-PAGE protein profiles of cut gladiolus flowers were determined from a tight bud stage to senescence. Both increases and decreases were observed in major polypeptides that may be connected to postharvest flower longevity. Total protein content of gladiolus flower petals decreased by ≈70% during the profile period. This could explain the relatively short postharvest life of 3 to 5 days for individual gladiolus flowers. Total protein profiles were probed with an ACC synthase antibody to establish the relationship of this enzyme in NC senescence.

072

A Model Describing rRelease of Flower Bud Dormancy in 'Prize' and 'Gloria' Azaleas

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'Prize' and 'Gloria' azaleas were budded at 29C day/24C night without growth regulators. Dormant-budded plants were held at 2, 7, 13, or 18C for 0, 0.5, 1, 2, 4, 6, 8, or 10 weeks and then forced in walk-in growth chambers (29C day/24C night). A model was developed to describe the effect of cooling temperature and duration on days to marketability (eight open flowers) and percent of buds showing color. Holding at temperatures below 7C, increases days to marketability up to 7 days. Extended cooling (beyond 6 weeks) at temperatures <7C increases percent of buds showing color. Extended holding at temperatures >7C decreases buds in color due to development of bypass shoots during cooling and increased bud abortion. Plants not receiving a cool-treatment or cooled for <2 weeks do not flower uniformly. Furthermore, the percentage of plants reaching marketability dramatically decreases for plants held longer than 6 weeks at temperatures >7C. Both cultivars show similar trends, but 'Gloria' has greater variability.

073

Changes in Chrysanthemum Meristem and Lateral Bud Development at Elevated Temperatures

Richard K. Schoellhorn, James E. Barrett,* and *Terril A. Nell*, Environmental Horticulture Dept., Univ. of Florida, Gainesville, FL 32611.

'Improved Mefo' chrysanthemums were grown at 22C/18C and 34C/28C day/night temperature regimes to evaluate the failure of lateral bud development following pinching of this temperature sensitive cultivar. The number of viable buds on plants at the high temperatures was 40% of number at low temperature. Loss of bud viability was categorized as those buds that were: 1) absent, or 2) those in which growth was present, but inhibited. Inhibited buds were visible swellings surrounded by dense masses of secondary cell wall material. Anatomical studies were completed to verify the absence of lateral buds and determine what cellular changes imposed inhibition on those buds that did develop. A second group of experiments demonstrated that moving low-temperature plants to the high temperature caused production of viable buds to decline. Plants were moved from high temperatures to low, and reciprocally to high from low temperature. Anatomical sampling of apical meristems began at time of shift and at 1, 2, 4, and 8 days after temperature shift. High-temperature meristems possessed predominantly non-viable lateral buds, with few viable buds present.

074

The Effect of Timing and Duration of Supplemental Irradiance on Flower Initiation of Plug-grown Geraniums

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Plug-grown *Pelargonium* x *hortorum* 'Pinto Red' seedlings were grown under natural daylight (average of 4.7 mol/day) or with supplemental irradiance from high-pressure sodium lamps. Seedlings were grown under 8-, 16-, or 24-h photoperiods with supplemental irradiances of 2.5, 3.75, or 5.0 mol/day at each photoperiod. Supplemental irradiance was provided for 7, 14, 21, and 28 days beginning 7, 14, 21, 28, and 35 days after sowing. Seedlings were transplanted 63 days after sowing to 8-cm containers (121 plants/m^2) and grown to flower. Leaf number at time of transplant was not affected by photoperiod, but increased as daily irradiance and weeks of supplemental irradiance increased. Seedlings were more responsive to supplemental irradiance applications beginning 28 and 35 days than at 7 to 21 days after sowing. Ninety-two percent of seedlings receiving 28 days of 5.0 mol/day supplemental irradiance under a 24-h photoperiod starting 35 days after sowing had initiated flower buds at time of transplant; 75% of those receiving 3.75 mol/day were initiated. Plants receiving less than 3 weeks of supplemental irradiance or with an irradiance period beginning less than 28 days after sowing had not initiated flowers at transplant.

075

The Influence of Plug Storage Time, Greenhouse Temperature, and Photoperiodic Manipulations on the Plant Habit and Flowering of Several Perennial Species

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Plugs of *Arabis* 'Spring Cham', *Cerastium* 'Columnae', *Salvia* 'Blue Queen', and *Saxifraga* 'Purple Robe' (128 plugs/tray) were cooled at 2 to 3C for 0, 4, or 8 weeks. Plugs were potted in 10-cm containers and placed in warm (20C day, 17C night) or cool (10C day, 8C night) and provided with various long- and short-day combinations. In general, all taxa flowered more rapidly in the warm house, but were not significantly taller. *Arabis* showed no response to cooling or photoperiodic treatments, but *Cerastium* and *Saxifraga* had significantly longer internodes when subjected to increasing number of LD cycles. Plants of *Salvia* and *Cerastium* also flowered more rapidly when subjected to increasing cycles of LD, but height of *Salvia* and *Arabis* was reduced when LD were followed by SD. Other species of perennials will also be discussed.

076

Stimulating Germination of Australian Everlasting Daisies

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Australian everlasting daisies (*Asteraceae*, Tribe Inulae) have considerable potential as bedding plants, but little is known about their germination requirements. Florets have a papery corolla, which imparts considerable longevity of the floral display even under dry conditions. The influence of temperature, light and gibberellic acid (GA_3) was determined for several species with spectacular floral displays. Germination in petri dishes was optimum over the range of 10 to 20C, with little or no germination at extreme temperatures. Light stimulated germination in most species with little or no germination occurring under dark conditions. In the dark, GA_3 stimulated germination to similar levels observed in light-treated seeds. In most species, germination in the dark was optimum over the GA_3 concentration range 1 to 100 mg·liter^{-1}, and 500 mg·liter^{-1} was often inhibitory.

077

Regulation and Function of a Pollen-specific ACC Synthase Gene from Petunia

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At anthesis, petunia pollen contains large amounts of the ethylene precursor 1-aminocyclopropane-1-carboxylic acid (ACC). This ACC is thought to contribute to the rapid burst of ethylene produced by the pistil following pollination. An analysis of ACC content in developing anthers revealed that ACC began to accumulate the day before anthesis, indicating its synthesis was a late event in pollen development. We employed degenerate DNA primers to conserved amino acid sequences of ACC synthesis to amplify a cDNA from anther mRNA by RT-PCR.

The resulting cDNA (pACS2) was sequenced and found to represent ACC synthase. Use of pACS2 as a hybridization probe revealed an increase in ACC synthase mRNA concomitant with the increase in ACC content. Further analysis indicated the ACC synthase mRNA was localized specifically to the haploid pollen grain. In an attempt to determine the function of ACC in pollen maturation or pollen–pistil interactions, we have generated a series of transgenic petunias designed to inhibit the accumulation of ACC in pollen. For these experiments, we have employed a pollen-specific promoter (LAT52) from tomato to drive the expression of antisense pACS2 or the coding region of ACC deaminase. The results of the experiments will be discussed.

24 ORAL SESSION 9 (Abstr. 078–085) Modeling & Statistics/Cross-commodity

078

Does Quality Pay?

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Quality is extremely important to the processors of horticultural and agricultural commodities. It is important from the standpoint of producing high-quality end-products as well as resulting in lower costs and higher profits. However, producers of commodities receive few benefits from the production of higher quality for several reasons. One important reason is that producers lack information about the qualities processors require. In addition, producers are uninformed of the end-user quality their crops manifest. Presently, little incentive exists for producers to improve quality, other than that provided by USDA Grades and Standards. Using experimental economics, empirical evidence is provided demonstrating that increased awareness of crop quality requirements of processors by producers influences market efficiency, pricing efficiency, and crop quality management strategies of producers.

079

Statistical Design and Analysis of Producer/Consumer Evaluations to Assess Plant Quality

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An experiment was performed to investigate the effect of various nitrogen sulfer combinations on the quality of poinsettias. After various physiological measurements were taken, commercial growers, retailers, and consumers were asked to evaluate the salability of the plants. In order to avoid evaluator fatigue, only a limited number of plants could be evaluated. This presented both experimental design and data analysis problems. In view of these constraints, and in order to obtain meaningful results, an unreplicated 7 x 8 factorial design was used. Data were analyzed using the method of half-normal plots in conjunction with a modification of the analysis of variance procedure. Rationale and alternative designs will be presented, as well as the step-by-step procedure for using this method as contrasted with the standard ANOVA technique.

080

A Three-phase Model for the Analysis of Sigmoid Patterns of Growth

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A growth function was developed for describing the progression of shoot elongation over time. While existing functions, such as the logistic function or Richards function, can be fitted to most sigmoid data, we observed situations where distinct lag, linear, and saturation phases were observed but not well represented by these traditional functions. A function was developed that explicitly models three phases of growth as a curvilinear (exponential) phase, followed by a linear phase, and terminating in a saturation phase. This function was found to be as flexible as the Richards function and can be used for virtually any sigmoid data. The model behavior was an improvement over the Richards function in cases where distinct transitions between the three growth phases are evident. The model also lends itself well to simulation of growth using the differential equation approximation for the function.

081

A Three-phase Model of Poinsettia Shoot Elongation using Flower Initiation Date as a Parameter

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Stem elongation of commercially produced flowering poinsettia (*Euphorbia pulcherrima* L.) is often sigmoid. However, sigmoid mathematical functions traditionally used for representing plant growth fail to adequately describe poinsettia stem elongation when a shoot has a long vegetative growth period. A model was developed that explicitly described three phases of poinsettia stem elongation: 1) the initial lag phase, where stem length increases approximately exponentially; 2) a period when elongation is linear; and 3) a plateau phase, where elongation rate declines to zero and stem length reaches an asymptotic maximum length. The timing of the plateau phase was linked to flower initiation date. Fit of the resulting model to data from single stem 'Freedom' poinsettia grown with different periods between transplant and flower initiation had an R^2 of 0.99. Model parameters had clear biological meaning, and the poinsettia model has horticultural application for simulation and graphical tracking of crop height.

082

Optimization of Nitrogen Fertilization of Subirrigated Container-grown Chrysanthemum using a Simulation Model

*Mark V. Yelanich** and *John A. Biernbaum*, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824-1325.

A model constructed to describe nitrogen dynamics in the root zone of subirrigated container-grown chrysanthemum was used to develop and test nitrogen fertilization strategies. The model predicts the nitrogen concentration in the root zone by numerical integration of the rates of nitrogen applied, plant nitrogen uptake, and nitrogen movement to the medium top layer. The three strategies tested were constant liquid N fertilization, proportional derivative control (PD) based upon weekly saturated medium extraction (SME) tests, or PD control based upon daily SME tests. The optimal concentration of N to apply using a single fertilization concentration was 14 mol·m^{-3}, but resulted in greater quantities of N being applied than if PD controller strategies were used. The PD controllers were better able to maintain the predicted SME concentration within 7 to 14 mol·m^{-3} optimal range and reduce the overall sample variability over time. Applying 14 mol·m^{-3} N at every irrigation was found to be an adequate fertilization strategy over a wide range of environmental conditions because N was applied in excess of what was needed by the plant.

083

Modeling Nutrient Uptake and Prolonged Use of Nutrient Solutions in Soilless Tomato Culture

Mohamed Benmoussa and *Laurent Gauthier**, Dept. de genie rural, FSAA, Universite Laval, Quebec, Quebec, Canada G1K 7P4.

In soilless culture, the buffering capacity of the root environment for nutrients is low. This, combined with fluctuations of climatic factors and changes in nutrient uptake rates, can lead to nutrient imbalances. In order to achieve high yield and better quality, it is necessary to keep the nutrient concentrations in the root environment at the target levels. This requires frequent analysis and adjustments to the nutrient solution. Currently, leaching of the growing media or renewal of the nutrient solution is commonly used to avoid accumulation or depletion of nutrient in the root environment. However, this practice lowers the efficiency of fertilizers and can lead to the contamination of the ground water. One way to remedy to this problem is through the use of nutrients uptake models to track the composition of the nutrient solutions. The objective of this study was to develop such models. Such models can be used to maintain balanced nutrient solutions for longer periods. This can lead to reduced leaching and improved fertilizer use efficiency. Macronutrient (N, P, K, Ca, and Mg) uptake models were developed for tomato plants grown in an NFT system using data collected from experiments conducted in the Laval Univ. greenhouses. Analysis of the experimental results showed that the main factors affecting nutrients uptakes are light and transpiration.

084

Integration of a Crop Growth Model in a Greenhouse Management Software System

Hassan Zekki, André Gosselin,* and *Laurent Gauthier*, Dept. de genie rural, FSAA, Universite Laval, Quebec, Quebec, Canada G1K 7P4.

In greenhouses, computerized climate control systems can be used to dynamically and automatically regulate climatic and environmental parameters. To support such a mode of operation, a crop growth model that was developed for greenhouse tomato plants (TOMGRO) was chosen. The model describes the phenological development and increase in dry weight of various organs from planting till maturity under variable environmental conditions. The assimilate partitioning is based on sink strength. A FORTRAN version of TOMGRO was converted to the Smalltalk object-oriented programming environment. This model was integrated into GX, a dynamic climate management software system that was developed at Laval Univ. GX defines a general architecture that may accommodate different decision-making modules based on mathematical models and rule bases. The TOMGRO model is being used to evaluate different production scenarios and will be used to calculate and predict crop growth rates, development, and yields. The model can be used to perform real-time and seasonal cost–benefit analysis and for the dynamic optimization of greenhouse climatic parameters.

085

Split-plot Analysis—Now and Then

*George C.J. Fernandez**, Dept. of Agricultural Economics, Univ. of Nevada, Reno, NV 89557-0107.

Split-plot design is a very popular experimental design in analyzing factorial treatments in horticultural experiments. Two different sizes or types of experimental units are assigned to main plot and the split-plot treatments. The SAS procedure GLM with the TEST option is commonly used to analyze the split-plot data by assigning the correct error term to test the main plot factor. In SAS GLM, no option is available to compare the two main factors within a split-plot factor. The CONTRAST tests and LSMEAN comparisons are valid only for comparing split-plot factors within a main plot treatment. The main factor standard error provided by the LSMEAN option is also incorrect. The new PROC MIXED procedure available in SAS 8.08 or above can be used to correct these problems in split-plot analysis. The analysis of split-plot experiments using the PROC MIXED is presented here.

44 ORAL SESSION 10 (Abstr. 086–093) Breeding/Fruits & Nuts (Temperate)

087

Potential for Noninfectious Bud-failure in 'Carmel' Almond Orchards in California

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The potential for noninfectious bud-failure in propagation source material for 'Carmel' almond in California has been determined in progeny tests from commercial nursery sources. Percentage BF increased with time (temporal), but decreased in severity (spatial). Analysis of variability in nursery sources showed that the key to successful selection for low BF potential is the individual tree, although variability exists among nurseries, budsticks (within trees), and individual buds (within budsticks). One-half of the individual trees of the nursery population tested have produced BF progeny so far within the test period. Future BF from the remainder was project by a BF model to be beyond the critical economic threshold. Two low BF-potential single tree sources were identified for commercial usage and progeny tests have started on an additional 19.

088

Genotype x Temperature Interaction during Germination of Several Species of Prunus under Stratification

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Previous work has concluded that 7C is the optimum temperature for promoting peach and apricot seed germination. However, these results were based only on genotypes from septentrional regions. The objective of this study is to describe the behavior of a wider range of genotypes and species from temperate-subtropical regions, as a background to detect potential germplasm sources for adaptation to this environment. Seed samples from five species of Prunus were evaluated during stratification at several temperature regimes: Ambient fluctuating from 8 to 16C, 7C, 10C, and 14 ±1.5C, from 1993 to 1995. Seed germination was monitored twice a week. Great differences were registered among species and genotypes for both speed and percent germination within each temperature treatment. With local species and genotypes germinating equally well and faster at warm temperatures than previously reported. These results will provide an important screening tool when selecting for adaptation to local climates, and also as a way to determine annual "winter quality," in terms of chilling accumulation in the southern distribution range of temperate fruit crops in the north hemisphere.

089

'QAS-13': A New Promising Cold-hardy Scab-resistant Apple Selection

Raymond L. Granger[1], Y. Groleau[1], C. Fortin[1], Gilles L. Rousselle[2],* and *L.P.S. Spangelo[3]*, [1]Agriculture and Agri-Food Canada, Horticultural R&D Centre, 430 Grouin Blvd., St-Jean-sur-Richelieu, Quebec, Canada J3B 3E6; [2]Agriculture and Agri-Food Canada, Research Branch, 930 Carling Ave., Ottawa, Canada K1A 0C5; [3]1710 Spruce Wood Place, Victoria, BC, Canada V8N 1H3.

'QAS-13' is an advanced apple selection that has a proven performance and is in the process of becoming a new cultivar that carries the *Vf* gene for resistance to apple scab (*Venturia inaequalis* Cke. Wint.) derived from 'Malus floribunda 821'. It combines field immunity to scab and cold tolerance under Quebec climate and soil conditions. The Ott.521 (Melba x 11-51) x 'Spartan' cross was made in Ottawa in 1968. The fruits are very attractive and exhibit a smooth and shiny finish somewhat similar to that of 'Spartan'. Their glossy, medium- to dark-red color is slightly striped over a greenish-yellow background and covers up to 85% of the fruit surface. Their picking season coincides with that of 'Spartan', which is ≈1 week before that of 'Red Delicious'. They are round-oblate to oblate in shape with an average diameter of 70 to 75 mm and weigh ≈140 g/fruit. The skin is smooth, thin, and moderately tough, with widely spaced conspicuous beige lenticels. Both the stem and calyx cavities are fairly deep. The stem resembles that of 'McIntosh'. the 'QAS-13' apples keep better than 'McIntosh' apples both in CA and air storages. Taste panelists have consistently ranked the 'QAS-13' apples above 'McIntosh' apples both at harvest and after storage. The 'QAS-13' trees are less vigorous than those of 'McIntosh', but more productive. However, they have exhibited a slight susceptibility to frog eye leaf spot (*Botryosphaeria obtusa*) similar to that of 'McIntosh'.

090

Effect of Fruit Maturity on Bitter Rot of Apple

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The susceptibility of five apple cultivars to bitter rot was examined by inoculating fruit with multiple isolates of *Colletotrichum gloeosporioides* and *C. acutatum*. Fruit were inoculated at three maturity dates in 1994. Fruit maturity was analyzed for firmness, soluble solids, and acidity. 'Smoothee' and 'Red Rome' were wounded-inoculated by placing 0.1 ml of inoculum (106 conidia/ml) into wounds while 'Granny Smith', 'Golden Delicious', and 'Red Delicious' were inoculated by spraying unwounded fruit with inoculum until runoff. Free moisture was maintained on fruit for 15 h by enclosing fruit in a plastic bag. Bitter rot was quantified by counting lesion number and measuring lesion diameter. In general, more-mature fruit had a higher number and larger lesions than younger fruit. Lesion diameter was highly correlated with increased fruit soluble solids ($r = 0.76$) and decreased firmness ($r = -0.77$). The results indicate that fruit susceptibility increases as fruit ages. Differences in susceptibility were observed among apple cultivars and differences in virulence were observed among bitter rot pathogens.

091

Phylogenetic Studies on *Prunus* Species by DNA Fingerprints

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Twenty-eight *Prunus* species were examined in order to survey their genetic diversity. Genomic DNA was extracted from 36 varieties and used for the template DNA of PCR. DNA fingerprints were generated by random primers or semi-random primers, some primers consensus to the repeated units as telomers, and three sets of sequence-tagged primers specific to domains of chloroplast DNA

(psbA, rbcL-ORF106, atpB-rbcL). PCR products generated from these three domains were digested by 12 restriction enzymes. RFLPs were detected among varieties and subjected to the UPGMA. Thirty-six varieties were classified approximately into two groups: "Plum group" and "Cherry group." It was inferred that these two groups were divided in old time. *P. tomentosa*, *P. japonica*, *P. glandurosa*, and *P. besseyi*, which are classified into the cherries, showed the same fingerprint patterns from chloroplast DNA of the plum group; plums and cherries have a large genetic diversity. It was supposed that the diversity of plums depended on nuclear DNA, besides the diversity of cherries on both nuclear and chloroplast DNA.

092

Genetic Relationships of Diploid Plums Based on RAPD Polymorphisms

Unaroj Boonprakob and David H. Byrne*, Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133.

Diploid plums such as *Prunus salicina*, *P. simonii*, *P. cerasifera*, *P. americana*, *P. angustifolia*, *P. mexicana*, and their hybrids have a high level of RAPD polymorphisms. Of 71 successfully used primers, there are 417 reproducible RAPD markers and only 55 (13%) markers are not polymorphic. Genetic relationships of these diploid plums based on RAPD data is estimated using genetic distance (GD) defined as $GD_{ij} = 1 - S_{ij}$, where S_{ij} is similarity coefficient. Two similarity coefficients, Jaccard's and simple matching coefficient, are compared. Simple matching always yields higher similarity coefficients. Genetic distance within and between each gene pool: California, southeastern U.S., foreign, is estimated. Genetic distances of these diploid plums ranged from 0.32 to 0.68, and agreed well with the natural geographic distribution of the species. The cluster analysis using unweighted pair-group methods using arithmetic averages (UPGMA) was used to construct phenograms to summarize the relationships among these cultivated diploid plums and plum species.

093

Heritability, Genetic, and Phenotypic Correlations of Several Peach Traits

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Heritability estimates are useful to predict genetic progress among offspring when the parents are selected on their performance, but they also provide information about major changes in the amount and nature of genetic variability through generations. Genetic and phenotypic correlations, on the other hand, are useful for better planning of selection programs. In this research, seedlings of 39 families resulting from crosses among 27 peach [*Prunus persica* (L.) Batsch] cultivars and selections were evaluated for date of full bloom (DFB), date of ripening (DR), fruit period development (FDP), flower density (FD), node density (ND), fruit density (FRD), fruit weight (WT), soluble solids content (SS), apical protuberance (TIP), red skin color (BLUSH), and shape (SH) in 1993 and 1994. The data were analyzed using the mixed linear model. The best linear unbiased prediction (BLUP) was used to estimate fixed effects and predict breeding values (BV). Restricted maximum likelihood (REML) was used to estimate variance components, and a multiple-trait model to estimate genetic and phenotypic covariances between traits. The data indicates high heritability for DFB, DR, FDP, and BLUSH, intermediate heritability for WT, TIP, and SH, and low heritability for FD, ND, FRD, and SS. They also indicate year effect as a major environmental component affecting seedling performance. High correlation estimates were found between some traits, but further analysis is needed to determine their significance.

45 ORAL SESSION 11 (Abstr. 091–100) Nutrition/Floriculture

094

Influence of Fertilizer Rregime on Leaf Chlorosis/Necrosis of Two Varieties of Chrysanthemum

Trinidad Reyes, Terril A. Nell ,* and *James E. Barrett*, Dept. of Environmental Horticulture, Univ. of Florida, Gainesville 32611.

'Tara' and 'Boaldi' were fertilized with 150 and 450 ppm from 20N–4.7P–16.6K soluble fertilizer and moved at flowering to postproduction conditions (21 ± 2C and 10 $\mu mol \cdot m^{-2} \cdot s^{-1}$). Shipping was simulated for 1 week at 26C. 'Tara' exhibited burned leaf margins (necrosis) and chlorosis following shipping. At 150 ppm, leaves had brown, dried margins, but the damage did not progress indoors. Necrosis was worse at 450 ppm. Leaf chlorosis/necrosis of non-shipped plants at the 450 fertilizer level did not appear until the 3rd week indoors. At experiment termination, no leaf damage occurred in non-shipped 'Tara' or 'Boaldi' with 150 ppm. 'Boaldi' did not show damage after shipping regardless of the treatment but symptoms (necrosis and wilting of leaves) evolved during the first 2 weeks indoors on plants fertilized with 450 ppm. A 50% reduction in root soluble carbohydrates was found at the highest fertilizer rate at flowering, suggesting that leaf chlorosis/necrosis is related to carbohydrate depletion in chrysanthemum.

095

Aluminum Amendments Increase Retention of Triple Superphosphate-P in Soilless Container Media

*Kimberly A. Williams** and *Paul V. Nelson*, Dept. of Horticultural Science, North Carolina State Univ., Raleigh, NC 27695-7609.

Soilless container medium components such as peatmoss and perlite have almost no capacity to retain PO_4-P, and preplant amendments of triple superphosphate (TSP) are readily leached. Al amendments were tested to reduce P losses from these media. $Al_2(SO_4)_3$ solutions at rates of 320 and 960 µg Al/cc were applied to a 70 peat : 30 perlite medium and dried at 70C. Adsorption isotherms were created at 25C for the $Al_2(SO_4)_3$-amended media and an unamended control using solutions of $Ca(H_2PO_4)_2$ at concentrations of P ranging from 0 to 500 $\mu g \cdot ml^{-1}$. Isotherms showed that P retention increased as Al concentration increased. In a greenhouse study, *Dendranthema xgrandiflorum* 'Sunny Mandalay' was grown in these media with 100 g P/m^3 from TSP incorporated into the mixes before planting. PO_4-P, soluble Al, and pH were determined on unaltered medium solutions collected throughout the cropping cycle and foliar analyses were determined on tissue collected at mid- and end-crop. The highest rate of Al was excessive and resulted in low pH and soluble Al levels in the medium solution early and in the cropping cycle, which were detrimental to plant growth. When Al was applied at 320 µg/cc, soluble Al levels in medium solution were not significantly higher than in the unamended control, PO_4-P leached from TSP was reduced, and sufficient PO_4-P was released throughout the cropping cycle to result in optimal plant growth.

096

Persistence and Replacement of Preplant Fertilizers from Highly Leached Peat-based Root Media

John A. Biernbaum, William R. Argo, Brian Weesies, Allen Weesies,* and *Karen Haack*, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824-1325.

A series of experiments was conducted to quantify the rate of nutrient loss from a container medium in a 15-cm-wide (1.3-liter) pot with a container capacity (CC) of 0.7 liter/pot under mist propagation and to determine the effectiveness of reapplying fertilizer to medium at 90% of CC with either top watering or subirrigation. Reducing the volume of water applied per day decreased the rate of nutrient leaching. Based on CC leached (CCL), the rate of nutrient loss was similar for all treatments. Differences in the rate of macronutrient removal from the media were measured, but, by 2 CCL, the concentration of all nutrients tested was below acceptable levels for the saturated media extract. With top watering, reapplying water-soluble fertilizer (WSF) at volumes under 0.2 liter/pot did not affect the nutrient concentration in the lower half of the pot at WSF concentrations up to 86 mol N/m^3. Applying up to 0.8 liter/pot did increase nutrient concentrations in the lower half of the pot, but the media nutrient concentrations were lower than that of the applied WSF concentration. Applying WSF with subirrigation was limited by the moisture content of the media prior to the irrigation.

097

Effect of Lime, Irrigation Water Quality, and Water-soluble Fertilizer on pH and Macronutrient Management of Peat-based Root Media

*William R. Argo** and *John A. Biernbaum*, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824-1325.

Impatiens were planted into peat-based media containing two dolomitic liming materials [$Ca(OH)_2 \cdot Mg(OH)_2$ at 1.8 $kg \cdot m^{-3}$ or $CaCO_3 \cdot MgCO_3$ at 8.4 $kg \cdot m^{-3}$] and subirrigated for 17 weeks using four irrigation water qualities (IWQ) with varied alkalinity, Ca^{2+}, Mg^{2+}, and SO_4-S content and three water-soluble fertiliz-

ers (WSF) with varied NH_4:NO_3 ratio, Ca^{2+}, Mg^{2+}, and SO_4-S content. After 8 weeks, medium pH ranged from 4.5 to 8.5. Lime type did not affect the long-term increase in medium pH, Ca^{2+}, and Mg^{2+} concentrations with IWQ/WSF solutions containing low NH_4-N and high Ca^{2+} and Mg^{2+} concentrations. The carbonate lime did buffer the medium pH, Ca^{2+}, and Mg^{2+} concentrations with IWQ/WSF solutions containing high NH_4-N and low Ca^{2+} and Mg^{2+} concentrations. With both lime types, there was a linear increase in tissue Ca and Mg as the applied concentrations increased from 0.5 to 4.0 mol·m^{-3} Ca^{2+} and 0.3 to 3.0 mol·m^{-3} Mg^{2+} with the various IWQ/WSF. The relationship was similar for both lime types up to week 8, after which tissue Ca and Mg decreased with the hydrated lime and low solution Ca^{2+} and Mg^{2+}. Relationships were also developed between the applied SO_4-S concentration and tissue S and medium pH and tissue P.

098

Controlled-release Fertilizer and Constant Media Moisture Affects the Growth of a Salt-sensitive and Salt-tolerant New Guinea Impatiens Cultivar

*Darren L. Haver** and *Ursula K. Schuch*, Botany and Plant Science Dept., Univ. of California, Riverside, CA 92521.

Salt-sensitive ('Illusion') and salt-tolerant ('Blazon') New Guinea impatiens cultivars were grown for 70 days with a controlled-release fertilizer at 3.3, 6.6, or 9.9 g/pot under constant media moisture of 1–3 kPa or 4–6 kPa. Optimum growth for both cultivars occurred using 6.6 g/pot and a media moisture level of 1–3 kPa. The leaf area (LA), leaf number (LN), leaf dry weight (LDW), stem dry weight (SDW), and root dry weight (RDW) were significantly reduced at 9.9 g/pot in 'Illusion', with values similar to those at 3.3 g/pot. LDW, SDW, RDW, LA, and LN were similar for 6.6 g/pot and 9.9 g/pot in 'Blazon'. At 4–6 kPa LDW, SDW, RDW, LA, and LN decreased from low to high in 'Illusion'. LA in 'Blazon' also decreased from low to high, but LDW, SDW, RDW, and LN were unaffected. Media EC levels were greater in the upper half of the media regardless of moisture level. EC values as high as 7.3 dS·m^{-1} in the upper half of the media and as high as 5.2 dS·m^{-1} in the lower half of the media were measured without causing plant mortality.

099

Response of New Guinea Impatiens to Various Levels of Salinity in a Subirrigation System

*Nancy K. Todd** and *David Wm. Reed*, Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133.

Concerns over groundwater contamination due to greenhouse runoff have caused many growers to turn to subirrigation as an alternative watering method. One reported problem is the movement of salts to the top layer of the rootzone due to zero leaching. Many growers are faced with the added challenge of subirrigating plants with poor-quality water than contains a high salt content before the addition of fertilizer. An experiment was conducted to investigate the movement of salts in the root zone and the effects on root development and overall plant growth. Plants were grown using water treated with NaCl + $CaCl_2$ (1:1 equivalent basis) at the following total concentrations: 0, 2, 4, 6, 8, 10, 14, and 18 mM. Treatment time was 10 weeks (marketable stage). At harvest, height was measured and plants were cut off at the soil line and divided into shoots (stems and leaves) and roots for fresh and dry weight. Leaf area was measured. The root zone was divided into three layers—top, middle, and bottom (≈3 cm each). Roots were separated from each soil layer and soil samples collected for measuring EC and pH using 1:2 dilution. Soil samples showed EC in the top layer of the root zone was much higher than the middle and bottom layers. Root weight also decreased substantially in the top layer of the root zone. Height, FW, DW, and leaf area of plants did decrease with increasing salt concentration, indicating that the detrimental effects of poor-quality water on subsequent plant growth, especially in a subirrigation system.

100

Effects of Fertilizers, Salinity, and Medium on Growth of *Phalaenopsis* Orchid

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Seedling *Phalaenopsis* (*P.* Taisuco Eagle x *P.* Taisuco Rose) plants with an 8- to 10-cm leaf span were grown in 10-cm pots filled with a medium consisting of 70% fine fir bark and 30% peatmoss (by volume). Plants were given (in N–P_2O_5–K_2O) 10–30–20, 15–10–30, 15–20–25, 20–5–19, 20–10–20, or 20–20–20 fertilizers at the 100 or 200 mg N/liter rate. Pots were leached with water following every two fertigations. After 7 months, leaf span, leaf size, total leaf area, and fresh weight were not affected by fertilizer type. The differences in leaf numbers were small. The higher rate of fertilizer resulted in plants with wider leaf span (32.8 vs. 28.5 cm), more (5.5 vs. 4.8), larger (103 vs. 89 cm^2) leaves, and greater total leaf area (355 vs. 275 cm^2) than did the lower rate. In another experiment, similar plants with a leaf span of 15 to 18 cm were grown in 10-cm pots with 100% fine fir bark or a mixture of 80% fine fir bark and 20% peatmoss. They were fertigated with water having an EC - 0.05, 0.40, 0.75, 1.10, or 1.40 dS·m^{-1} containing 1 g·$liter^{-1}$ 20–20–20 fertilizer three times and then drenched with their respective water containing 0.6 g·$liter^{-1}$ $Ca(NO_3)_2 \cdot 4H_2O$. After 11 months, water salinity did not affect the date of spiking. Plants receiving water with EC = 1.10 dS·m^{-1} had more leaves and spikes than other treatments. Plants in the bark/peatmoss mix began spiking earlier, had more leaves (6.7 vs. 5.7), and more inflorescences (1.9 vs. 1.5) than those in 100% bark. There was no salinity x medium interaction in all the parameters recorded.

100A

Phytotoxicity and Plant Growth Regulation Associated with Insecticidal Dipping of Rooted Poinsettia Cuttings

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Potential phytotoxicity and plant growth-regulating activity of insecticidal dips for poinsettias was investigated by dipping, then growing unpinched, rooted cuttings of 'Red Sails', 'Freedom', and 'V-14 Glory' in the following insecticidal emulsions for five durations: 2% insecticidal soap (Safer's), 2% horticultural oil (Sunspray Ultrafine), fluvalinate (Mavrik Aquaflow), oxythioquinox (Joust), kinoprene (EnstarII), azadirachtin (Margosan-O), fenoxycarb (Precision), and an oil-carrier formulation of *Beauveria bassiana* (Naturalis-L). Dips in soap, oxythioquinox, Naturalis-L, and oil were phytotoxic to all three cultivars. Also, kinoprene and fenoxycarb were phytotoxic to 'Red Sails'. At dip durations of 10 s and greater, soap, Naturalis-L, and oil were phytotoxic. Oxythioquinox was phytotoxic at durations of 1 min, 15 min, and 1 h. Only fluvalinate was not phytotoxic as a 4-h dip. After 2 weeks, plants dipped in oxythioquinox, Naturalis-L, and oil were stunted. By week 4, differential cultivar effects were seen: six dips (all but fluvalinate and azadirachtin) stunted growth of 'Red Sails', whereas only Naturalis-L and oil retarded growth of 'V-14 Glory'. Six weeks after treatment, growth of all cultivars was stunted by oxythioquinox, Naturalis-L, and oil, but was not retarded by fluvalinate or azadirachtin. Dip duration significantly affected growth by weeks 4 and 6, when all durations of Naturalis-L and oil reduced growth. Additionally, 4-h dips of oxythioquinox and kinoprene stunted plants after 4 weeks, and 1- and 4-h dips of oxythioquinox, kinoprene, and fenoxycarb adversely affected growth after 6 weeks.

46 ORAL SESSION 12 (Abstr. 101–108) Growth Regulators/Fruits & Nuts

101

Improving Fruit Firmness and Reducing the Need for Hand-thinning in Peach by using Sprays of Release® LC

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'Loadel' cling peach [*Prunus persica* (L.) Batsch] trees were sprayed with Release® LC (Abbott Laboratories, North Chicago, Ill.) in 1993. Preharvest (harvested 16 July) sprays of 50, 75, 100, and 120 ppm applied on 15 June improved fruit firmness without altering fruit maturity (flesh color by commercial standards) in 1993. In the following 1994 season, flower number per centimeter of shoot length was reduced by sprays ranging from 50 to 120 ppm applied on 15 June and 9 July. No hand-thinning was required on trees treated on 15 June. Trees treated 9 July had 50% fewer fruit removed than on untreated trees, where more than 3000 fruit were removed by hand-thinning. Salable yield was higher than untreated control trees where Release® LC had been applied at 50 ppm on 15 June and 9 July. Fruit size equaled those of hand-thinned controls. As concentration increased on 15 June, salable yield decreased linearly. Fruit size (diameter and individual weight) increased with reductions in salable yield. Interestingly, fruit were evenly distributed along shoots after Release® LC treatment, similar to those found after hand-thinning. Release® LC will be available for commercial

chemical thinning of stone fruit in California during 1995. Additional results from peach and other stone fruit will be presented.

102

Bloom Thinning of Peach, Nectarine, and Apricot

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Chemicals being tested for bloom thinning of apples are effective for bloom thinning of stone fruit. Sulfcarbamide (Wilthin) and Endothall applied to peaches, nectarines, and apricots at 90% of bloom open reduced fruit set by 50%. Fruit size and quality of crop were improved. Slight phytotoxicity occurred on leaves and twigs, but no injury occurred on fruit. Two years of data will be presented and comparisons will be made with other new thinning agents.

104

Effect of Concentration and Time of Accel Application on Cropping of Selected Cultivars

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The effect of Accel concentration and time of application on fruit size and yield was studied using 'Delicious' (Redchief), 'Empire', 'Jonathan', and 'Gala'. High-volume sprays of Accel were applied at 25 to 150 mg·liter^{-1} to 'Delicious' and 'Empire' at king fruit diameter (KFD) of 5 to 20 mm. 'Jonathan' and 'Gala' were treated at KFD of 5 to 20 mm with 10 to 40 g/A. The effect of spray volume (500 to 2000 liters·ha^{-1}) and surfactant (Regulaid) was studied using 'Jonathan'. Response was indexed by yield and fruit size distribution at harvest. Although yield in 'Delicious' was reduced with all concentrations of Accel, the percentage of fruits in the larger-size classes (3"+) was not significantly increased. In contrast, with 'Empire', Accel reduced fruit load similar to hand-thinning (HT) and percentage of large fruit equaled or exceeded that of the HT treatment. Increasing concentration of Accel was related to an increase in fruit size; early application (5 mm KFD) was more effective than late (10, 20 mm KFD) application. There was no significant effect of spray volume or Regulaid. Increasing Accel rate (10 to 20 g/A) resulted in significant yield reduction and increase (4% to 9%) in mean fruit weight in 'Gala'.

105

Interaction of NAA with Accel and Promalin on Fruit Size in 'Delicious' and 'Empire' Apples

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NAA and Accel are used for fruit thinning of apples. However, when combined, many small (<65 mm) fruit were produced in 'Delicious'. We extended our studies using Redchief 'Delicious' and 'Empire', and, since BA is common to both Accel and Promalin, to study the effect of NAA-thinning sprays on Promalin-treated Redchief trees. NAA (10–15 mg·liter^{-1}) and Accel (25–100 mg·liter^{-1}) were applied to Redchief and 'Empire' at 100-mm king fruit diameter (KFD). NAA interaction with Promalin was studied using Redchief. Promalin (1.5 pt/A) was applied as a single spray (80% king bloom, KB) and as a split application (0.75 pt/A, 80% KB and repeated at 10-mm KFD) with NAA (15 mg·liter^{-1}) at 10-mm KFD. In 'Delicious', 2% to 9% of the fruit from Accel-treated trees was <65 mm in diameter, compared to 11% for NAA alone. However, when NAA was applied with Accel, 22% to 30% of the fruit was <65 mm and percentage of large fruit (75 mm+) was reduced by 24% to 36%. There was no strong interaction for fruit size in 'Empire', but the combination decreased yield. NAA applied to Promalin-treated 'Delicious' increased percentage of small fruit dramatically (14% to 25%). No increase in small fruit was observed with Accel of Sevin.

106

Growth Response of Apple Fruit to NAA and Accel: Effect of Intraspur Competition and Position on a Spur

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Apple fruit size is influenced by position on the spur, and location and number of competing fruits. King fruit appear to have the greatest potential to size and grow best in the absence of intraspur fruit competition (ISFC). Accel (A) and NAA (N), commercial thinning chemicals, influence fruit size beyond their effects on crop load. A 2-year study was conducted to determine the effect of ISFC and position (king, K, or lateral, L) on fruit growth in response to A and N. Branches from 'Redchief Delicious' were thinned, after petal fall, to one K, one L, one K + one L, or two L fruits per spur. Whole-tree treatments of N (15 mg·liter^{-1}), A (50 mg·liter^{-1}, 1993; 25 mg·liter^{-1}), and a combination (N+A) were applied at 10-mm king fruit diameter. A nontreated control was included. In 1993, N and N+A reduced fruit size only with ISFC, while A increased fruit size in the absence of ISFC. In 1994, A had no effect, but N and N+A reduced fruit growth with ISFC. In both seasons, A and N decreased the frequency of spurs bearing multiple fruit, while N+A dramatically increased number of spurs with multiple fruits (branch survey).

107

'Empire' Apple Responses to Fruit-thinning Chemicals

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Effects of NAA at 5, 10, and 15 ppm, Accel at 50, 75, and 100 ppm, NAA at 7.5 ppm plus carbaryl at 600 ppm, and a nontreated control on fruit set, fruit size, length–diameter ratio, seed numbers per fruit, and total yield of fruit were evaluated during the 1994 season. All treatments were applied to 10-year-old 'Empire'/M.9/MM.111 trees as dilute sprays at a rate of 935 liters·ha^{-1} with an airblast sprayer on 3 June. King fruit measured 9–11 mm in diameter at time of application. Fruit set (fruits per 100 blossom clusters) was reduced significantly by Accel at 50 ppm (17%) and by NAA plus carbaryl (26%) in comparison with the nontreated control. Total yield of fruit was increased by all treatments; however, fruit from trees treated with NAA plus carbaryl was significantly larger than that from all other treatments. Percentages of small fruit, <108 g, were reduced by all treatments. Percentage of fruit ≥153 g was increased significantly only by NAA plus carbaryl. Length–diameter ratios and numbers of fully developed seeds per fruit were not influenced significantly by treatments. NAA at rates of 5, 10, and 15 ppm, or Accel at 50, 75, or 100 ppm, were less effective than a combination of NAA at 7.5 ppm plus carbaryl at 600 ppm in reducing fruit set and in affecting fruit size or fruit size distribution.

108

Response of Several Apple Cultivars to Thinning Sprays of Benzyladenine, NAA, Carbaryl, and Combinations Thereof

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In 1994, benzyladenine (BA, formulated as Accel, containing 1.8% BA and 0.18% GA_{4+7}) was evaluated as an apple fruit-thinning agent. Naphthaleneacetic acid (NAA, 10 ppm) and carbaryl (60 g·liter^{-1}) were also used, as well as combinations of these chemicals with BA. Whole trees were treated with either an airblast sprayer or a hand gun, BA being used at 15–20 g/acre. Good responses to BA were obtained in one of two trials, with both 'Empire' and 'Gala', but 'Jonagold' and 'Jonathan' were not responsive (one trial each). In general, response to NAA and carbaryl was more consistent. In only one orchard ('Gala') did BA appear to increase fruit size without reducing crop load. Combinations of BA with NAA or carbaryl were generally no more effective than one chemical alone, but such combinations overthinned in one experiment with 'Empire'.

47 ORAL SESSION 13 (Abstr. 109–114) Postharvest Physiology/Vegetable Crops

109

Pungency and Sugar Changes in ILong-day Onions Due to Different Storage Times and Temperatures

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Twenty-four genotypes of 'Walla Walla' sweet onion (*Allium cepa* L.) grown in two locations were evaluated for several characteristics associated with bulb flavor and storage losses. The range of pyruvic acid content in bulbs stored (at 5C and 65–75% RH) for 0, 2, and 4 months were 3.4–7.54, 3.48–18.81, and 3.92–12.61 (μmol·g^{-1}), respectively, among different genotypes. Bulb quality of several genotypes decreased during storage, as indicated by lower total sugar concentration (fructose, glucose, and sucrose) and greater pungency. At 5C after 4 months of storage, the range of marketable bulbs (percent by weight) was 31% to 89% among genotypes; however, at 15C, only two genotypes survived with

60% marketable bulbs. Pungency and sweetness changed independently during storage. Pyruvic acid was not correlated (r = 0.038) with the percentage of marketable bulbs remaining after 4 months of storage. In comparison with the short-day sweet onions ('Vidalia' and 'Texas Grano 1015Y), 'Walla Walla' sweet onions showed two-fold higher sugar : pungency ratio among genotypes.

110

Changes in Onion Bulb Quality during Storage of Short- and Long-day Cultivars

*David E. Kopsell** and *William M. Randle*, Dept. of Horticulture, Univ. of Georgia, Athens, GA 30602-7273.

Short-day (SD) and long-day (LD) cultivars of onion (*Allium cepa* L.) representing various storage and flavor characteristics were greenhouse-grown to maturity. Bulbs were harvested and cured, then stored at 4C and evaluated monthly for pyruvic acid concentration (EPY), soluble solids content (SCC), and weight loss (WL). The EPY of 'Dehydrator #3' (SD) decreased linearly with storage while EPY of 'Granex 33' (SD) increased linearly. The EPY of 'Zenith' (LD) had a quadratic response, decreasing then increasing during storage, while EPY of 'Sweet Sandwich' (LD) increased then decreased quadratically during storage. Cultivar SSC generally decreased, while WL increased during storage.

111

Electronic Sensing of Melon Ripeness Based on Volatile Gas Emissions

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A nondestructive electronic sensory system (electronic sniffer) that responds to volatile gases emitted by fruit during ripening was developed. It is based upon a single semi-conductor gas sensor placed within a rigid plastic cup equipped with a gas inlet to flush the head between samples. This gas sensor reacts with the range of reductive gases such as the aromatic volatiles that are naturally emitted by the ripening melon fruit. The sensor cup is placed on the exterior of the fruit and the change in electrical conductivity is recorded. In 1994, we examined the electronic sniffer as a tool to nondestructively determine ripeness in 'Superstar', 'Mission', and 'Makdimon' melons. Fruits were manually classified into five ripeness stages based on external appearance and slip stage. Melons were first sampled nondestructively for color, weight, size, and slip stage, and then subjected to the electronic sniffer. Then, fruit volatiles, flesh firmness, and total soluble solids were measured. The electronic sniffer was able to accurately classify melons into three ripeness classes: unripe, half-ripe, and ripe for 'Superstar' and 'Mission'. The sniffer was only able to separate ripe from over-ripe in 'Makdimon', which is known to become over-ripe and deteriorate rapidly. Using the sniffer as a tool to nondestructively measure ripeness and its potential application in fruit quality will be discussed.

112

Enhancing Ripening Characteristics of "Netted" and 'Honeydew"-type Melons

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"Netted" (*Cucumis melo* var. *reticulatus* Naud.) cantaloupes typically abscise when mature, and have a shorter postharvest life than "Honeydew" (*Cucumis melo* var. *inodoris* Naud.) -type melons. The amount of ethylene and carbon dioxide produced by two cantaloupe genotypes (slipping), one Honeydew genotype (non-slipping), and the F_1 hybrids derived from the slipping x non-slipping genotypes were measured during ripening to understand the genetic control of ethylene and fruit abscission. Sterile, nondestructive gas sampling ports inserted into 20-day-old fruit were used to extract samples from the central cavity of the melons and monitor ethylene and carbon dioxide from day 30 until the fruit was horticulturally mature. Honeydew melons had a lower rate of respiration during maturation and ripening than Netted melons, and Netted melons produced 10-fold more ethylene during ripening than Honeydew types. F_1 fruit produced ethylene at levels similar to the Netted parent, abscissed 2 to 4 days later than the Netted parent, yet respired during maturation and ripening like the Honeydew-type parent. Ethylene production, respiration, and abscission appear to be controlled by dominant gene action.

114

Controlled-atmosphere Storage of Shredded Carrots

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Quality and physiology of carrot shreds were monitored during storage in air, low O_2 (0.5%, 1%, and 2%), or high CO_2 (3%, 6%, and 10%) at 0, 5, and 10C to evaluate the response to controlled-atmosphere (CA) storage. Oxygen uptake and CO_2 production from respiration were reduced under low-O_2 or high-CO_2 atmosphere, the reduction being greater at lower O_2 and higher CO_2 levels. The respiratory quotient was about 1 with samples in air, more than 1 in low-O_2, and less than 1 in high-CO_2 atmosphere during storage at all temperatures. No differences were found in ethylene production, which were less than 0.2 $\mu l \cdot kg^{-1} \cdot h^{-1}$ with all samples. The CA containing 0.5% O_2 and 10% CO_2 reduced weight loss and formation of white-colored tissue and decreased pH, but did not affect microbial count and texture at all temperatures. Off-odor and black root rot were not detected in both CA and air atmospheres.

48 ORAL SESSION 14 (Abstr. 115–122) Crop Protection/Cross-commodity

115

Techniques for Inoculation of Guayule Seedlings with Two Soil-borne Pathogens

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Soil-borne pathogens such as *Macrophomina phaseolina*(the causative agent of charcoal rot) and *Phymatotrichum omnivorum* (the causative agent of cotton root rot) contribute to mortality of transplanted guayule (*Parthenium argentatum*, Gray) seedlings in southern Texas. In order to select guayule genotypes for resistance to these pathogens, it would be useful to develop reliable greenhouse inoculation procedures for screening guayule seedlings. Twelve-week-old guayule seedlings ('11591', a USDA standard breeding line) were inoculated using two inoculation methods (soil-drenching and root-dipping) in two soil media (field soil and commercial soil mix). Plants were rated for disease severity 2 to 5 months after inoculation and pathogens were re-isolated from diseased plants to establish Koch postulates. The soil drenching technique, using field soil, caused rapid development of disease symptoms that were consistent with re-isolation frequencies of pathogens from the diseased plant tissues.

116

Transgenic Resistance to Virus Diseases in Squash and Cantaloupe

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Three transgenic yellow crookneck squash (*Cucurbita pepo* var. *melopepo*) and five transgenic cantaloupe (*Cucumis melo*, Reticulatus group) lines were field-tested in 1993 and 1994, respectively, for resistance to Zucchini Yellow Mosaic Virus and Watermelon Mosaic Virus II. During both years, non-transgenic plants were inoculated with virus before transplanting to provide a high virus threat to the transgenic plants. Before and after transplanting, serological (ELISA) testing was used to obtain baseline information on transformed plants and to confirm field virus infection. In both years, plant disease development was rated weekly; yield was assessed during 1993. Disease progression, yield, and end-of-season ELISA indicated a significant reduction in frequency of disease incidence in the transgenic lines. Total squash yields did not differ between the transformed and unchanged lines, but the transgenic lines yielded more marketable fruit than the non-transgenic line.

117

Bicarbonates and Botrytis: VI. Control of Gray Mold Enhances Geranium Growth

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Botrytis cinerea Pers. causes gray mold on greenhouse-grown geraniums (*Pelargonium* x*hortorum* L. H. Bailey), among many other crops. Bicarbonates effectively control rose powdery mildew (Plant Dis. 76:247–480) and inhibit *B. cinerea* in vitro colony growth and conidial germination (Phytopathology 84:546, 1065). To examine bicarbonate effects on gray mold incidence and geranium growth, we sprayed seedling geranium cultivars Red Elite and Scarlet Elite weekly with 0, 25, and 50 mM NH_4HCO_3 or $KHCO_3$. Seedlings were transplanted in Metromix 360 and misted every 24 m for 5 s to enhance disease development. Data were collected biweekly on disease incidence, floral number, plant height, and dry weight. Both cultivars performed similarly. Disease incidence decreased with application of bicarbonates. $KHCO_3$ at 25 mM slightly increased dry weight and height over 0 mM, whereas 25 and 50 mM NH_4HCO_3 greatly increased both features. Fifty mM $KHCO_3$ decreased height slightly, but had no effect on dry weight. Floral number decreased slightly with all bicarbonate treatments. It is indicated that $KHCO_3$ at low levels and NH_4HCO_3 enhance seedling geranium growth by controlling gray mold incidence and by providing additional nutrients. (Supported by H&I Agritech Inc., Ithaca, NY 14850.)

118

Tomato Little-leaf Syndrome—A Possible Explanation

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Since the fall of 1986, tomato growers in northwestern Florida and southwestern Georgia production areas have encountered plants in their fields with unusual growth characteristics. Early symptoms consist of interveinal chlorosis of the young leaves. Subsequent top growth becomes severely distorted with leaflets along the midrib failing to expand properly, resulting in a "little-leaf" appearance. Additional symptoms included cessation of terminal growth, leaves with twisted and brittle midribs, and axillary buds failing to develop properly. Fruit that set on mildly affected plants are distorted, with radial cracks extending from the calyx to the blossom scar. In severely affected plants, fruit failed to set. The problem usually occurs at very low levels, but in 2 years since 1986, the problem has caused some economic damage. To determine a possible cause, samples were taken for virus detection. None were detected in affected plants. Samples were also taken of tissue and soil from affected areas for nutrient and pesticide analysis. No explanation could be developed from any of the tissue or soil samples. The problem usually occurs in wet areas and after very warm temperatures. The problem appears to be very similar to a nonparasitic disease that occurs in tobacco, called "frenching." In tobacco, frenching occurs in wet, poorly aerated soils with a soil pH >6.3 and during warm temperatures. There seems to be an organism or organisms present under certain conditions that live on the root surface and exude chemicals that cause this distorted growth.

119

Pest Resistance in Redbud

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Mexican redbud (*Cercis canadensis* var. *mexicana*) exhibits resistance to leaf cutter bees (*Megachile* spp., LCB). Resistant trees (CMG) have glossy leaves and sustain little LCB damage as compared to dull-leaf Mexican redbud (CMD) and the closely related eastern redbud (*Cercis canadensis*, CC). On average, LCB made 35 times as many cuts per week on CC as on CMG and CMD, even though there were half as many leaves available. Mexican redbud leaves are twice as thick as CC leaves, which may account for LCB preference for the latter. However, leaves from CMG and CMD are similar in leaf thickness, cuticle wax content, and resistance to penetration, yet LCB had an even stronger preference for the former. More than 83 times as many cuts per week were made on CMD over CMG, even though the number of leaves was comparable. CMG leaves have a thicker cuticle on the upper surface that lacks wax crystals present in the CMD and CC. The upper cuticle from CMG leaves also contains fewer lipids and an altered lipid composition (notably fewer long-chain alcohols) compared to CMD.

120

Potential of Proteinase Inhibitors for Insect Pest Control: The Case of the Colorado Potato Beetle

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Bioengineering economically important plants with proteinase inhibitors (PIs) is a promising method for the control of insect pests. In the case of the Colorado potato beetle (CPB; *Leptinotarsa decemlineata* Say), the major insect pest of potato fields, 80% of the digestive proteases are of cysteine type. We showed that 60% of these cysteine proteases are inhibited by oryzacystatins (OCs). The use of these cysteine protease inhibitor genes therefore appears of great interest for the production of Coleoptera-resistant transgenic plants of potato. Complementary studies of biochemical in vitro assays showed an apparent absence of direct interference between OCs and potato proteases. The high regeneration efficiency of the genetically transformed plants with OC gene and the "normal" phenotypical growth of the resulting transgenic potato plants suggested that these foreign genes do not interact with important physiological processes in the potato plants. In vivo assays of PIs against CPB at various developmental stages suggest the significant potential of OCs as an effective way to control CPB populations and crop damage.

122

Role of Endogenous Allelochemicals in Host Plant Resistance to Japanese Beetles

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No-choice feeding trials were conducted with adult Japanese beetles on leaves from 14 taxa of rosaceous trees. Feeding intensity (leaf area consumption) ranged from 0.08 to 6.1 cm^2/day for *Prunus virginiana and P. sargentii*, respectively. Analysis of endogenous chemical constituents suggested that the mechanisms of resistance varied for the different plant genera. Among the *Prunus* taxa there was a significant negative correlation between cyanide potential and feeding intensity ($r = -0.56$). Tissue toughness (resistance to tearing) was also negatively correlated with feeding intensity ($r = -0.39$) for all taxa. Soluble sugars (glucose, fructose, sucrose, and sorbitol) had no significant phagostimulatory effect, separately or in combination.

51 ORAL SESSION 15 (Abstr. 123–128) Breeding/Small Fruit & Viticulture

123

Morphological Variation in Western Trailing Blackberry (*Rubus ursinus*) in the Pacific Northwest

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Trailing blackberry cultivars, such as 'Marion', can be traced to relatively few chance selections of *Rubus ursinus* Cham. & Schlecht. Wild *R. ursinus* offer a range of horticulturally desirable traits to breeders, from high fruit quality to improved cold hardiness. Cuttings from 460 plants, representing 20 populations in southern British Columbia, Washington, and Oregon, collected in 1993. Rooted clones were planted in 1994 in a replicated field trial to assess morphological variation. A greenhouse study was also undertaken, with 10 clones represented from each site, in two replications. Preliminary data from the greenhouse and field studies show variability in the following morphological characters: Glandular hairs; cane and prickle color; cane diameter; prickle density; internode length; leaf color, size, shape and density; and senescent leaf drop and color change. Floricane morphology will be assessed in 1995. Analysis of these data will determine relative genetic distances among the populations and enhance the understanding of the diversity available in *R. ursinus.*

124

New Strawberry Selections from the Quebec Breeding Program

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Promising 1989 strawberry selections from the Agriculture Canada/McGill Univ. breeding program have been evaluated since 1990 at three different sites in Quebec. 'Kent', 'Glooscap', 'Honeoye', 'Bounty', and 'Veestar' were used for comparison. Yield, average fruit weight at each harvest, firmness, color, taste, and other fruit characteristics were evaluated. SJ89288-2 had the highest yield with large fruit. SJ89700-1 and SJ89264-6 produced similar yield to 'Kent' and 'Glooscap', with firm and large fruit. SJ89700-1 had bright red skin color and SJ89264-6 had bright pale red color. Both are suitable from fresh-market and pick-your-own (PYO). SJ8976-1, another selection, had a firm, large, bright pale red fruit. All four selections have good shelf life quality and will be tested at four sites during 1993–95.

125

Effect of June Yellowbuds on Yield, Fruit Weight, and Fruit Quality in 'Blomidon' Strawberry

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Twelve clones of 'Blomidon' strawberry (*Fragaria* x *ananassa*) exhibiting a range of severity of June Yellows symptoms were grown in field plots to measure effects on productivity. Field plot layout was a randomized block design with four blocks. Plots were matted rows developed from five plants spaced at 45 cm in-row. Fruit samples were frozen and later analyzed for soluble solids concentration, total acidity, and pH. In the greenhouse, self-pollinated seedlings grown from these clones were rated for symptom expression as an additional measure of severity of June Yellows. Large differences in marketable yields were recorded, ranging from 1.94 $t \cdot ha^{-1}$ to 14.67 $t \cdot ha^{-1}$. Clones with severe symptoms produced smaller fruit. Small clonal differences were measured in total acidity and pH. A strong correlation was observed between the percentage of symptomless seedlings and the yield of the parental clone. This may lead to a test to predict whether a new cultivar will succumb to June Yellows.

126

Actinidia spp. Seedling Evaluation

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Kiwifruit (*A. chinensis*, *A. deliciosa*) seedlings were propagated from seeds collected from their native habitat in China. They were planted at the Pacific Agri. Res. Center in 1988 for the purpose of selecting superior fruit. Out of 2212 Actinidia seedlings, 1425 flowered by 1994, with 794 being male and 631 female. Some selections flowered 1 month earlier and matured 3 weeks earlier than 'Hayward' kiwifruit. One accession had fruit of comparable size to 'Hayward' while maturing about 2 to 3 weeks earlier. Some hairless selections had an average fruit weight of 90 g, °Brix index of 18%, light flesh color, 207 mg/100 g of vitamin C, and early maturation. Most of the seedlings were hardy under a coastal British Columbia climate.

127

Anthracnose Fruit-rot Resistance in Highbush Blueberry Cultivars

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Thirty-three *Vaccinium corymbosum* selections and cultivars were artificially inoculated with spores of *Colletotrichum gloeosporioides* in the green fruit stage. Fruit was harvested when ripe and incubated under high-humidity conditions for 1 week, before evaluation. A wide range of susceptibility to anthracnose fruit-rot was found, ranging from 8% to 85%. Among the most-resistant cultivars were: 'Elliott' (8%), 'Murphy' (8.3%), 'Stanley' (13%), and 'Weymouth' (16.9%). Among the most-susceptible cultivars were: 'Bluetta' (85%), 'Spartan' (82.7%), 'June' (69.9%), and 'Northblue' (69.5%). Uninoculated checks had a maximum of 6% infection.

128

Metrical Analysis of a Semi-seedless Rabbiteye Blueberry Selection

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A rabbiteye blueberry selection, T-285, appears parthenocarpic when grown in the greenhouse and sparsely seeded when grown in the field. This semi-seedless character was analyzed to determine the nature and degree of its cross- and self-fertility in comparison to its parents, 'Tifblue' and 'Delite'. Ovule numbers from T-286 were similar to those of 'Tifblue', but lower than those of 'Delite'. Seed numbers of open-pollinated 'Tifblue' and T-286 were similar, and lower than 'Delite', but T-286 was notable in having fruit 60% larger than 'Tifblue' and 10% larger than 'Delite'. Both 'Tifblue' and T-286 had a tendency to produce some open-pollinated fruit with few or no seed present. None of the selections produced significant amounts of fruit when self-pollinated. When cross-pollinated, all selections set more seed, but this was less pronounced with T-286 than with either of its parents.

52 ORAL SESSION 16 (Abstr. 129–136) Nutrition/Vegetables

129

Effects of Various Nitrate : Ammonium Ratios on Sweetpotato Growth

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A study was initiated in the greenhouse to examine the effects of five NH_4^+:NO_3^- ratios on sweetpotato growth. Plants were grown from vine cuttings of 15-cm length, planted in 0.15 x 0.15 x 1.2-m growth channels using a closed nutrient film technique system. Nutrient was supplied in a modified half-strength Hoagland's solution with a 1:2:4 N:K ratio. NH_4^+:NO_3^- ratios investigated were 100:0, 0:100, 40:60, 60:40, and a control that consisted of a modified half-Hoagland solution with an N:K ratio of 1:2:4 and an NH_4^+:NO_3^- of 1:7. Treatments were initiated 30 days after planting (DAP). Sequential plant harvest began 30 DAP and continued at 30-day intervals until final harvest at 150 DAP. Results showed a linear increase in fresh storage root fresh weight until 90 DAP for all treatments. However, from 60 DAP until the end of the growing season, plants grown in a 100% NH_4^+ solution consistently produced significantly less storage roots than in all other treatments. While all other treatments showed a decrease in storage root fresh weight after 90 DAP, plants grown in 100% NO_3^- and the control solution continued to increase linearly in storage root production. Storage root dry weight throughout the growing season followed similar trends to that of storage root fresh weight. Data suggest that a nutrient solution containing NO_3^- as its sole nitrogen source may be adequate for sweetpotato growth. This would make it possible for utilizing a one-way pH control method for nutrient solution.

130

Preplant Calcium Affects Onion Bulb Quality and Shelf-life

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Field-grown 'Granex 33' onions were subjected to four preplant calcium (Ca) treatments and evaluated for bulb quality and shelf-life over two seasons. Mature, cured bulbs were analyzed at harvest and after 1, 2, and 3 months of 4C storage. As preplant calcium increased, percentage of seed stems decreased, yield and soluble solids concentration increased, and then decreased, bulb firmness increased. Bulb pungency was unaffected by Ca fertility, except at the highest treatment. Percent bulb rot during storage first decreased with increasing Ca fertility, but then increased at the highest Ca treatment.

131

Antiplatelet Activity is Positively Correlated with Pungency and Solids in Onion (*Allium cepa* L.)

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Onion (*Allium cepa* L.) and other vegetable *Alliums* have long been recognized for the antiplatelet properties. Consumers may benefit from the medicinal value of onions because they are commonly eaten raw in salads and the antiplatelet factor is destroyed by heat. Recent work indicates antiplatelet activity in *Allium* sp. may be due to the presence of native organosulfur compounds. The concentration of organosulfur compounds correlates positively with pungency, varies with onion cultivar, and is influenced by environmental factors. Bulb dry matter content, or solids, is positively correlated with pungency. Because antiplatelet activity may also be based on the activity of organosulfur compounds, it is possible these three factors are significantly correlated. The objective of this investigation was to examine the relationship among pungency, solids, and antiplatelet activity in four diverse onion genotypes. Replicated trials consisting of two mild and two pungent genotypes were conducted at four locations in 1994. Onion bulbs were harvested and analyzed for all three traits. Results from this investigation indicate significant positive correlations between antiplatelet activity, pungency, and solids in onion.

132

Selenium Affects Sulfur Uptake and Metabolism in Onions (*Allium cepa* L.)

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The affects of selenium (Se) on sulfur (S) uptake and metabolism were evaluated in 'Granex 33' onions. Plants were grown in a half-strength Hoagland's solution and modified with increasing Se fertility. Selenium was added as sodium selenate. During growth, plants were sampled biweekly and divided into root, bulb, and foliar tissue. Tissues were dried and ground for total S, and wet-ashed for total Se (GFAA). Selenium increased S uptake by onions. As Se increased in concentration, S utilization first increased then decreased in a quadratic trend.

133

Effects of Varying Sulfate Concentrations on Growth and Mineral Nutrition of the Greenhouse Tomato

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In hydroponic recirculating systems, sulfate ions can accumulate to excessive levels and interfere with other nutrient ions. The objective of this research was to determine the effects of four sulfate concentrations on growth and mineral nutrition of greenhouse tomato plants (*Lycopersicon esculentum* Mill. cv. Trust). Tomato seeds were sown in flats and subsequently transplanted into rockwool slabs. Ten days after transplanting, plants were given four sulfate concentrations in nutrient solutions (S_0 = 0.1, S_1 = 5.2, S_2 = 10.4, and S_4 = 20.8 mM). The plots were arranged in a randomized complete-block design with four replications. Treatment S_0 reduced dry weight of the top portion of the plant. A sulfate shortage in the nutrient solution decreased S concentrations in the leaf and decreased fruit number. Activities and concentrations of major ions in solutions expressed in mM or as row-centered logratios were correlated with corresponding foliar concentrations expressed in grams of nutrient per kilogram of dry matter or as row-centered logratios. Data were presented in this manner in order to explore interactive models describing relationships between mineral composition of both nutrient solutions and plant tissues. High concentrations of sulfate ions in the nutrient solution up to 20.8 mM did not affect tomato growth or yield. Tomato plants appeared prone to sulfate deficiency, but tolerant to sulfate concentrations up to 20.8 mM in the nutrient solution.

134

Foliar-applied Boron and Root-applied Potassium Affect Growth, Yield, Quality, and Nutrient Content of Tomato

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Fresh-market tomato (*Lycopersicon esculentum* Mill.) was grown in a growth chamber, hydroponically, and in a field to evaluate the effect of foliar-applied boron (B) and root-applied K on growth, yield, quality, and tissue nutrient levels. Plant and root dry weight, plant height, fruit set, total yields, marketable yields, fruit shelf life, fruit firmness, and fruit crack were positively influenced by B treatments. Boron-treated plants contained more K than plants not treated with B. Plants not treated with B contained less calcium (Ca) than plants treated with B. Leaflets from plants treated with B maintained higher K levels during fruit development than leaflets from plants not treated with B. Roots from plants treated with foliar B had significantly more B than roots from plants not treated with B. Fruit from B-treated plants had significantly more B than fruit from plants not treated with B. This indicates B was translocated from leaves to root and fruit tissues.

135

Improving Nitrogen Management of Vegetable Crops Through Intensive Monitoring

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The production of cool-season vegetable crops in California's coastal valleys is characterized by high N input (typically 200–300 kg·ha^{-1} per crop), with two crops per year the norm. N. removal in harvested biomass seldom exceeds 100 kg·ha^{-1}, suggesting a high degree of inefficiency in N management. A project was conducted on a commercial farm in Santa Maria to document the utility of intensive monitoring of soil and plant N status on improving N management. Eight fields were monitored through successive cropping cycles. Slow-release N fertilizer was applied preplant at 110–250 kg·ha^{-1} in subplots in each field to provide a reference of known N sufficiency against which to compare field productivity; these reference plots also received the same in-season fertilizer N applied in the balance of the field. N monitoring techniques included: in situ and controlled-environment soil incubation to estimate net N mineralization, soil NO_3-N analysis by a "quick test" technique using colormetric test strips, and petiole sap analysis by NO_3-N selective electrode. It was consistently demonstrated that, for lettuce, cauliflower, and broccoli, maximum crop productivity was obtained with seasonal N applications 50–100 kg N/ha less than the industry norm and that fertilizer cost savings more than offset the cost of crop and soil monitoring.

136

Response of Desert Lettuce to Controlled-release N Fertilizer

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Lettuce produced in the desert typically shows large yield responses to N fertilization. However, concern about the potential threat of nitrate-N to groundwater has prompted additional studies aimed at developing improved N management practices. Field experiments were conducted between 1992 and 1995 to evaluate the response of crisphead lettuce to controlled-release N fertilizer (CRN). The use of CRN was compared to a soluble N fertilizer applied preplant (PP), and a soluble N fertilizer applied in split-sidedress applications (SD). Rates of N fertilizer application ranged from 0 to 300 kg·ha^{-1}. Lettuce generally showed significant responses to N rate and N management practice. However, response to management practice varied by site-season. When conditions for N loss were high, SD and CRN management strategies were superior. However, in other site-seasons, SD management sometimes resulted in inferior head quality and marketable yield when compared to other management strategies. Data averaged over six site-seasons shoed improved yield and quality to CRN management strategies compared to PP and SD strategies.

53 ORAL SESSION 17 (Abstr. 137–144) Growth & Development/Fruit & Nuts (Temperate)

137

Selection of the Best Pollinizer for Late-flowering Almond Varieties

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In order to select the best pollinizer for late-flowering varieties of Azar (A.H.50), Shokoufeh (AH.3) Sahand (L-62), and Feragues, a range of studies were carried

out at Azar-Shahr Horticultural Research Station (Tabriz, Iran) and actions undertaken for introduction of the best pollinizers for these varieties under both laboratory and orchard conditions by a Dactroil Statistical Plan with a completely random base plan. Seven types of pollens from Shokoufes (AH.3), Azar (A.H.50), Sahand (L-62), Ferragnos (Fer), Neplus Ultra (N.P.U.), None Paril (N.P.), and Harir (A.H.25) were selected and the pollen prepared. Pollen was collected from the experimental grounds. Hand-pollination was repeated in three stages for 3 days. Honeybees and other insects were controlled before and after artificial pollination to not interfere with the experiment. Percent fruiting was recorded twice 1 month after pollination (1 June) and again 1 July and analyzed statistically. Average fruiting for female flowers (pollen receivers) was from 0% to 47%. Thus, all varieties could not produce fruit (control). Average fruiting from other pollens with different ratios were significant from 1% to 5%. The almond varieties Azar, Shokoufeh, Sahand, and Ferragnos are self-incompatible and there is no need to emasculate pollen in pollination programs. However, Azar and Harir are incompatible with each other. Pollination efficiency of late-flowering almond varieties depends on the pollinizers and the compatibility with the cultivars, provided that pollination is carried out only by insects, particularly honeybees. The effect of wind on pollination in our almond orchards appeared to be insignificant.

138

Nonstructural Carbohydrates and Mesocarp Development as a Result of Blossom Thinning in Peach

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The relationship between cell division, nonstructural carbohydrates and fruit size was investigated using 5-year-old 'Encore' peach [*Prunus persica* (L.) Batsch]. The trees, which were trained to two opposing scaffolds, were selected for uniformity based on tree size and floral bud density. One-year-old shoots ranging in size from 20 to 30 cm were tagged from throughout the canopy. At anthesis, one entire scaffold was thinned of 75% of its flowers, leaving 25% in the mid-section of each shoot. The opposing scaffold served as the control. Samples were taken at three intervals for histological analysis: Anthesis, 30 days, and 45 days after full bloom. Nonstructural carbohydrates were analyzed on samples taken at five intervals: Anthesis, 10, 20, 30, and 45 days after full bloom. Volumetric size increased 29% by 30 days after full bloom, and 64% by 45 days after full bloom. Final fruit size (volumetric) was increased 8% by harvest.

139

Abundance of *cab* RNA in Expanding Leaves of Peach cv Loring under Non-flowering Conditions

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Leaf expansion in peach (*Prunus persica*) cv Loring was monitored by measuring the increase in blade length during the spring and early summer of 1994, a season in which no flowers were observed on the sampled trees. Expansion was correlated with time after vegetative budbreak and with leaf position on growing apical shoots. In preliminary studies, information from these measurements was used to identify the relative maturity of leaves during the growing season in order to define sampling times that would represent "old," "mature," and "young" leaves. Leaves in these categories were sampled and pooled on two different dates, and total RNA was isolated from each sample. The RNAs were examined by Northern blot analysis using a ^{32}P-labeled cDNA clone encoding a peach *cab* (chlorophyll a/b binding protein) gene. Estimates of abundance based on the intensities of RNA bands hybridizing to the probe indicated that RNAs representing the *cab* gene family were most abundant in "mature" leaves. Further examination of abundance in pooled, individual leaves representing positions 1 through 19 (numbered acropetally) revealed a substantial decline in abundance in leaves from positions 1 through 5, which were already showing signs of senescence. These results are consistent with enhanced expression of the *cab* gene in the most photosynthetically active leaves.

140

Vegetative Flush Development and Leaf Area Contribution to Citrus Canopies

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The recent infestation of Florida citrus by the Asian citrus leafminer required that more information be obtained about the time interval for a flush to expand and the leaf area contributed by flushes in seasons when leafminer populations are likely to increase and cause leaf area loss. Time for leaf and shoot expansion was determined for spring and summer flush. Leaf area contribution from previous-year and current flushes was determined by seasonal tagging and measuring leaf area for flush in frame areas of 1/4 m^2 surface projected to the center of the tree. Flush of 1/3 m length required 30 days to expand from first leaf feathers to full expansion. Summer flush in 1994 was 40% to 45% of total leaf area. Spring and previous year's flush averaged 20% each. Fall flush contributed 5% to 12% to leaf area, more on young, low-bearing trees. Summer flush resulted in more canopy leaf area and previous year's flushes less leaf area than expected by the end of the growing season.

141

Accumulation and Partitioning of Dry Matter in Fruiting and Nonfruiting Pineapple Plants

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'Smooth Cayenne' pineapple plants were propagated from suckers of uniform size. The plants were grown in containers, and a large percentage of them naturally flowered in synchrony at 13 months. This provided an opportunity to study the accumulation and partitioning of dry matter in fruiting and nonfruiting plants of uniform age. Six plants with or without fruit were harvested when the syncarps developed color. Plants and fruit were separated into crown, syncarp, slips, peduncle, leaves, stems, and roots. Plants without fruit were separated into leaves, stem, and roots. There were no suckers, and the stem was divided at the ground level. Leaves were counted and all tissue was dried to a constant weight. Total dry matter accumulation and the ratio of below- to above-ground dry matter was not different between the two groups of plants. The plants were similar in size and leaf number at the time of flowering, but the number of leaves was fixed at that time in the plants with fruit. As a result, plants that did not flower had about twice as many leaves as the plants with fruit at the termination of the study. Thus, the vegetative growth of continued at a rate similar to that of the reproductive structures of the plants that did flower.

142

Effects of Elevated CO_2 on Sorbitol Partitioning in Sink and Source Apple Leaves

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Apple and many other *Rosaceae* plants translocate sucrose as well as sorbitol. How photosynthates are partitioned between sorbitol and sucrose in the *Rosaceae* is not understood. This study was designed to examine the effects of elevated air CO_2 on partitioning of sorbitol and other soluble sugars in sink and source apple leaves. Young 'Gala' apple plants were exposed to the ambient air and 700, 1000, and 1600 $\mu l \cdot liter^{-1}$ of CO_2 for 8 days under a light intensity of 928 $\mu mol \cdot m^{-2} \cdot s^{-1}$ with a 14-h day/10-h night cycle. Sorbitol, sucrose, glucose, and fructose concentration in sink and source leaves were determined by HPLC analysis. In source leaves, sorbitol was significantly increased, while sucrose was decreased as the air CO_2 was elevated from 400 to 1600 $\mu l \cdot liter^{-1}$. The sorbitol/sucrose ratio varied from 1.31 in air and 2.26 at 1600 $\mu l \cdot liter^{-1}$ of CO_2. In sink leaves, sorbitol concentration did not vary across the four CO_2 levels; however, sucrose was higher at the three super-atmospheric CO_2 levels. Our results suggest that increased photosynthesis via elevated CO_2 favors photosynthate partitioning into sorbitol rather than sucrose. A mechanism for regulating this partitioning will be discussed.

143

Apple Shoot and Trunk Growth as Affected by Rootstock

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Annual shoot and trunk xylem growth increment of 'Starkspur Supreme' in the 1984 NC-140 uniform rootstock trial was studied of 10 selected rootstocks representing a range of tree sizes. Shoot growth was measured weekly from budbreak through harvest in each of four seasons. After 11 seasons of growth, whole trees were cut, placed in water containing diffuse fuschin dye for 30 to 60 min during mid-day. After that, a section of trunk (10 to 15 cm long) was excised at 25 cm above the graft union. Trunk xylem thickness and percent of water transport active xylem were measured. Shoot length during the study was related to both the duration and rate of growth; however, growth duration contributed more to variation among stocks. In all stocks, it appears that almost all xylem translocated water and that there was very little "plugged" or active xylem. There were no differences among stocks for the relative percentage of active xylem. Annual xy-

lem increment width varied with stock. The vegetative growth of these trees will be discussed relative to the production efficiency of scions on these stocks.

144

Rootstock and Scion Interact to Affect Apple Tree Performance: A 5-year Summary of the 1990 NC-140 Trial

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In 1990, a trial was established at 17 locations in the United States and Canada including the scions 'Golden Delicious', 'Jonagold', 'Empire', and 'Rome'' and the rootstocks M.9 EMLA, B.9, Mark, O.3, and M.26 EMLA. In 1994, trees on M.26 EMLA were the largest and trees on B.9 and those on Mark were the smallest, regardless of scion. Trees on M.9 EMLA were intermediate. 'Golden Delicious' and 'Empire'' trees on O.3 were larger than those on M.9 EMLA. 'Jonagold' and 'Rome' trees on O.3 were similar in size to those on M.9 EMLA. With all scions, B.9 and Mark resulted in the lowest cumulative yields. With 'Jonagold', 'Empire', or 'Rome' as the scion, O.3, M.26 EMLA, and M.9 EMLA resulted in the greatest and similar yields. With 'Golden Delicious' as the scion, however, trees on M.9 EMLA yielded only as much as those on B.9 or Mark. Trees on B.9 and those on Mark were the most yield-efficient, regardless of scion. 'Golden Delicious' and 'Rome' trees on O.3 were similar to those on B.9 and those on Mark, but 'Jonagold' and 'Empire' trees on O.3 were less efficient than those on B.9 or on Mark. Overall, M.26 EMLA resulted in the lowest efficiency; however, M.9 EMLA resulted in more efficient trees only with 'Empire' as the scion. Participants include: J.L. Anderson (Utah), W.R. Autio (Mass.), J.A. Barden (Va.), G.R. Brown (Ky.), P.A. Domoto (Iowa), D.C. Ferree (Ohio), A. Gaus (Colo.), R.L. Granger (Quebec), R.A. Hayden (Ind.), F. Morrison (Kan.), C.A. Mullins (Tenn.), S.C. Myers (Ga.), R.L. Perry (Mich.), C.R. Rom (Ark.), J.R. Schupp (Maine), and L.D. Tukey (Pa.).

54 ORAL SESSION 18 (Abstr. 145–150) Culture & Management/Floriculture

145

Municipal Solid Waste Compost and Fertigation Frequency on Growth of Potted Poinsettia

Catherine S.M. Ku, John C. Bouwkamp,* and *Frank R. Gouin*, Dept. of Horticulture and Landscape Architecture, Univ. of Maryland, College Park, MD 20742-5611.

Municipal solid waste (MSW) may be a potential substitute for peat substrate in soilless medium. Adequate N and P are needed for a complete composting of MSW. MSW piles treated with diammonium phosphate (MSWP) or without P on Mar. 1994 were cured for 5 months. In Fall 1994, a factorial treatment combination of nine mixes and 3 fertigation treatments were evaluated in a completely randomized design on soft-pinched, single-stem 'Red Sail' poinsettia. Mixes were MSW or MSWP ranging from 33% to 100% by volume in 1 peat : 1 perlite (v/v) and Sunshine mix was used as the control. Fertigation treatment began on the 1st, 2nd, or 3rd week after potting. Fertigation solution contained 266 mg·liter^{-1} N from 30N–4.4P–8.8K. The total fertigations ranged from eight to 10 for the 13-week study. With MSW mixes, shoot dry mass at the week 1 fertigation was 36% larger than at the week 3 fertigation. At the week 3 fertigation, shoot dry mass with 100% MSWP was ≈53% greater than with the 100% MSW. Shoot dry mass with 100% MSWP was similar to the control at the week 1 fertigation.

146

Determining the Juvenile Phases of *Coreopsis grandiflora*, *Gaillardia grandiflora*, *Heuchera sanguinea*, and *Rudbeckia fulgida*

Mei Yuan, William H. Carlson, Royal D. Heins,* and *Arthur C. Cameron*, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824-1325.

Most plants have a postgermination juvenile phase in which flower induction will not occur. Some species require a cold period for flower induction and will not respond to the cold treatments during the juvenile phase. We determined juvenile phases of *Coreopsis grandiflora* 'Sunray', *Gaillardia grandiflora* 'Goblin', *Heuchera sanguinea* 'Bressingham', and *Rudbeckia fulgida* 'Goldsturm'. Plants were exposed to 5C for 0, 10, or 15 weeks when *Coreopsis* had 0, 2, 4, 6, 8, or 10 leaves (>1 cm); *Gallardia*, 4, 8, 12, or 16 leaves; *Heuchera*, 8, 12, 16, or 20 leaves; *Rudbeckia*, 5, 10, 15, or 20 leaves. Plants were grown under a 4-h night interruption lighting (LD) or under a 9-h photoperiod (SD) after cold treatments. Based on time to flower and final leaf count, the juvenility of *Coreopsis*, *Gaillardia*, *Heuchera*, and *Rudbeckia* ended when they had about 6, 10, 12, and 15 leaves, respectively. Cold treatments were necessary for flower induction of *Coreopsis* and *Heuchera* and they increased the flowering percentage of *Gaillardia* and *Rudbeckia*. *Heuhera* was a day-neutral plant, *Rudbeckia* was on obligate LD plant, and *Gaillardia* and *Coreopsis* were quantitative LD plants.

147

Effects of Temperature, Photoperiod, and Light Quality on Flowering in Several Herbaceous Perennial Species

Catherine Whitman, Royal Heins, Arthur Cameron,* and *William Carlson*, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824-1325.

The influence of low temperatures on *Campanula carpatica* 'Blue Clips' and *Lavandula angustifolia* 'Munstead' flowering was determined; plants were stored at 5C for several weeks and forced under 9-h photoperiods with a 4-h night interruption (NI). *C. carpatica*, *L. angustifolia*, and *Asclepias tuberosa* were forced under NI at five temperatures (15–27C) and time to flower under each treatment was calculated. Flower number and size were reduced at highest temperatures. The effectiveness of cool-white fluorescent (CWF), high-pressure sodium (HPS), incandescent (I), and metal halide (MH) lights in inducing flowering in *C. carpatica* and *Coreopsis lanceolata* 'Early Sunrise' was compared. Lighting was delivered as a 7-h daylength extension with PPF ranging from 0.05–2.0 μmol·m^{-2}·s^{-1}. Minimum irradiances above which all *C. carpatica* flowered were approximately 0.14, 0.12, 0.1, and 0.17 μmol·m^{-2}·s^{-1}, respectively. *C. lanceolata* under CWF displayed irregular flowering throughout the range of intensities used. Under HPS and MH, minimum irradiances for 100% flowering were 0.37 and 1.0 μmol·m^{-2}·s^{-1}, respectively, with sporadic flowering at lower intensities. Under I light, all *C. lanceolata* exposed to 0.12 μmol·m^{-2}·s^{-1} or more flowered.

148

Water Relations and Growth of *Catharanthus roseus* 'Cooler Peppermint' as Influenced by Moisture Stress Conditioning

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Catharanthus roseus 'Cooler Peppermint' were grown under four different watering regimes [well-watered (WW), wilt plus 1 day (W+1), wilt plus 3 days (W+3), and wilt plus 1 day during the last 2 weeks only (L W+1)] and two different light levels [1100 and 750 μmol·m^{-2}·s^{-1}]. Stress treatments affected finished plant size and leaf area as well as stomatal conductance, water potential and time to wilt during two dry-down periods imposed at the end of an 8-week production cycle. W+3 plants were 50% smaller with 50% less leaf area compared to WW plants. During the second dry-down period, WW plants in high light wilted in 2 days vs 4 days for the W+3 plants. Similarly, WW plants in low light wilted in 3 days vs 6 days for the W+3 plants. The W+3 plants maintained significantly higher water potentials and greater stomatal conductances than the other treatments throughout both dry-down periods.

149

Poinsettia Bract Edge Burn: Potential Causes and Role of Calcium Sprays and *Botrytis*

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Bract edge burn (BEB) is a serious commercial problem, and a cooperative trial with six cultivars was conducted at the above research locations and in commercial greenhouses in the respective areas. 'Success' and '21-91' had less BEB than 'Celebrate 2', 'V-14 Glory', or 'Supjibi'. BEB symptoms increased with time during postproduction. Number of bracts with BEB spots on 'V-14 Glory' at boxing, unboxing, 7 and 14 days were 1, 3, 6, and 10, respectively. Weekly Ca sprays (400 ppm at start of color) reduced or prevented BEB in the greenhouse at all locations where BEB developed and reduced the development in BEB during postproduction. BEB increased with fertilizer level and was higher in plants with elevated potassium or ammonium. These effects were reversed by Ca sprays. BEB was increased by boxing wet plants or inoculating plants with *Botrytis*. BEB was reduced by boxing dry plants, fungicide treatment, or terminating fertilization. BEB symptoms for different cultivars will be presented.

150

Sodium Silicate Sprays Reduce the Incidence of Bract Edge Burn in Poinsettia

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Bract edge burn (BEB) starts as a necrosis on veins near the margins of mature bracts. Typically, BEB first appears at anthesis and symptoms progress over time. In 1993, the incidence of BEB on plants sprayed with sodium silicate (Na_2SiO_3)—490 ppm Si at weekly intervals during bract development—was compared to unsprayed controls using the cultivar Supjibi. BEB appeared soon after anthesis on unsprayed plants, and, by 309 days post-anthesis, 11.5% of the bracts on unsprayed plants had BEB, but only 0.4% of the bracts on Na_2SiO_3-treated plants had symptoms. Calcium levels in bract margins were similar (0.194% in both treatments. In 1994, the following spray treatments were applied weekly from 31 Oct. to 5 Dec. (initial anthesis) to the cultivars Supjibi and V-17 Angelika White: $CaCl_2$ (400 ppm Ca), Na_2SiO_3 (50, 100, 150, or 200 ppm Si), DI H_2O (sprayed control), or unsprayed control. Both cultivars developed similar BEB symptoms and responded similarly to all treatments. One week post-anthesis, 5.7% of the bracts on unsprayed plants (averaged for both cultivars) developed BEB and 2.5% of the bracts on sprayed controls developed BEB, but only 0.19% of the bracts on $CaCl_2$- or Na_2SiO_3-treated plants developed BEB symptoms. By 5 weeks post-anthesis, the incidence of BEB was similar for plants sprayed with $CaCl_2$ and Na_2SiO_3 at 100, 150, or 200 ppm (1.1%, 6%, 6.7%, and 5.7%, respectively); but higher on sprayed controls (22%), and still higher on unsprayed plants (28.5%).

70 ORAL SESSION 19 (Abstr. 151–158) Breeding/Vegetable Crops I

151

Comparison of Molecular Marker and Morphological Data to Determine Minimum Distance among Tomato Cultivars

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Precise cultivar descriptions are necessary to support Plant Variety Protection and utility applications for patent protection. However, accurate discrimination among cultivars is contingent upon the dependability of the method used to delineate lines. The efficiency and reliability of Amplified Fragment Length Polymorphisms (AFLPs), Random Amplified Polymorphic DNAs (RAPDs), microsatellite polymorphisms, and phenotypic traits were studied in order to determine a method's ability to accurately predict pedigree relationships among a set of 20 California processing tomato cultivars. All molecular marker and phenotypic trait data sets were independently produced using identical cultivar seed sources. Data was reduced to a genetic distance measure and presented as a multidimensional scaling (MDS) plot. Principal component analysis using the scored quantitative phenotypic traits was computed and is compared to molecular marker data results. Experimental error, sampling variance, and independence of scored bands for each molecular marker technique are presented. These estimates should assist breeders to determine a sufficient level of characterization, determine a minimum distance considered to be unique, and defend pedigree relationships.

152

Comparison of Five Molecular Marker Systems in Assessing Genetic Relationships among 39 Elite Corn Belt Inbreds

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The statistical properties associated with molecular markers are important when used to characterize germplasm. Evaluation of these properties are necessary for informed selection of one marker system over another. Five different molecular marker systems, Amplified Fragment Length Polymorphism (AFLPs), Arbitrary Primed Polymerase Chain Reaction (AP-PCR), Random Amplified Polymorphic DNA (RAPDs), Restriction Fragment Length Polymorphism (RFLPs), and Isozymes were used to evaluate 39 elite corn belt inbreds. Each system was characterized for fragment frequency distribution, and band correlation distribution as a measure of independence. A regression model estimating resolution and rate of information addition was constructed using the sampling variance. All marker systems were evaluated according to this model. The model facilitated genetic relationships among the inbreds to be compared at equivalent performance level among all marker systems. Four performance levels resulted in 10 comparisons. Pairwise test of significance were conducted using *t* tests where the null-distributions were obtained by the bootstrap procedure. The maker system were ranked, assisting breeders in selecting marker systems for germplasm organization.

153

Integration of RAPD Marker Genetic Linkage Maps in *Phaseolus vulgaris* L.

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Currently, we are studying the genetics and linkage relationships of important quantitative and qualitative traits in common bean, including disease resistances, plant architecture, seed size and shape, and pod size, shape, and fiber content. Study of the genetics of these traits is being facilitated through the use of RAPD marker-based linkage maps in four RI populations. Cultivated *P.vulgaris* has two primary centers of diversity—Meso-american and Andean, the RI populations used for mapping are Meso x Andean (Bat93 x Jalo EEP558 and Eagle x Puebla 152), Andean x Andean (PC50 x Xan159), and Meso x Meso (BAC6 x HT7719) crosses. Maps in these four populations are being integrated through the use of cosegregating markers. Integration of maps will allow integration of the linkage relationships of relevant genes and also allow more efficient sampling of markers for future linkage studies.

154

Comparison of Genetic Diversity in Core and Whole Germplasm Collections for *Phaseolus vulgaris* L.

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The number of *Phaseolus vulgaris* germplasm accessions numbers more than 30,000. While the large numbers of accessions increase the probability of preserving genetic variability they simultaneously limit the efficient and routine utilization of this resource. From the approximately 4000 *P. vulgaris* accessions in the C.I.A.T. whole collection that were collected in Mexico, a core collection of 400 accessions was developed based on variation for agronomic performance, ecological adaptation, and seed characteristics. Random samples of 90 accessions each were drawn from the core and whole collections and evaluated for 224 polymorphic RAPD bands. Based on analysis of the RAPD data there were no significant differences in genetic diversity between the two samples. The correlation of marker frequency for the two samples was 0.984 confirming that the two samples represent the same population.

155

Diallel Analysis for Rain Check in Tomato

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To investigate the genetic control of rain check (cuticle cracking) in tomato (*Lycopersicon esculentum*), a full diallel cross including five parents ranging from very resistant to very susceptible was grown in late spring 1994. A randomized complete-block design with four replications was used and the proportion of fruit showing check was measured on all mature fruit from eight plants per replication at three harvests. Analysis of variance indicated significant ($P < 0.0001$) variation for line, harvest, and line by harvest interaction. The proportion of fruit affected increased with each successive harvest. Reciprocal differences were tested on a by-harvest basis and found to be nonsignificant. Reciprocals were combined and a Hayman's analysis was performed on a by-harvest basis on the means. Additive effects on variance were significant ($P < 0.05$) for all harvests. Under high environmental stress (harvest 3), dominance effects were negative and significant ($P < 0.05$). Narrow-sense heritability ranged from 0.54 to 0.67 and increased with increasing environmental stress. General combining ability was significant for all harvests, whereas specific combining ability was significant only for harvest 3 ($P < 0.05$).

156

Inter- and Intraspecific RAPD Variation in Four *Ipomoea* Species

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Randomly amplified polymorphic DNA (RAPD) analysis was performed on 18 accessions belonging to four different species of the genus *Ipomoea*, including sweetpotato and three related species. Twenty-two out of 30 primers tested revealed polymorphisms among these four species. Eight primers were selected on the basis of the number and repeatability of polymorphism produced. With these, a total of 98 different DNA bands were obtained and 85% of them were polymorphic. Based on the presence/absence of the bands, a genetic similarity among accessions and among species was calculated. Unweighted pair-group method with arithmetical averages (UPGMA) based on the similarity coefficients clearly discriminated these four species. *Ipomoea trifida* and sweetpotato share more genetic similarity. *Ipomoea triloba* and *I. leucantha* fall into another cluster. This study demonstrated that RAPD techniques can be a very useful tool for genotype/accession identification and studying the genetic relationship among genotypes/accessions of sweetpotato and among species of *Ipomoea*.

157

Application of RFLP Analysis for the Assessment of QTLs in Cucumber (*Cucumis sativus* L.)

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Cross progeny (F_3 and BC) of a *Cucumis sativus* var. *sativus* (GY 14) x *C. sativus* var. *hardwickii* (PI 183967) mating were used in conjunction with RFLP analysis to identify regions of the genome influencing yield and fruit quality, and to test the consistency of QTLs over environments and generations. QTLs affecting earliness, sex expression (*F*), fruit yield, and fruit size were identified. The number and map location of these QTLs was consistent over environments (years and plant densities). Differences in number and map location of QTLs were found when F_3 and BC families were compared. Some of these differences could be attributed to disparities in population size (102 and 59 for F_3 and BC families, respectively), dominance, and the amount of genetic information available (F_3 > BC). Two shared chromosomes regions were identified that conditioned days to anthesis, fruit number, and weight. One of these regions coincided with the QTL affecting number of barren nodes, while the other was near the *F*-locus. Three to five QTLs were found to control fruit length (L), diameter (D), and L/D ratio. Depending on the locus, QTLs affecting fruit size appeared to express themselves with various degrees of dominance according to the direction of dominance observed in either parent.

158

Genetic Relationships among Accessions and Cultivars of Faba Bean (*Vicia faba* L.) Based on RAPD Molecular Markers

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Knowledge of relative genetic distance among genotypes is useful in a breeding program because it permits organization of germplasm resources. Genetic distance (GD) was estimated among 113 faba bean, *Vicia faba* L. genotypes, which included three botanical varieties from different geographical areas around the world. The genotypes included 87 accessions from Bolivia, 14 accessions from the Middle East and North Africa, five accessions from Australia, and seven commercial varieties from Europe. Twenty-three RAPD primers were scored yielding four to 13 polymorphic bands resulting in a total of 165 bands. Our objective was to determine genetic relationships among accessions and cultivars as measured by RAPD markers. The genetic relationships were estimated using the ratio of discordant to total bands scored. A multidimensional scaling (MDS) plot indicated four clusters corresponding to: i) European commercial cultivars; ii) the Middle East, North Africa, and Australian accessions; iii) the Bolivian highland landraces; and iv) the Bolivian collection maintained in a valley environment. A permutation test confirmed the four clusters ($P < 0.01$). Sampling variance results indicated that a CV of 10% could be obtained with as few as 148 bands between groups. Selection and drift appears the main cause of divergence of two populations in the Bolivian faba bean collection.The results of this study indicated that RAPDs are a powerful tool for evaluation of germplasm conservation methods in faba bean.

71 ORAL SESSION 20 (Abstr. 159–166) Nutrition/Fruits & Nuts (Subtropical & Tropical)

159

Foliar Nitrogen Fertilization of Citrus in Florida

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Foliar applications of urea nitrogen (N) is a relatively new practice in Florida citrus production resulting from applied research and changes in citrus fertilizer management philosophy. The present study investigated the effect of leaf age and surface morphology on leaf wettability as measured by contact angles, and absorption efficiency of foliar-applied N. Young leaves (0.25 and 1 month) were more efficient than old leaves in the absorption of foliar-applied N. Contact angles of water, urea-, and triazone-N solutions were low in the young leaves. The adaxial surfaces had lower contact angles than abaxial surfaces in each leaf age group. Inefficient N absorption and large contact angles in old leaves (3 and 6 months) were related to surface wax deposition and cuticle thickness, which increased with leaf age. ^{15}N- and ^{14}C-labeled urea are being used to determine precisely how the cuticle and wax affect foliar N absorption in citrus leaves.

160

Foliar and Soil Zn Applications Increase Yield of Grapefruit Trees

*Dariusz Swietlik**, Texas A&M Univ.–Kingsville, Citrus Center, P.O. Box 1150, Weslaco, TX 78599.

The effects of soil and foliar Zn applications on growth, yield, and fruit quality of 'Rio Red' grapefruit were studied in the field for 4 years. Two annual foliar sprays applied in winter (W), spring (S), or W+S were compared to a single application of 10 or 30 g of Zn/tree applied to the soil around the tree as ZnDTPA or ZnEDTA chelate. In the first 2 years, when control trees displayed severe Zn deficiency symptoms affecting 60% to 70% of the tree foliage, the W and W+S sprays resulted in significant yield increases. Similar yield increases were obtained after a single soil application of 30 g Zn as ZnEDTA. The effects of other soil treatments were statistically insignificant. Foliar Zn deficiency symptoms were much more severe in winter than summer months irrespective of treatment. As the trees aged, however, the severity of symptoms decreased in all treatments. Corrective foliar or soil Zn applications were found to increase grapefruit yield when 15% or more of the canopy foliage showed Zn deficiency symptoms in January, ≈2 months before anthesis.

161

Nitrate-N Distribution Pattern in Ground Water under a Florida Citrus Grove

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An 8-ha block of 9-year-old Valencia orange trees, surrounded on three sides by drainage ditches, was divided into four equal-sized plots. A 4-m deep sampling well was drilled in the middle of each plot and a short piece of perforated pipe was placed above the water level in the bank of one of the drainage ditches to intercept seepage water. Water from the well in the third plot and the corresponding seepage pipe contained consistently NO_3-N in the 20-ppm range, in contrast to the other sampling points, ranging from 0.1 to 9 ppm. Electrical conductivity was higher in plots 3 and 4, downstream from plots 1 and 2, in the ground water flow. Sodium in the water followed the same pattern P and K were the same, and pH was higher in plots 1 and 2 than in 3 and 4. Soil pH (5.2–5.8) and water-extractable NO_3-N showed no patterns, organic matter (0.79% to 0.12%) and soil moisture (5.5% to 6.3%) were higher in plots 3 and 4. Leaf nitrogen (2.60% to 2.90%) was highest in the high-nitrate plot 3. The soil on the east side of this plot showed a higher nitrate-holding capacity compared to the other plots in an anion-exchange capacity procedure.

162

Fertilization of Young 'Hamlin' Orange Trees with Controlled-release Fertilizer

*J.J. Ferguson** and *F.S. Davies*, Horticultural Sciences Dept., 1251 Fifield Hall, Univ. of Florida, Gainesville, FL 32611.

Young 'Hamlin' orange trees [*Citrus sinensis* (L.) Osbeck] were fertilized six times/year with water-soluble N fertilizer at recommended rates (0.20, 0.34, and 0.38 kg N/tree per year) and with controlled-release fertilizer one time/year [Osmocote, IDBU, and a 44.5% urea-N fertilizer coated with a sulfonated ethylene-propylene-diene polymer (Sherritt, Inc.)] at 0.04, 0.06, and 0.08 kg N/tree per year for years 1, 2, and 3, respectively. There were no differences in trunk diameter, tree height, or tree rating among treatments in any year, although there was a slight reduction in tree rating for some trees with biuret symptoms in the Sherritt treatment in year 2. Leaf nitrogen content was acceptable for all treatments in all 3 years, except for the Osmocote treatment in year 2, which had low to deficient levels. Levels of other nutrients were all within acceptable ranges, except for low potassium levels for the Osmocote in year 2. There were no significant differences in yields of young trees in year 3, the first bearing year. Given its 44.5% N analysis, the total amount of Sherritt controlled-release fertilizer applied to young citrus trees was 4% that of the standard, water-soluble fertilizer and from 39% to 45% that of the two other controlled-release fertilizers in years 1, 2, and 3.

163

Assessment of Nitrogen Uptake Capacity in Mature Alternate-bearing Pistachio (*Pistacia vera*) Trees

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The interrelationships between crop load, root growth, and nutrient uptake in mature, pistachio trees were examined in this study. Nutrient uptake was determined during the spring, summer, and fall using labeled nitrogen (^{15}N) and boron (^{10}B) and by differences in whole-tree accumulation between tree harvests for other nutrients (e.g., P, K, Ca, Zn). Nitrogen and boron uptake were double in fruiting compared with nonfruiting trees in the spring. Most of the labeled N was found in the developing fruits and leaves. Total labeled N recovery during the spring flush period, however, was low, indicating that much of the N in the fruit came from N reserves from within the tree rather than uptake from the soil. In contrast, significant amounts of N were taken up from the soil during the summer uptake period. Thus, our data support the hypothesis that sink demand (i.e., fruit development) conditions N uptake in pistachio. The relationship between root growth and N uptake was also examined in this study. Root observation chambers were constructed, and root growth determined by tracing roots growing up against the glass windows. Root length, root growth rate, relative root growth rate, and total tree fine root weight were all greater in nonfruiting compared to fruiting trees during the fruit development period (late May to mid-July). Surprisingly, fruiting trees had less root growth, but greater N uptake than nonfruiting trees during this period. This evidence suggests that N uptake is decoupled from root growth in mature pistachio trees.

164

Effect of Pollen of Five Different Male Palm Trees on the Chemical Characteristics of Jiroft Mazafati Date

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The type of pollen of date palm trees could affect the chemical characteristics of the fruit, and determine the quality and quantitative aspects. Careful selection of proper pollen for pollination of date palm is very important. This research was conducted for the selection of the best pollinizers and to study the effects of five varieties of male trees from the Shahdad area on the chemical characteristics of 'Jiroft Mazafati' date. A completely random block was used for analysis of the 2 years of data (1991–1993). The study sight was in the Jiroft area of Kerman Province, Iran. Samples of fruit were collected after the pollination process and the required information recorded. Total dry matter, fruit moisture, total sugar content, fruit ash, and fruit pH were measured. Statistical calculations analysis and compound variations and evaluations of the treatments by Duncan's test indicate that, statistically, the different treatments have no effect on the fruit pH, and the difference are not significant. There are statistically significant effects on the other chemical characteristics of the fruit.

165

Effect of Urea, Some Micronutrients, and Growth-regulator Foliar Sprays on the Yield, Fruit Quality, and Some Vegetative Characteristics of 'Washington' Navel Orange Trees—Vegetative Growth and Mineral Leaf Content

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This investigation was carried out during the experimental seasons of 1991–92 and 1992–93 on 25-year-old 'Washington' navel orange trees grown in an orchard at Beni Suef (≈120 km south of Cairo). This part of the investigation studied the effect of foliar spraying urea (0.5%), a mixture of Zn (0.4%), Mn (0.3%), Fe (0.5%), and Cu (0.3%) in sulfates from 23% Zn, 28% Mn, 19% Fe, and 30% Cu, respectively, and two growth regulators (GA_3 at 25 ppm and α-NAA at 10 ppm) on some vegetative aspects and leaf content of some macro- and micronutrients. The investigation also included the effect of number and date of spraying (one spray 3 weeks before flowering, one spray 4 weeks after fruit set, and two sprays at the two dates) on the studied traits. The results showed that the overall treatments included two sprays of urea, micronutrients (Zn, Mn, Fe, and Cu) and NAA at 10 ppm achieved the highest values for average leaf area and shoot diameter in both seasons. The treatment on shoot length was more effective when GA_3 replaced NAA. Leaf analysis showed that the application of any of the nutrients was responsible for a pronounced increase in leaf content of that element, but reduced the contents of others. Growth regulator treatments lowered leaf content of the determined elements. However, all other treatments in this study reduced leaf content of P and K.

166

Effect of Urea, Some Micronutrients, and Growth Regulator Foliar Sprays on the Yield, Fruit Quality, and Some Vegetative Characteristics of 'Washington' Navel Orange Trees—Yield and Yield Components

Ahmed M. Akl, Abdel-Fattah M. Eid,* and *Mohamed Y. Hegab*, Horticulture Dept., Faculty of Agriculture, Minia Univ., Minia, Egypt.

This investigation studied the effects of foliar sprays of urea (0.5%), a mixture of Zn (0.4%), Mn (0.3%), Fe (0.5%), and Cu (0.3%) in sulfates from 23% Zn, 28% Mn, 19% Fe, and 30% Cu, respectively, and two growth regulators (GA_3 at 25 ppm and α-NAA at 10 ppm), as well as number and date of sprays, on the number of fruit/tree, average fruit weight, and yield/tree in kilograms. Spraying 'Washington' navel orange trees with urea and/or micronutrients significantly increased the number of fruit/tree, average fruit weight, and yield/tree expressed in kilograms. However, the treatment including both of them was the most effective in 1991–92 and 1992–93. Application of GA_3 and NAA effectively increased the value of the three traits compared with the control; however, spraying the trees with NAA was responsible for higher fruit numbers, while GA_3 was more effective in increasing fruit weight. Two sprays of urea, micronutrients, and NAA (or GA_3), the first applied 3 weeks before flowering and the second 4 weeks after fruit set, were more effective than spraying once at any of the two dates in producing high numbers of fruit/tree, average fruit weight and yield per tree by weight.

72 ORAL SESSION 21 (Abstr. 167–174) Temperature Stress (General)/Cross-commodity

167

Imitation of Cold Stress in 'Beautiful Arcade' Apple Root using Electrical Impedance Analysis

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2,3,5-triphenyltetrazolium chloride (TTC) staining and electrical impedance (?) analyses of apple roots (*Malus domestica* Borkh. 'Beautiful Arcade') taken in late March from either the field or from 3C refrigerated storage (cold-stored). LT_{50} levels using TTC were much lower than those found using electrical impedance. No loss of viability in the roots was detectable using TTC staining until a freeze–thaw stress of –9C whereas ? analysis detected changes in cell viability

after a freeze–thaw stress of only –3C. With increasing cold stress, two parameters: extracellular electrical resistance (R_0) and time constant ?, decreased linearly for cold-stored roots and exponentially for field roots. Impedance analysis also revealed that the values for both extracellular R_0 and total tissue electrical resistance ($R_?$) for the field roots were approximately 5 and 8 times lower, respectively, than in the cold-stored roots. It is believed that the smaller R_0 and $R_?$ values obtained from the field roots were due to natural in-field freeze–thaw cycling prior to the controlled stress tests in the laboratory. Based on the analyses of winter hardiness using the two methods, the impedance technique ? provided the physiological information not only about the hardiness level, but also about freeze–thaw history prior to the hardiness assessment.

168

Freeze Tolerance of 'Braeburn' Apple Shoots

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Differential thermal analysis (DTA) and tetrazolium triphenyl chloride (TTC) were done on shoots of 4-year-old 'Braeburn' apple trees for 3 years. The trees acclimated slowly in autumn. If cold temperatures last long enough in winter, shoots will acclimate as low as –40C. Shoots are sensitive to warm temperatures and deacclimated rapidly. An attempt to run a controlled test on freeze resistance of 'Braeburn' did not respond to DTA. Moisture samples indicated trees were freeze dried. Different sets of trees were rehydrated and showed an exotherm pattern. Exotherms could be seen after 3 days at 26C, 14 days at 10C, and 21 days at 4C. Another controlled freeze test was performed on 1-year-old 'Braeburn' trees. Trees were acclimated outdoors. An exotherm pattern could be seen upon DTA analysis. After artificial freezing, DTA and TTC tests showed pith killed at –24C, primarily xylem at –28C, and all tissue at –35C. After freezing, trees were placed in a greenhouse and warmed over 2 months. Upon dissection, we found xylem produced before freezing was dead, but a large amount of new xylem was generated. Trees appeared to have normal leaf and shoot growth for about a month, but eventually wilted and died. Dissection of these showed the same results as the first set dissected. New xylem evidently was not enough to carry the growth of the trees.

169

Cold Hardiness in Two Interspecific *Populus* Hybrids

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Cold hardiness was studied in two interspecific *Populus* hybrids (*P. trichocarpa* x *P. deltoides*, and *P. trichocarpa* x *P. maxomowiscii*), using laboratory freezing tests of mid-winter dormant tissues and fully expanded leaves in the autumn. These laboratory measurements were compared to field observations. Hybrids having one parent from southern-source populations and the other parent from northern sources were compared to hybrids in which both parents were from southern-source populations. *Populus* hybrids with one parent of northern origin were generally hardier than hybrids from parents of southern sources; however, significant differences in cold hardiness were detected between hybrids having the same genetic parents. Field observations generally supported laboratory measurements and showed clonal differences in mid-winter cold hardiness and autumn leaf frost tolerance. Fully expanded leaves of different clones from the same parent also exhibited differences in frost tolerance.

170

Gene Expression and Membrane Changes in Bermudagrass during Cold Acclimation

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Bermudagrass (*Cynodon dactylon*) cultivars may exhibit increased tolerance to cold following periods of exposure to moderately cold temperature (i.e., acclimation). We are evaluating biochemical changes and the regulation of gene expression in two cultivars—'Midiron' and U-3—during this acclimation period. Total membrane lipid fatty acids per unit of total lipids (MLFA/TL; $\mu g \cdot mg^{-1}$) increased in crowns over the 4-week exposure to chilling temperatures (8C day/2C night). Of the fatty acids comprising 95% of total MFLA, concentrations of short-chain and saturated FAs declined significantly while unsaturated longer-chain FA concentration increased. As a result, the double bond index (percent of each FA x number of double bonds in the FA) increased during the period of low temperature exposure, indicative of increasing membrane fluidity. Changes in MFLA were evident as early as 4 days following exposure to chilling temperatures. Identification of mRNA species expressed in response to low temperature utilized differential display-PCR. Initial screening with paired T11N1N 2 3'-anchor and 5'-random decamer primers has identified transcripts differentially expressed as early as 23 h post-exposure and was maintained for at least an additional 36 h. Isolation, reamplification, and cloning of these identified PCR products is in progress.

171

Effect of Chilling on Respiration and Induction of Cyanide-resistant Respiration in Cucumber Roots

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The effect of chilling stress on induction of the cyanide-resistant pathway was investigated using roots of 3-day-old cucumber (*Cucumis sativus* L.) grown at 26C and then chilled at 2C, 10C, or 15C for 24, 48, 72, and 96 h. A 24-h post-chilling treatment was imposed on different sets of chilled cucumber roots at 26C. Exposing seedlings to 2C, 10C, and 15C, as well as to a post-chilling treatment, induced differential responses in the activity of the cyanide-resistant pathway. Cucumber seedling roots exhibited an increase in the cyanide-resistant pathway after a 96-h chilling treatment at 2C. The involvement of the cyanide-resistant pathway in the chilling stress response will be discussed.

172

Influence of Warming Temperatures on Shoot Dehardening of Container-grown Nursery Stock

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Studies were conducted with *Physocarpus*, *Weigela*, *Hibiscus*, *Euonymus*, *Forsythia*, *Spiraea*, *Lonicera*, and *Taxus* to evaluate the effects of warming temperatures on shoot dehardening. Container-grown plants were stored pot-in-pot, allowing shoots to receive natural outdoor conditions until early March. Control plants remained at 0C (32F), while treatment plants were placed in a temperature-controlled chamber at 21C (70F) and given up to 8 days of warming. Controlled-temperature freezing was used to evaluate plant hardiness. Hardiness levels of *Weigela*, *Spiraea*, and *Forsythia* rapidly decreased after 1 day of warming and again after the 7th day. *Hibiscus* gradually decreased in hardiness until the 7th day. The influence of polyhouse storage, in which plants were stored pot-in-pot, on the dehardening of *Weigela*, *Hibiscus*, and *Euonymus* was compared to outdoor storage, where plants were stored pot-in-pot. The warming effects of the polyhouse decreased the cold hardiness of the species studied. Results of the warming effects will be presented.

173

Involvement of HSP Synthesis and Protease Inhibitors in Heat Shock-induced Cucumber Seedling Chilling Tolerance

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Heat shock induction of chilling tolerance in cucumber seedlings is not blocked by inhibitors of protein synthesis. Treatment of germinating seeds with cycloheximide and actinomycin-D, prior to heat shock and chilling, does not block the heat shock induction of chilling tolerance, while the inhibitors alone promote chilling tolerance of seedling roots. To test whether the heat shock effect might be acting on proteases, two protease inhibitors (bestatin and PMSF) were tested for their ability to induce chilling tolerance. Although PMSF slowed germination, it still provided protection against chilling, but bestatin was much more effective.

174

Evidence for Genetic Variability in the Speed of Cold Acclimation among Tuber-bearing Wild Potato Species

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Frost damage to the foliage is a common problem where potatoes are grown, and results in significant reductions in tuber yield. Frost injury also limits the cultivation of high-yielding *S. tuberosum* cultivars in the mountain regions of Central and South America, where potato is a staple crop. Recent studies have shown that some wild potato species possess a high degree of non-acclimated frost tolerance (growing in normal conditions) as well as high cold acclimation capacity (able to increase frost tolerance upon exposure to cold). Natural frosts affecting potatoes are of two types: a) late spring or early fall frost, where the minimum temperature during the frost episode can be very low; b) frost during the growing season, where the minimum temperature during the frost episode is

not as low. It is expected that potato species able to acclimate rapidly would survive better from the latter type of frosts, whereas species having higher acclimation capacity might have a great chance to survive better from the former type of frosts. The objective of this study was to find out if there is genetic variability for the speed of acclimation among different tuber-bearing wild potato species. The species used were: *S. acaule*, *S. commersonii*, *S. megistacrolobum*, *S. multidissectum*, *S. polytrichon*, *S. sanctae-rosae*, and *S. toralapanum*. Relative freezing tolerance of these species was measured during cold acclimation. Preliminary results suggest that there are differences in the speed of acclimation among these species. We found that these species can be divided into four groups: i) non-acclimators; ii) rapid acclimators, with low to medium acclimation capacity; iii) slow acclimators, with low to medium acclimation capacity; iv) slow acclimators, with high acclimation capacity. We plan to use this information in our breeding program aimed at improving the freezing tolerance of potatoes.

73 ORAL SESSION 22 (Abstr. 175–182) Seedling Establishment/Vegetables

175

The Effects of Mechanical Conditioning on Tomato Transplant Growth and Field Performance

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Stretching is a problem in high-density transplant production. Mechanical conditioning provides good height control for many crops, but information concerning the dosage and timing of stimulation, and possible effects on field performance are necessary for successful commercial implementation. Mechanical conditioning was applied to processing tomatoes (' Ohio 8245') grown in #288-deep flats (≈2000 plants/m^2). Brushing was applied by daily gentle stroking of the plant canopy with a Styrofoam planter flat. The appropriate dose as determined by stroking 0, 10, 20, or 40 times daily back and forth. Twenty strokes provided sufficient height control with minimal plant damage. The interval between strokes was also varied, using 0.6 6, 60, or 600 s. These intervals were all equally effective in reducing the growth rate of the canopy. This broad range provides flexibility in commercial use of this technique. To test for effects on field performance, two methods of conditioning were used: brushing and impedance. Brushing was 20 continuous strokes daily. The impeded plant canopy was compressed slightly by a piece of Plexiglas suspended overnight. The treatments were applied from canopy closure until transplanting to the field. At transplanting, brushed and impeded plants were significantly shorter than control plants without a reduction in shoot dry weight. The treatments did not affect the speed at which the plants grew in the field. Within 5 weeks after transplanting, there were no significant differences between treatments in any measured parameter, including final yield. Therefore, both brushing and impedance provide a flexible and effective method for controlling tomato transplant height without adversely affecting establishment or yield.

176

Matriconditioning Integrated with GA to Hasten Seed Germination and Improve Stand Establishment of Pepper and Tomato

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Emergence and stand establishment of pepper and tomato seeds often are slow and erratic, particularly under stress conditions. Field emergence trials sometimes have not responded to priming in pepper. In this study, we examined the combining effect of matriconditioning with GA_{4+7} to hasten germination and improve stand establishment of pepper and tomato seeds. The results showed that, in all cases, even under stressful conditions, the combined matriconditioning plus GA treatment was effective in improving germination and emergence of pepper and tomato seeds. Emergence was improved in 20% when seeds were treated with GA_{4+7} up to 200 mM. Thus, matriconditioning during which germination is suspended, provides a unique means to rapidly and efficiently digest the endosperm by GA-induced enzymes and reduce not only the mechanical restraints but also provide the energy for embryo growth.

177

Efficiency of Nitrogen Assimilation in Tomato Seedlings as Affected by Nitrogen Regime and Photoperiod

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Excessive nitrogen can be detrimental to transplant quality when supplied during the period of suboptimal photoperiod conditions. This investigation was made to determine the relationship between nitrogen and photoperiod on the growth rate of the transplants. The growth analysis included the determination of the net assimilation rate (NAR) and the nitrogen productivity (NP). 'Camone' tomato (*Lycopersicon esculentum* Mill.) seedlings were grown in the greenhouse under two photoperiods 8 and 12 h) at a constant light intensity and fertilized with three different N concentrations (8, 15, and 30 mmol·liter^{-1}) applied four times. Longer photoperiods enhanced plant growth by increasing the internode, LAR, SLA, and SWR. Root fresh weight, dry weight, stem dry matter, NAR, and RWR were minimal when 30 mmol·liter^{-1} N concentration was supplied, while LAR and SLA were at their maximum level. The interaction between N and photoperiod was significant. Increasing N supply during an 8-h photoperiod decreased growth. During a 12-h photoperiod, 15 mmol·liter^{-1} was the optimum N concentration for fresh growth and 8 mmol·liter^{-1} for shoot dry growth. The RGR had the lowest value, with 30 mmol·liter^{-1} N and 8-h photoperiod. PNC was highest when plants received 30 mmol·liter^{-1} N during an 8-h photoperiod, and when the plants received 15 and 30 mmol·liter^{-1} N during the 8-h photoperiod. LNC doubled in plants fertilized with 30 mmol·liter^{-1} N compared to those with 8 mmol·liter^{-1} when grown under a 12-h photoperiod. The NP was at the maximum in plants fertilized with 8 mmol·liter^{-1} N at the 12-h photoperiod. The lowest NP values occurred when plants were fertilized with 30 mmol·liter^{-1} N. When photoperiod is a limiting factor in growing seedlings, N supply must be limited to optimize the efficiency of its utilization by the plant.

178

Evaluating the Impact of Transplanting Depth on Tomato Yield

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Tomato transplants when planted to the cotyledon leaves, or to the first true leaf, yielded more than transplants set to the top of the root ball. Yield increase appears to be a function of increased extra-large fruit number, which suggests advanced maturity. Results held across four widely separated geographic locations for both spring and fall plantings. These data suggest that planting tomato transplants deeper is commercially beneficial in Florida.

179

Nitrogen Fertilization Effects on Growth, Yield, and Quality of Lettuce (*Lactuca sativa*) Transplants

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'South Bay' lettuce transplants were grown in F392A styrofoam Speedling® flats at different levels of N to evaluate the effect of N on transplant quality and subsequent yield and head quality in the field. Plants were irrigated eight times over a 4-week growing period by floating flats for 30 min in nutrient solution containing eight 0, 15, 39, 45, or 60 mg·liter^{-1} N supplied from NH4NO3. Dry shoot mass, leaf area, and plant height increased linearly with increasing N rates and dry root mass and stem diameter increased in a quadratic fashion. Transplants with the greatest plant biomass were, therefore, produced with 60 mg·liter^{-1} N. Plants from the 15, 30, 45 and 60 mg·liter^{-1} N treatments were planted in sandy soil in plastic-mulched beds under drip irrigation. To optimize lettuce head maturity among the treatments, plants from the N treatments were harvest 53, 56, and 59 days after transplanting (DAT). The optimum time to harvest was determined to be 56 DAT. There was no yield response (measured in terms of head mass) or quality response (measured in terms of head height, head diameter, head compactness or core length) to N applied during transplant production. This indicated that transplants produced with 15 mg·liter^{-1} N gave equally good yield to those produced with 30, 45, or 60 mg·liter^{-1} N when N was applied via flotation irrigation.

180

Thermotolerance in Lettuce

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Lettuce seeds differentially fail to germinate at temperatures above 21C according to genotype. Twenty-one lettuce lines were screened for their ability to germinate at temperatures from 24C to 36C. Four cultivars, 'Dark Green Boston', 'Valmaine', 'Floricos 83', and 'PI251245', were selected for this study because of their range of ability to germinate at temperatures above 24C. Seeds of the four cultivars were collected from mother plants grown in growth chambers at 20/10C(day/night temperature), 25/15C, 30/20C and 35/25C. Seeds were germinated on a thermogradient table from 24C to 36C under light (12 h). Seeds from 'Floricos 83' produced above 30C had higher germination percentage at 33C and 36C than those produced below 30C temperatures. At 30C germination temperature seeds of 'Valmaine' produced above 30C had 98% germination compared to 45% of those produced below 30C. 'Dark Green Boston' seeds produced at 35C had higher germination percentage(70%) at 30C than those produced at other temperatures. Seeds collected from the mother plant grown above 30C day temperatures had greater germination than those grown below 30C.

181

Preventing Thermodormancy in Lettuce Seeds by Fluridone Treatment

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Fluridone (FL), a catotenoid biosynthesis inhibitory herbicide, prevented supraoptimal temperatures from inducing thermodormancy in seeds and permitted seedling emergence in several lettuce cultivars. A 48-h dark soak at 35C with 23 µM FL completely prevented the induction of thermodormancy in 'Mesa 659' and 'Emperor' lettuce seeds as more than 90% of the seeds germinated on transfer to water in darkness at 25C. Abscisic acid (100 µM) applied with FL did not prevent FL from acting. Dormancy was released completely in the naturally dormant 'Garnet' and 'Grand Rapids' lettuce seeds at 25C in darkness by 1 µM FL. FL applied following thermodormancy induction at 35C in 'Mesa 659' lettuce seeds had little effect on releasing the induced dormancy. A 2-h presoak of 'Mesa 659' lettuce seeds with 0.47 µM FL followed by washing, drying, and sowing in a peatlite mix at 25C/35C (12 h/12 h), permitted 80% seedling emergence. Higher concentrations resulted in the emergence of albino seedlings. Similar results were obtained with seeds of other lettuce cultivars ('Prizehead', 'Emperor', 'Ithaca', and 'Empress'). A 6-h matriconditioning (MC) (A.A. Khan, Hort. Rev. 13:131–181, 92) of 'Mesa 659' lettuce seeds in 7.5 µM FL enhanced the emergence to a greater extent than by MC alone at 25C/35C. The FL procedure in alleviating high-temperature stress in lettuce and other seeds is being tested further.

182

Seed Coat Permeability Influences Sinapine Leakage from Non-germinable *Brassica* Seeds

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Sinapine leakage to detect seed germination potential on a single-seed basis in *Brassica* has been developed as a rapid test. In this test, sinapine leakage predicts that a seed is non-germinable; however, the major source of errors in this method are false-negative (F–)—i.e., the method predicted a seed was germinable because the seed did not leak, and it did not germinate. The sinapine leakage index (SLI) was used to asses the F– for any seed lot by dividing the number of non-germinable seeds that leaked sinapine by the total number of non-germinable seeds. Seed lots including cabbage, cauliflower, and broccoli (*B. oleracea* L., Captitata, Botrytis, and Italica groups, respectively) were used to examine the F–. The leakage rate as measured by T_{50}, the time for 50% of heat-killed seeds to leak, was linearly correlated to SLI. Cabbage seeds were viewed by scanning electronic microscopy and leaking non-germinable seeds either had cracks or were shrunken. NaOCl pretreatment has been found to increase the rate of sinapine leakage and SLI. The mode of NaOCl was due to high pH altering the seed coat permeability. Chemical analysis was conducted on isolated seed coats for pectin, tannins, hemicellulose, cellulose, phenolic lignin, and cutin. It was found that the higher SLI (more permeable) lots contained lower amounts of cutin, suggesting that cutin may restrict the diffusion of sinapine through the testa.

84 ORAL SESSION 23 (Abstr. 183–190) Breeding/Floriculture & Ornamentals

183

'Florida Calypso': A Multicolored Caladium for the Landscape and Containers

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Caladiums, grown for the colorful foliage in containers and the landscape, are the major floricultural tuber crop grown in Florida. They are planted for their variety of leaf colors, shapes, color patterns, and their ability to grow in areas of reduced light and high temperatures. 'Florida Calypso' (FC), a fancy leaf caladium with dark-red central venation and rose and white blotches, was released by the Univ. of Florida in 1995. It is in the same color classification as 'Carolyn Whorton' (CW), a top-selling rose/pink cultivar. When grown with on de-eyed 6.5-cm-diameter tuber per 10-cm pot, FC was 33 cm tall, produced five leaves within 33.4 days from planting, and had 33.6 leaves after 8 weeks, compared to 42.9 cm, 48.2 days, and 11.0 leaves, respectively, of CW. When grown in the field for tuber production, FC produced larger tubers, had a greater total tuber yield by weight, and had a higher production index than CW. Tuber yields of FC were not significantly different than 'Candidum', the cultivar produced most in Florida. 'Florida Calypso' can be grown in heavily shaded areas or in full sun in the landscape and in 10- to 40-cm containers.

184

DNA Amplification Fingerprinting (DAF) Identifies Closely Related Cultivars in Six Series of Chrysanthemum

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The genetic distance of closely related cultivars of *Dendranthema grandiflora* (chrysanthemum) was assess using DAF. Twenty-three cultivars of chrysanthemum included in the study were members of the following series: Anne (3), Blush (3), Boaldi (4), Charm (5), Davis (4), and Pomona (4). The genetic variability within and between series were evaluated using 11 arbitrary octamer primers. A few polymorphic loci were evident that uniquely identified closely related cultivars within a series. In contrast, many polymorphisms were observed between members of different series. Genetic distances between cultivars within and between series were evaluated using marker comparison and analyzed with PAUP (phylogenic analysis using parsimony) and UPGMA (unweighted pair group cluster analysis using arithmetic means). The average distance between series was 10-fold greater than between cultivars within a series. Furthermore, series with similar flower morphology, pompon or daisy-like, were more closely related than those with different phenotypes. DNA from all cultivars belonging to a series were also bulked to generate DNA profiles containing unique amplified products for each series. Polymorphic loci that were generated by the DAF technique can possibly be used for patent protection and phylogenetic studies, and may be useful in breeding chrysanthemums.

185

Molecular Phylogeny and DNA Amplification Fingerprinting of Petunia

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Seed of five species of petunia and 10 cultivars of *Petunia* x*hybrida* were obtained from several sources and plants were fingerprinted using DNA amplification fingerprinting (DAF). Within some species, variable fingerprints were generated between individual plants from the same seed source and/or different sources. Consistencies were found among DAF profiles by bulking the leaf tissue from 10 different plants, but not five plants. Each of 10 octamer primers used during the study revealed polymorphic loci between the species and cultivars. Among the 201 bands produced, 146 (73%) loci were polymorphic and these could be used to distinguish between each of the species and cultivars. Scoring for presence and absence of the amplified bands was used to generate a phylogenetic tree and to calculate the pairwise distances between each of the taxa using parsimony (PAUP) analysis. The tree generated using DAF molecular markers

separated *P. axillaris* from *P. parodii* (two white-flowered species), and distinguished between the violet-flowered species, *P, inflata*, *P. integrifolia*, and *P. violacea*.

186

Colchicine-induced Amphidiploids of Rose Interspecific Hybrids

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An objective of our rose breeding research is to transfer resistance to blackspot and other diseases from wild diploid species to modern rose cultivars. Interspecific hybrids among blackspot-resistant diploid species were chosen for chromosome doubling to produce fertile amphidiploids that could be hybridized to the tetraploid commercial germplasm. Five such F_1 interspecific hybrids were treated with colchicine. The study included two different application procedures (shake in colchicine solution or colchicine in media), four colchicine concentrations (0.05%, 0.1%, 0.15%, and 0.20%), and five treatment periods (1, 3, 5, 8, and 10 days). After colchicine treatment, all the materials were cultured in vitro. One thousand-thirty-seven surviving explants were selected for typical "gigas" characteristics of doubled diploids. Chromosome counts on shoot tips of these selected genotypes confirmed 15 amphidiploids. The best colchicine treatment varied among the interspecific hybrids. Higher colchicine concentrations or duration reduced growth rating, rooting, and percent survival. The recognition of amphiploids and ploidy chimeras from young seedlings will also be discussed.

187

Amphidiploids as a Source of Blackspot Resistance in Rose Germplasm Development

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Extensive field screening of rose (*Rosa* spp.) germplasm at two sites in Texas has determined that most modern roses are susceptible to blackspot [*Diplocarpon rosae* (Lib.) Wolf]. Fortunately, there is a high level of resistance in a number of diploid rose species, such as *Rosa laevigata*, *R. ganksiae*, *R. rugosa*, *R. wichuraiana*, and *R. roxburghii*. These species were used to create three amphidiploids: 84-1000 (*R. roxburghii* x *R. laevigata*), 86-3 (*R. banksiae* x *R. laevigata*), and 86-7 (*R. wichuraiana* x *R. rugosa rubra*). These were examined for fertility to determine their usefulness in a breeding program. 86-7 had the most abundant pollen production and the greatest pollen fertility, as measured by hip set (38%), followed by 86-3 (19%), and 84-1000 (13%). The female fertility of 86-3 and 84-1000 is low, and 86-7 is female-sterile. Although 86-7 showed poor female fertility, F_1 hybrids exhibited a wide range of fertility, indicating that the fertility of this germplasm can be quickly increased in subsequent generations.

189

Protected/Unprotected Study of Blackspot Resistance in Rose

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Five commercial cultivars and one species of rose were evaluated in a field trial for resistance to blackspot caused by *Marssonina rosae*. The trial was set up as a split-plot with two treatments. Each subplot was either protected on a weekly basis with a fungicide application to control blackspot or left to progress naturally with the disease. The trial was evaluated for blackspot resistance and for growth characteristics. Only the one species, *Rosa roxburghii*, was disease-free in both situations. Two cultivars, Peace and Sunflare, were the least resistant. They averaged 65% defoliation and a 50% infection rating. This corresponded to a 50% reduction in height and a 90% reduction in fresh weight of the plant. 'Red Radiance' had ≈20% less defoliation than the two above cultivars, which was reflected by a 20% increase in growth. 'Old Blush' had a higher resistance rating, but its propensity to quickly drop its foliage upon infection left it with a similar growth reduction as 'Red Radiance'. 'Carefree Wonder' was the most-resistant commercial cultivar. It had only a 43% decrease in fresh weight. 'Red Radiance' and 'Carefree Wonder' both displayed much greater defoliation during December, whereas the other susceptible cultivars showed the same degree of defoliation as earlier in the season.

190

Breeding for Drought Tolerance in New Guinea Impatiens

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Six commercial cultivars (Anna, Aurore, Danhill, Danlight, Melanie, and Thelca), one drought-tolerant cultivar (Orangeade), nine breeding selections, and one check genotype of *Impatiens hawkeri* Bull were evaluated for differences in drought tolerance based on water loss and time to wilt. The six commercially available cultivars had significantly higher mean water loss than the breeding selections and 'Orangeade'. These cultivars wilted in 5.11 days vs. 7.33 for 'Orangeade' and 9.10 for the breeding selections. These results suggests that sufficient variability exists in New Guinea impatiens germplasm for the reduction of water loss to improve drought tolerance. Regression analysis revealed that total transpirational water loss 96 h after withholding water was an excellent predictor of the time to wilting (a simple measure of drought tolerance) after water was withheld (R^2 = 0.95). Thus, a simple, efficient, and objective method for selection of drought-tolerant genotypes has been developed for New Guinea impatiens. A comparison of offspring to parental genotypes showed that, after only one cycle of selection, water loss was significantly reduced by more than 30%. These results suggest that there is sufficient genetic variability present for the development of more drought-tolerant cultivars.

85 ORAL SESSION 24 (Abstr. 191–198) Photosynthesis/Vegetables & Fruit

191

Effects of Continuous Lighting and Light Spectral Composition on Photosynthesis and Related Processes of Greenhouse-grown Tomato and Pepper Plants

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Growing tomato and pepper plants under continuous light causes negative effects such as leaf chlorosis and deformities, and decreased growth and yield. Such effects are more pronounced on tomato plants. Our general objectives are to identify the physiological process(es) responsible for these negative effects and to explain the difference in sensitivity of tomato and pepper plants to continuous light. The specific objective of this experiment was to determine the effects of continuous light and light spectral composition on photosynthesis and related processes of tomato and pepper plants. Tomato and pepper plants were place on 7 June 1994 in growth chambers under photoperiod treatments of 12 h [high-pressure sodium (HPS) lamps], 24 h (HPS lamps), and 24 h [metal halide (MH) lamps]. For all treatments, FPP was 350 $\mu mol \cdot m^{-2} \cdot s^{-1}$, temperatures were 21C (day) and 17C (night), and RH was 70%. Every 2 weeks (7 June until 2 Aug.), tomato and pepper leaf samples were harvested and frozen in liquid nitrogen for subsequent measurements of starch content (Robinson et al, 1988, Plant Physiol.), sucrose phosphate synthase activities (Dali et al., 1992, Plant Physiol.) and chlorophyll and carotenoid content (determination on HPLC). A system that measured gas exchange and chlorophyll fluorescence of fresh leaf samples was used to determine the photosynthetic rate and quantum yield of CO_2 fixation and electron transport. Development of the negative effects of continuous light on plants was monitored. Light spectral composition of the two types of lamps was measured using a spectroradiometer. Results show that, under continuous light, pepper plants were less-efficient than tomato plants in using light for CO_2 fixation, but were more efficient in dissipating the extra energy received. This may explain why pepper plants are less sensitive to continuous light than tomato plants. MH lamps caused more-severe chloroses on tomato leaves than HPS plants. We believe that the higher proportion of UV-light provided by MH lamps may be related to this effect. Detailed results will be presented.

192

Impact of Mites and Miticides on the Photosynthetic Biology of Strawberry and Red Raspberry Leaves

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Limited twospotted spider mite feeding significantly reduced the CO_2 assimilation rate of red raspberry leaves and damaged the photosynthetic apparatus prior to visible damage to the leaf. The impact of miticides on the photosynthetic biology of raspberry and strawberry leaves was tested in growth chambers, greenhouses, and the field, with similar results across environments. In general, miticides appear to reduce the photosynthetic capacity of the leaves for 10 to 14 days, with reductions of ≈30% occurring within the first several days. Chlorophyll fluorescence and fourth-derivative spectroscopy of intact leaf lamina showed changes in the structure and function of the photosynthetic apparatus in response to chemical treatment. High temperature reduced physiological processes in strawberry plants grown at two diurnal regimes (30/24C, 21/15C); however, the relative degree of reduction in photosynthetic activity due to miticide application was similar for both. A preliminary screening of mite-resistant and -susceptible red raspberry genotypes after prolonged infestation suggested varying levels of physiological tolerance of mite damage, which are not well-correlated with visual appearance.

193

Effect of Fruiting on Net CO_2 Assimilation Rates of Peach and Nectarine Trees

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Growth of peach fruits is characterized by a double-sigmoid curve; two periods of rapid enlargement (stages I and III) separated by a lag phase (stage II). Seasonal net CO_2 assimilation rates (NAR) were compared in leaves from fruiting and non-fruiting (deblossomed) trees of 'Harrow Diamond' (early), and 'Vivid' (mid-summer) peach (*Prunus persica* L. Batsch.) and 'Fantasia' (late) nectarine (*P. persica*) to determine 1) the influence of fruits on photosynthesis and 2) the relationship between NAR and fruit growth. Seasonal trends in NAR tended to be qualitatively similar among the three cultivars, despite genotypic and phenotypic differences. There was a distinct increase in NAR at the time of horticultural fruit maturity (stage III) of each cultivar. Shortly after harvest, NAR rates declined. The average seasonal NAR of fruiting 'Harrow Diamond', 'Vivid', and 'Fantasia' trees was 9%, 11%, and 10% higher, respectively, than that of corresponding nonfruiting trees. Parallel data for total chlorophyll was 28%, 20%, and 19% higher, and specific leaf weight (SLW) was 3%, 5%, and 6% lower, respectively. A negative correlation between NAR and SLW may indicate a feedback inhibition of photosynthesis.

194

Carbon Partitioning as Affected by Shoot Type and Light Exposure in Peach

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Carbon partitioning and translocation in 1-year-old fruiting limbs of the peach cultivar Elegant Lady was studied, as affected by source [leaves on actively growing extension shoots (EXT), or on lateral shoots emerging from nodes with (F) or without (NF) fruit], five times during the season [2, 4, 7, 11, 17 weeks after full bloom (WAFB)]. Growing shoot apices were the strongest sinks early in the season (2 WAFB), with the EXT apices capable of attracting more C, and over longer distances, than the NF or F ones. The major source of newly synthesized carbohydrates for fruit growth 2 WAFB was the F lateral shoot; i.e., the most-important C contributor for fruit growth well into stage II (11 WAFB in this study). EXT shoots began contributing to fruit growth before the NF ones: 4 WAFB on, they exported to the fruit in amounts similar to the F shoots. This contribution was even larger 17 WAFB, when the F shoots retained more C than the other two shoot types. The NF shoots exported to the growing apices 2 WAFB, but this export decreased 4, 7, and 11 WAFB, compared to the other treatments. Seventeen WAFB, they contributed to fruit growth in the same amounts as the EXT shoots, and more than the F ones. Shade did not consistently affect patterns of carbon partitioning within limb components, except for the F treatment, where it diminished C export to the fruit in the first four treatment dates. Partitioning within fruit components (mesocarp, endocarp, and seed) followed the fruit growth curve, with more C allocated to endocarp tissues at 11 WAFB (stage II).

195

Carbon Partitioning in Primocane-fruiting Red Raspberry as Influenced by Groundcover and Supplementary Irrigation

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Field experiments consisting of trickle irrigation (TI), IRT-76 plastic film (PF), and straw mulch were initiated to determine the influence of soil temperature and water status on carbon partitioning during the establishment of *Rubus idaeus* L. 'Heritage' (1993, 1994), 'Autumn Bliss' (1994), and 'Summit' (1994) micropropagated raspberries. Environmental, vegetative, reproductive, and nutrition data were collected. Photosynthesis (Pn) measurements were recorded under field conditions using a Li-Cor LI-6200 portable photosynthesis system. Neither node number nor shoot : root ratio was influenced by TI, PF, or straw mulch. PF, however, increased root and shoot weight, total flowers produced, total berries harvested, and foliar N and P. Although differences existed among cultivars, field Pn measurements indicated that, regardless of groundcover treatment or cultivar examined, the maximum Pn rate occurred at a root-zone temperature of 25C. Hence, results from this study indicate that conditions in both the air and root zone physical environment regulate carbon assimilation and partitioning.

196

An Inexpensive, Whole-plant, Open Gas-exchange System for the Measurement of Photosynthesis in Potted Woody Plants

David P. Miller, G. Stanley Howell,* and *James A. Flore*, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824.

The measurement of whole-plant CO_2 uptake integrates leaf-to-leaf variability, which arises from such sources as angle of incident radiation, source/sink relationships, age, and biotic or abiotic factors. Respiration of above-ground vegetative and reproductive sinks is also integrated into the final determination of whole-plant CO_2 assimilation. While estimates of whole-plant CO_2 uptake based on single-leaf determinations have been used, they do not accurately reflect actual whole-plant assimilation. Chambers were constructed to measure gas exchange of entire potted grapevines. The design and construction are simple, inexpensive, and easy to use, allowing for the measurement of many plants in a relatively short time. This enables the researcher to make replicated comparisons of the whole-plant CO_2 assimilation of various treatments throughout the growing season. While CO_2 measurement was the focus of this project, it is also possible to measure whole-plant transpiration with this system.

197

Simulating Biotic Stress with Terbacil on Apple

*J. A. Flore** and *Edgardo Disegna*, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824.

Terbacil an inhibitor of photosynthesis was applied to 10-year-old 'Redchief' apple trees in the field carrying a heavy or light fruit crop,or to trees in pots. This simulated the effect of photosynthetic inhibition (PN-I) by either biotic or abiotic stress. Current as well as the next season's crop and physiology were determined. The magnitude and duration of photosynthetic inhibition was dose-dependent. A concentration of 63 mg·liter^{-1} was applied at 15-day intervals from bloom through harvest. Photosynthesis was in inhibited by 50% to 80% within 24 h of application, but recovered to control levels 10 to 14 days later. Terbacil at 15 and 30 DAFB induced fruit abscission, but not at later dates. The earlier the application the greater the effect on current seasons yield and fruit size. There was also a significant interaction with crop load. There were no significant effects on fruit soluble solids, fruit firmness, fruit density, or fruit color at harvest. Terbacil did not affect cold acclimation, deep winter hardiness, or deacclimation. Pn inhibition at 30, 60, 80, and 100 DAFB reduced return bloom.

198

Crop Load Effects on Irrigated and Non-irrigated *Vitis vinifera* L. cv. Thompson Seedless

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A study was conducted to determine the effects of crop removal on gas exchange parameters of 'Thompson Seedless' grapevines grown in the San Joaquin Valley of California. Vines were either irrigated at full ET or not irrigated throughout the growing season. Clusters were removed subsequent to veraison, when the fruit soluble solids were ≈15°Brix. Reductions in leaf net CO_2 assimilation rate (A) were measured within 1 day of fruit removal for both irrigation treatments

and remained such until the end of the experiment. The greatest reduction in A due to crop removal on a diurnal basis was with the non-irrigated vines between 0800 and 1000 HR. The reduction in A subsequent to crop removal was not the result of an accumulation of either starch or sugars in leaf tissue. The greater reduction in A of non-irrigated vines after fruit removal may have been due to the lack of strong, alternate sinks as vegetative growth was minimal due to water stress during the experimental period.

86 ORAL SESSION 25 (Abstr. 199–204) Stress Physiology (General)/Fruits & Nuts

199

Physiological Basis for the Interaction of Mite and Crop Load on 'Starkrimson Red Delicious' Apple Trees

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Most research on the effects of European red mite (ERM) [*Panonychus umlli*(Koch)] on apples has shown highly variable results. Those variations were probably due to different genotypes, internal status of the tree (e.g., crop load), environment and timing and severity of mite stress. We propose that limitations in carbon availability for fruit growth is the primary mechanism of foliar feeder injury to apple trees. Heavy-cropping tress should be more sensitive to ERM stress than low-cropping trees and differences in responses of apple trees should be better-related to carbon supply/demand than to cumulative mite-days (CMD) along. Eighteen mature 'Starkrimson Red Delicious'/M26 trees were hand-thinned to low (≈20 $t \cdot ha^{-1}$) and high (≈40 $t \cdot ha^{-1}$) crop loads and submitted to low (<400 CMD), medium (400–1000 CMD), and high (>1000 CMD) target levels of ERM. A range of crop loads and CMDs was obtained. Mite population, fruit growth, single-leaf photosynthesis, and whole-tree gas exchange were monitored through the season. ERM reduced leaf and whole-tree net CO_2 exchange (Pn). Heavy-cropping trees showed fruit weight reduction earlier and more severely than low-cropping trees with high ERM injury. The main effect, variations in final fruit weight, was much better related to whole-tree Pn/tree than to CMD.

200

Changes in Water Relation Parameters in Leaves of Olive (*Olea europaea* L.) during Salinity Stress and Relief

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Water relation parameters were calculated from analysis of 92 pressure-volume isotherms of leaves of two olive varieties, 'Leccino' and 'Frantoio', measured after 4 weeks of salinity stress and 4 weeks of subsequent relief either in hydroponics or soil culture. 'Frantoio' was more salt-tolerant than 'Leccino', but no major differences in water relation parameters emerged between the two varieties. Increasing salinity from 0 to 200 mM NaCl decreased predawn leaf water potential from –0.5 MPa to –1.3 MPa, relative water content (RWC) from 97.6% to 89%, and leaf osmotic potential (Ψ_π) from –2.0 to –3.5 MPa. Relative water content at turgor loss point (RWC_{tlp}) was decreased from 89% to 85% (soil culture) and from 86% to 80% (hydroponic culture) in 0 to 200 mM CaCl-treated plants, respectively; a lower RWC_{tlp} was also retained during the relief from salinity. Active osmotic adjustments induced by salinity was the result of accumulation of both inorganic ions and compatible solutes (e.g., mannitol). Maintenance of lower Ψ_π and RWC_{tlp} during relief indicated that salinized plants were better adapted to withstand further stress and that this potential might be exploited to harden olive plants to be used in arid or saline environments.

201

Nitrogen Leaching, Water, and Nitrogen Use Efficiency of Citrus Trees Fertilized at Three Rates of Nitrogen

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Effects of nitrogen (N) rate and rootstock on tree growth, fruit yield, evapotranspiration, N uptake, and N leaching were measured over a 2-year period. Four-year-old 'Redblush' grapefruit trees on either sour orange (SO), a relatively slow-growing rootstock, or 'Volkamer' lemon (VL), a more-vigorous rootstock, were transplanted into 7.9-m^3 drainage lysimeter tanks filled with native sand and fertilized at three N rates. N rates averaged from about 14% to 136% of the recommended rate when trees were 5 and 6 years old. More N leached below trees on SO as trees on VL had greater N uptake efficiency. Canopy volume and leaf N concentration increased with N rate, but rootstock had no effect on leaf N. Fruit yield of trees on SO was not affected by N rate, but high N increased water use and yield for larger trees on VL. Canopy growth or yield per volume of water used (water use efficiency) was lowest at low N, but N use efficiency was highest at the low N rates.

202

The Effect of Salinity on Growth and Physiology of 'Hass' Avocado on Three Rootstocks

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Salinity effects on 'Hass' avocado was studied on three rootstocks, 'Thomas' (TH), 'Toro Canyon' (TC), and 'Duke 7' (D7). Four levels of salinity (1.4, 3.0, 4.5, and 6.0 $dS \cdot m^{-1}$) were applied to 1-year-old trees grown in sand culture for 10 weeks. Increased salinity resulted in decreased trunk cross-sectional area and reduced shoot growth. Specific leaf area and dry weight decreased linearly with increased salinity. TH was significantly more affected than TC of D7. Leaf necrosis was also greatest in TH. Older leaves had the highest percentage of leaf necrosis, while younger leaves of TH exhibited symptoms only in the 6.0 $dS \cdot m^{-1}$ treatment. TH had the highest Cl leaf levels. TC maintained the lowest Na levels in the scion plant organs, indicating an ability to sequester Na in the rootstock. TC also had the lowest Na:K ratio in leaf tissue, indicating that TC can utilize K as an osmoticum. Predawn xylem potential decreased linearly with increased salinity in all rootstocks. Leaf osmotic potential decreased with increased salinity; however, leaf age moderated the response, indicating an adjustment to the stress. No rootstock differences were observed. Net CO_2 assimilation (A) decreased with time only in trees exposed to 4.5 or 6.0 $dS \cdot m^{-1}$. Reduction in A due to increased salinity was less in younger leaves. No rootstock differences were noted. Chlorophyll per leaf area decreased with increased salinity to the greatest degree in TH.

203

Leaf Gas-exchange and Ion Content of Papaya Plants Simultaneously Exposed to Salinity and Flooding

*Thomas E. Marler**, College of Agriculture & Life Sciences, Univ. of Guam, Mangilao, GU 96923.

A container study and a hydroponics study were conducted to determine gas-exchange and ion content of 'Cariflora' papaya plants as influenced by a combination of salinity and flooding. Plants grown in nutrient solution were subjected to 1 or 8 $dS \cdot m^{-1}$ as salinity treatments and 6.54, 3.62, or 0.92 mg oxygen/liter as the flooding treatments. Plants in the container study were subjected to 0, 4, or 8 $dS \cdot m^{-1}$ as salinity treatments, and half of the plants in each salinity level were flooded. Leaf gas-exchange began to decline by day 1 in all plants receiving flooding, and was zero by day 5. In contrast, gas-exchange of plants experiencing salinity began a slow decline after 5 to 7 days. Stomatal conductance of salinized plants was 25% to 33% of the control plants in the container study after 39 days. No interaction occurred between flooding and salinity treatments since the stomatal response to flooding was so rapid across all levels of salinity. Roots and stems played a major role in storing Na^+ and Cl^- in salinized plants. For example, stems contained more than two times the dry weight concentration of both ions as did leaves. Older leaves accumulated more Na^+ and Cl^- than did younger leaves. Flooding decreased Na^+ and Cl^- accumulation in roots, stems, and leaves in all salinized plants.

204

Effect of Root Zone Temperature on the Mineral Composition of Xylem Sap and Plasma Membrane K^+–Mg^{++}–ATPase Activity of Grafted Cucumber and Figleaf Gourd Root Systems

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Cucumber (*Cucumis sativus* L.) seedlings were grafted onto cucumber- (CG) or figleaf gourd (FG, *Cucurbita ficifolia* Bouche) seedlings in order to determine the effect of solution temperature 12, 22, and 32C) on the mineral composition of xylem sap and plasma membrane K^+–Mg^{++}–ATPase activities of the roots. Low solution temperature (12C) lowered the concentration NO_3^- and $H_2PO_4^-$ in xylem sap of CG plants, but not of FG plants. Concentrations of K^+, Ca^{++}, and Mg^{++} in

xylem sap were less affected than anions by solution temperature. The plasma membrane of FG plants grown in 12C solution temperature showed the highest K^+–Mg^{++}–ATPase activity at all ATP concentrations up to 3 mM and at low reaction temperature up to 12C, indicating resistance of figleaf gourd to low root temperature.

87 ORAL SESSION 26 (Abstr. 205–208) Growth & Development/Small Fruit & Viticulture

205

Yield and Dry Matter Partitioning of Strawberry Plants Grown with Three Preplant Soil Fumigation Treatments

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Three preplant soil fumigation treatments were applied to a strawberry fruit production field in Summer 1993: 1) a mixture of 67 methyl bromide : 33 chloropicrin (wt/wt, 392 kg·ha^{-1}) (MBC); 2) chloropicrin (trichloronitromethane, 336 kg·ha^{-1}) followed by metam sodium (935 liters·ha^{-1}) CMS); and 3) nonfumigation (NF). Bare-rooted 'Camarosa' strawberry plants were established in each treatment on 1 Nov. in annual hill culture. Plant mortality was <1%; thus, differences in growth and productivity among treatments were due to sublethal effects of competitive soil organisms. Fruit yields were recorded weekly from 14 Jan. to 23 May 1994. For the NF treatment, early season (January–March), late season (April–May), and total yields were 86%, 69%, and 72%, respectively, of those of the MBC treatment. Early season yields were greatest for the MBC treatment, but late and total yields were greatest for the CMS treatment. From Jan. through May 1994, 20 plants were destructively harvested from each treatment at about monthly intervals for determination of leaf (LDW), crown (CDW), and root dry weight (RDW). For a given date, LDW, CDW, and RDW of plants in the MBC and CMS treatments were greater than those of the NF plants. From January to March, plants in the NF treatment allocated a proportionally greater amount of dry matter to roots, and proportionally less dry matter to crowns and leaves than fumigated plants. In April and May, root : shoot ratios were similar for all three treatments. These data demonstrate the marked influence of soil fumigation treatment on yield and dry matter partitioning of strawberry, and suggest that combinations of chloropicrin and metam sodium may be a viable, albeit expensive, alternative to fumigation with methyl bromide.

206

High-speed Blown Air as a Source of Thigmic Stress: Effect of Physiology and Yield of Red Raspberry

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The effect of mechanical stress from sources such as wind on the physiology of higher plants has been documented in many species. Some of these reported changes, such as decreased photosynthetic activity, are not well-documented and bear closer examination. Mechanical stress has been reported to decrease the productivity of some crop plants. In both field and greenhouse trials, high-speed blown air was used as a thigmic stress for the temporary, nonchemical suppression of primocane growth in red raspberry. Field trials with the cultivar Meeker in 1993–94 have shown that high-speed blown air can be used to adequately control primocane height for mechanical harvest, while increasing yield through greater numbers of fruit per cane. In both field and greenhouse experiments, photosynthetic activity or red raspberry leaves was not affected by 273 km/h of wind applied twice daily, 5 days per week. Anatomical analysis demonstrated changes in the cross-sectional anatomy of mechanically stressed canes. Stressed canes had increased callose deposition and greater numbers of secondary xylem cells.

207

Influence of Floricane Number on Primocane Growth, Cold Hardiness, and Yield Components in 'Marion' (*Rubus* sp.) Blackberry

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In Spring 1993 and 1994, treatments of 0, 4, 8, and 12 floricanes per plant were established in a mature 'Marion' planting. Primocanes were measured weekly for the number and length of primocanes and primocane branches. Maximum hardiness of primocanes was determined in Jan. 1994 and 1995 by controlled freezing. Yield components were measured in both the current and following season. Additional plants were harvested in summer and winter for dry-weight partitioning. Plants with no floricanes had an increased number and length of primocanes and branches than plants with floricanes in 1993, with similar trends in 1994. Primocane growth on plants without floricanes showed a 65% increase in primocane dry weight in 1993. However, in 1994, there were no significant differences among treatments. Primocane branch dry weight generally increased with decreasing floricane number. The relationship between primocane growth and the following season's yield components will be presented.

208

Relationship of Winter Stage of 'Concord' Grapevine Buds, Previous Season, and Return Bloom

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Overwintering buds and internodes of *Vitis labruscana* 'Concord' were taken from minimal- (MP) and balance-pruned (BP) vines in Dec. 1993 and Dec. 1994 from canes whose weight, crop weight, total nodes, and nodes with periderm were known. Winter characters recorded were: node-5's primary bud basal area, total nodes, and developmental stage of cluster primordia; stage of largest cluster in the secondary bud; vascular area of cane internode 5. Fifty node-5 buds were tagged in each treatment and flower and fruit number per cluster later recorded. Regression analysis showed no effect of a shoot's crop, cane weight, node number, or nodes having periderm on any character measured in the overwintering buds or canes for either treatment. Regression analysis did show mean flower number per cluster was linearly related to mean winter stage per cluster in both treatments, with all values falling on one line. Differences between treatments were one of degree of cluster development; BP vines had more-developed winter and spring clusters and more flowers and fruit per shoot. The slope of the regression was identical the last 3 years, although the y intercept varied each year; thus, a given cluster stage in the overwintering bud was capable of producing a variable number of flowers the next season, depending on year. Flower number per shoot appeared positively related to growing-degree-days the previous season.

88 ORAL SESSION 27 (Abstr. 209–216) Postharvest Physiology/Apples

209

Aroma Volatile Production in Preharvest AVG-treated 'Golden Delicious' Apple Fruit and the Effect of Poststorage Ethylene Treatment

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Changes in the profile of aroma volatiles during ripening and after ethylene treatment in apple fruit have revealed a close relationship exists between ethylene production and the timing and magnitude of volatile synthesis. Therefore, AVG (ethylene biosynthesis inhibitor) was used to study the relationship between volatile biosynthesis and metabolic processes affected by ethylene in apple fruits. AVG-treated fruit were stored either for 1 month at 2C in air or 5 months in ULO condition. During the post-storage ripening, the fruits were exposed to 50 μl·liter^{-1} of ethylene at least 12 h/day. Aroma production was determined at 20C. Total volatile compound production by AVG-treated fruit was much lower than that of untreated fruit. A significant increase in the production of most aroma volatile after 1 month storage in air was induced by ethylene treatment to AVG-treated fruits. I

was noted that branched-chain volatile, such as 2-methylbutylacetate, which originates from branched-chain amino acids, has increased prior to butylacetate and hexylacetate, which are derived from fatty acids. Ethylene treatment was unable to stimulate the production of straight-chain volatile compounds following the 5 months of ULO storage. These results are consistent with observations suggesting apple fruit lose their sensitivity to ethylene after long ULO storage.

211

Chlorophyll Fluorescence as an Indicator of Low O_2 or High CO_2 Stress in Apples during Storage

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Chlorophyll fluorescence, measured using a Plant Productivity Fluorometer Model SF-20 (Richard Brancker Research, Ottawa, Ont.), was evaluated as a rapid and nondestructive technique to detect low O_2 and/or high CO_2 stress in apples during storage. 'Marshall' McIntosh apples were held for 5, 10, 15, 20, or 25 days at 3C in the following four treatments: standard O_2 (2.5% to 3%) and low CO_2 (<1%); low O_2 (1% to 1.5%) and low CO_2 (<1%); standard O_2 (2.5% to 3%) and standard CO_2 (4% to 4.5%); or standard O_2 (2.5% to 3%) and high CO_2 (11% to 12%). Only 10% of the apples had skin discoloration after 5 days in 1% to 1.5% O_2, while 80% developed skin discoloration after 20 days in low O_2. Small desiccated cavities in the cortex, associated with CO_2 injury, developed in 10% of the apples after 20 days in 11% to 12% CO_2. Both 1% to 1.5% O_2 and 11% to 12% CO_2 for 5 days caused chlorophyll fluorescence [Fv = (P – T)/P] of apple fruit to decrease, as compared to those held in standard atmospheres. Additional exposure time did not significantly affect Fv in either the low-O_2 (1% to 1.5%) or high-CO_2 (11% to 12%) treatment. The results of this study suggest that chlorophyll fluorescence can detect low-O_2 and high-CO_2 stress in apples, prior to the development of associated physiological disorders.

212

Effects of "Colormotor" on Anthocyanin Accumulation, Fruit Coloration, and Superficial Scald Susceptibility of 'Delicious' Apples

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"Colormotor" is a new product formulated mainly from seaweed extracts for promoting anthocyanin synthesis and improving fruit coloration in apples. The product was applied (150 ppm) 3 weeks before harvest in 2 years of experiments with 'Delicious' apples. Colormotor treatment promoted anthocyanin accumulation by 2.5-fold and increased color index of fruit by 50% over controls. Only 23.5% of control fruit had full red color when harvested 140 DAFB, whereas 80% of the fruit sprayed with Colormotor had full red color. UDPG-o-3-glucosyltransferaw activity also was significantly greater in treated fruit. Treatment did not affect ethylene synthesis, fruit firmness, soluble solids, total sugars, or titratable acid incidence either at harvest or during prolonged storage. However, scald incidence after 20 weeks at 0C was significantly decreased by Colormotor treatment. The scald scores were 1.59 in control fruit and 0.67 in treated fruit, respectively, on a scale of 1 to 4.

213

Elevated CO_2 and/or Low O_2 Atmospheres Influence ACC Synthase and ACC Oxidase during Long-term Storage of 'Golden Delicious' Apple Fruit

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The objective of this study was to compare and contrast the mode of action by which elevated carbon dioxide and/or reduced oxygen atmospheres inhibit ethylene biosynthesis. 'Golden Delicious' apple fruit were placed at 0C in one of the following four atmospheres: 1) air; 2) air + 5% CO_2; 3) 2% O_2 + 98% N_2; or 4) 2% O_2 + 5% CO_2 + 93% N_2 and then sampled monthly for 4 months. Ethylene biosynthesis rates and in vitro ACC synthase activities were closely correlated in all treatments. In vitro ACC synthase activity and ethylene biosynthesis rates were lowest in fruit treated with 5% CO_2 + 2% O_2, while air-treated fruit had the highest ethylene biosynthesis rate and in vitro ACC synthase activity. Fruit treated with air + 5% CO_2, or 2% O_2 + 98% N_2, had intermediate ethylene and in vitro ACC synthase activities. In vitro ACC oxidase was significantly different among treatments, but not as closely correlated with the ethylene biosynthesis rate as in vitro ACC synthase activity. Western blot analysis of the ACC oxidase protein was performed to determine if activity differences among treatments were correlated with the amount of enzyme present in vivo. ACC synthase and ACC oxidase mRNA transcript of abundance was determined via Northern blot analysis. Results will be discussed regarding how ethylene biosynthesis is inhibited at the molecular level by elevated CO_2 and/or reduced O_2.

214

Lipid Changes during Heat Treatment of Apple Fruit

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Postharvest heat treatment of apples maintains fruit firmness and reduces decay during storage. Four days at 38C are beneficial, but 1 or 2 days are detrimental. The cellular basis of these effects may involve changes in cell wall and membrane lipid metabolism. Lipids from hypodermal tissue of 'Golden Delicious' apples were analyzed after 0, 1, 2, or 4 days at 38C. Major lipids included phospholipids (PL), free sterols (FS), steryl glycosides (SG), and cerebrosides (CB). Galactolipids (GL) were minor components. PL content fell ?10% after 1 day at 38C, was unchanged after 2 days, and began to rise again after 4 days. PL class composition did not change with heating, but fatty-acid unsaturation declined throughout. FS and CB content and composition changed little, whereas SG content cropped by ≈20% over 4 days. GL fell ≈50% during 1 day at 38C, with no change at days 2 or 4. A burst of PL catabolism followed by recovery of synthesis may in part explain the different effects of 1-, 2-, or 4-day heat treatments. GL loss (in plastids) may be related to the effect of heat on fruit color (yellowing).

215

Superficial Scald Development on Apples at Chilling and Nonchilling Temperatures

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'Cortland' and 'Delicious' apples were stored at 0C for up to 25 weeks, and at 20C in either open boxes or non-sealed poly bags for up to 8 weeks. At 20C, lesions occurred mostly around lenticels, but with some calyx bronzing and scald-like symptoms on shaded areas. At 0C, typical scald symptoms occurred. At both temperatures, high concentrations of alpha-farnesene and conjugated trienes occurred in conjunction with symptom appearance, and both these concentrations and discolorations decreased with later harvest of fruit. Scald development appeared to be chilling-enhanced, but not chilling-dependent.

216

Effect of Storage Humidity and Post-storage Handling Temperature on Bruising of CA-stored 'McIntosh' Apples

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In a 2-year study, 'McIntosh' apples were stored in a CA regime of 4.5% CO_2 + 2.5% O_2. Within the CA cabinets there were three humidity levels: >75% RH ($CaCl_2$ salt in the chamber), >90% RH (ambient), or >95% RH (distilled water in the chamber). After removal at 4 and 8 months, the fruit were warmed to handling temperatures of 0C, 10C, or 20C and subjected to three levels of impact bruising of 0, 10, or 20 lb with a Ballauf pressure tester with a 1.5 x 1.5-cm tip. The results showed that low-humidity CA storage decreased visible bruising. Although visible shrivel was not observed, the low-humidity treatment may increase the possibility of its occurrence. Respiration, measured as O_2 consumption or CO_2 production immediately after removal from CA storage, was lowest in low humidity (>75% RH) and highest in ambient humidity (>90% RH) CA storage. The humidity treatments did not affect firmness, soluble solids, titratable acids, or ethylene production. Increasing the temperature during post-storage handling decreased the amount of visible bruising without affecting other variates such as firmness, soluble solids, titratable acids, respiration, or ethylene production.

100 ORAL SESSION 28 (Abstr. 217–222) Biotechnology/Cross-commodity

217

Studies on DNA Polymorphism of Silver Maple (*Acer saccharinum* L.)

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Silver maple has great potential as a biomass feedstock. We compared three clones from each of seven provenances located on east to west and north to south transects across the natural range of silver maple and one red maple. DNA extracted by a modification of the CTAB technique (Murray and Thompson, 1980) was not suitable for RAPD analysis. Using this technique, polymorphism was either not reproducible or there was poor amplification for some clones. A new DNA extraction technique using PVPP, chloroform, and cesium chloride was tested (a modification of Yoon et al., 1991). this method yielded DNA that was more suitable for PCR amplification. Both RAPD and DAF (Caetano-Anolles and Gresshoff, 1994) methods were used for amplification. Polymorphism was detected among and within provenances. DAF was more efficient than RAPDs for determination of the genetic relationship among silver maple clones.

218

Unique and Quick in Vitro Procedure to Detect Grapevine Virus Diseases

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In many cases the diagnosis of a viral disease in perennial woody plants requires indexing by grafting on indicator plants. In the case of grapevine leafroll and corky-bark diseases, indexing requires 2 to 3 years for symptom recording. Both diseases are found in all grapevine-growing countries. It would therefore be advantageous to develop a sensitive, quick, and reliable diagnostic technique. Explant shoots infected with corky-bark were micrografted onto healthy indicator rootstocks and maintained in vitro. Typical corky-bark symptoms appeared on the indicator within 8 to 12 weeks. Osmotic stress, in vitro, induced by sorbitol, enhanced leafroll symptoms. Explants expressed symptoms after 2 to 3 months of growth on these media. The advantages of these techniques are: Rapid indexing, saving of space and labor, could be performed year-round. Further experiments are underway for adaptation of the micrografting to leafroll disease and the stress method for corky-bark disease.

219

Progress in the Characterization of Cold-hardy Grapes using Simple Sequence Repeat DNAs (SSRs)

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The cold-hardy *Vitis* (grape) collection at the USDA/ARS Plant Genetic Resources Unit in Geneva, N.Y., comprises ≈1300 accessions. While much of the collection has been evaluated for morphological and viticultural traits, little of it has been well-characterized genetically. Lack of genetic information hampers the identification of accessions, the determination of genetic relationships among them, the evaluation of potential new accessions, and the construction of a core subset of the collection. Because simple sequence repeat DNA polymorphisms (SSRs or microsatellites) have already been proven to be useful genetic markers in *Vitis vinifera* (non-cold-hardy wine, raisin, and table grapes), our research focuses on the use of the markers both for the identification ("fingerprinting") of species, hybrids, subspecies, cultivars (varieties), and accessions of cold-hardy *Vitis*, and for the determination of genetic relationships between these taxa. Our latest research results in this area will be presented.

220

RAPDs are Useful for Genetic Analysis of *Xylella fastidiosa* and for Development of Strain-specific PCR Primers

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Xylella fastidiosa is a fastidious gram-negative, xylem-limited leafhopper-transmitted bacterium that has proven to be the causal agent of many economically important horticultural plant diseases, including Pierce's disease of grapevine and citrus variegated chlorosis. Genetic relationships among 11 *X. fastidiosa* strains isolated from mulberry, almond, ragweed, grape, plum, elm, and citrus were determined using randomized amplified polymorphic DNA (RAPD). Twenty-two 10-base primers amplified a total of 77 discrete polymorphic bands. Phenetic analysis based on a similarity matrix corresponded well with previous reports on RFLP-based similarity relationships, indicating that RAPD-PCR amplification products can be used as a reliable indicator of genetic distance in *X. fastidiosa*. RAPD products have been cloned and sequenced, and pairs of 21-nucleotide PCR primers have been developed that detect *X. fastidiosa* in general and the causal agent of citrus variegated chlorosis specifically.

221

Somatic Embryogenesis using Immature Zygotic Embryos from Developing Fruits of Papaya (*Carica papaya*)

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An efficient protocol has been developed for the in vitro multiplication of papaya (*Carica papaya* L.) through somatic embryogenesis utilizing immature zgotic embryos. Somatic embryos were initiated on MS basel media supplemented with 5 mg·liter^{-1} 2,4-D, 400 mg·liter^{-1} glutamine, and 6% sucrose. After culturing for 2 months, 65% of the explants became highly embryogenic. Each explant produced 50 to 80 embryos in 4 months on culture induction medium. Frequency of embryogenesis was increased (75 to 150 somatic embryos on 80% explants) upon supplementing medium with 4% maltose as a carbon source and 100 mg·liter^{-1} L-asparagine. The embryogenic callus appeared yellow and embryos at different stages of development were well-organized. On regular subculturing, these cultures continued to produce secondary embryos. Following their transfer to the hormone-free medium supplemented with 4% maltose, these embryos germinated. The somatic embryogenesis system is rapid, repetitive, and highly proliferative. Thus, this system may have a potential use in the development of synthetic seed and transgenic papaya plants. Details of important factors affecting somatic embryogenesis will be discussed.

222

Development of Scar Markers Tightly Linked to the CTV Resistance Gene in *Poncirus trifoliata*

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Citrus tristiza virus (CTV) is the most-significant viral pathogen of citrus in the world. Rapid decline of trees on sour orange and stem pitting of grapefruit and sweet orange, two diseases induced by CTV, severely jeopardize citrus production worldwide. It is recognized that all future rootstocks should be resistant to this virus, and scion resistance to stem pitting stains is desirable. To facilitate introgression of the CTV resistance gene from *Poncirus trifoliata* and development of CTV-resistant varieties in citrus, gene mapping projects have been initiated and more than a dozen RAPD markers have been identified with tight linkage to the resistance gene. As part of our efforts to use marker-assisted selection with a large number of crosses, and ultimately to accomplish map-based cloning of the CTV resistance gene, we have been converting the most tightly linked RAPD markers into SCAR (sequence characterized amplified region) markers by cloning, sequencing the marker fragments, and designing locus-specific primers. One codominant and several dominant SCARs have been developed thus far. The updated progress and utilization of these SCARs in marker-assisted selection and possibly in characterization of a BAC library will be presented and discussed.

101 ORAL SESSION 29 (Abstr. 223–229) Nutrition/Small Fruit & Viticulture

223

Aluminum Uptake and Root Cation Exchange Capacity (CEC) in Mycorrhizal and Non-mycorrhizal Blueberry (*Vaccinium carymbosum* L.) Plants

*Wei Qiang Yang** and *Barbara L. Goulart*, Dept. of Horticulture, The Pennsylvania State Univ., University Park, PA 16802.

Aluminum (Al) uptake and root cation exchange capacity (CEC) of mycorrhizal (M) and non-mycorrhizal (NM) blueberry plants (*Vaccinium corymbosum* L.) were studied. Mycorrhizal roots took up more Al than non-mycorrhizal roots over a 48-h period. Different patterns of Al uptake occurred between M and NM roots. The M roots contained more Al at hour 1, followed by a deep decrease at hour 3, and then increased gradually. However, Al uptake in NM roots increased with time. Foliar Al analysis indicated that Al concentration increased with time in both M and NM plants, but a significant increase of foliar Al concentration during the first 3-h period was not observed in M plants. The results suggested that the rate of Al transport and the redistribution of foliar Al were different in M and NM plants. The higher Al concentration in M roots may be due to the higher CEC in M roots and vice versa. Further, the CEC of M roots was decreased by the respiration inhibitor (CN-) treatment while the CEC of NM roots was not, suggesting that CEC in M roots is related to respiration.

224

Effect of Boron and Calcium on in Vitro and in Vivo Lowbush Blueberry Pollen Germination

*Youzhi Chen** and *John M. Smagula*, Applied Ecology and Environmental Sciences, 5722 Deering Hall, Univ. of Maine, Orono, ME 04469-5722.

Ten clones of lowbush blueberry (*Vaccinium angustifolium*) having low leaf boron (B) concentrations (<20 ppm) were selected to receive fall foliar B (400 ppm), Ca (4000 ppm), B (400 ppm) + Ca (4000 ppm), or water (control). B concentration was raised in stem and bud tissue 3 months after application, but Ca concentration was unaffected. Two randomly selected 5-inch sod plugs from treatment plots within each clone were transported to cold storage at 2.7C for 1000 h to satisfy flower bud dormancy, then to a growth chamber at 24C to blossom. Pollen from plants receiving B had lower in vitro germination rates on 5% agar with 12% lactose after 20 h compared to control and Ca treatments. For in vivo germination, 10 blossoms were randomly selected on sod plugs of each treatment plot to receive 15 control-treatment pollen grains, which were allowed to germinate for 3 days. With the aid of fluorescence microscopy, a higher pollen germination percentage was observed in blossoms of plants receiving B, Ca, and B + Ca. B and Ca may have more influence on the ability of the stigma to stimulate pollen germination than on the germinability of pollen grains themselves.

225

Pruning Method Affects Lowbush Blueberry Yields

John M. Smagula and Scott Dunham*, Applied Ecology and Environmental Sciences, 5722 Deering Hall, Univ. of Maine, Orono, ME 04469-5722.

Flail mowing was compared to traditional pruning by oil fire over a 12-year period in two fertility experiments testing interactions with pruning method. In study one (1983–1986), urea at 0, 22.4, 44.8, 67.2, or 89.6 kg·ha^{-1} was applied preemergent in a split-block design with fertility as the main effect, and pruning method split within six blocks. Study two (1987–1994) continued the pruning and application of fertilizer on the treatment plots with similar rates, but diammonium phosphate (DAP) replaced urea as the fertilizer. Leaf tissue N concentrations were above the 1.6% standard and urea had no effect or decreased yield. There was no interaction of fertility and pruning and no effect of pruning method on yield. No interaction of fertility and pruning was found in study two, but DAP increased leaf P concentrations and yield and, after three cycles of mowing, yields had begun to decline in mowed plots compared to burned plots. No meaningful differences in leaf nutrient concentrations were found between plants in mowed and burned plots.

226

Calcium and Fruit Firmness in Highbush Blueberry: Natural Gradients and the Effect of Foliar Applications

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Calcium gradients were established in firm ('Bluecrop' and 'Blueray') and soft ('Ivanhoe') highbush blueberry (*Vaccinium corymbosum* L.) fruits from a 7-year-old planting at La Union, southern Chile. Manual firmness measurements established that 'Ivanhoe' fruit was softer than either 'Bluecrop' or 'Blueray'. In all varieties, Ca concentrations were: seed > pulp > epidermis; opposite trends were found for K+Mg/Ca ratios. Seed number and Ca concentration in the pulp were negatively correlated in 'Bluecrop' and 'Ivanhoe', but not in 'Blueray'. In a related experiment, the response of 'Bluecrop' to preharvest sprays of two calcium sources (chloride and nitrate) in four doses (0, 47.5, 35, or 190 g Ca/100 liters of water) was studied; dose and source interactions were not significant. Both calcium sources affected fruit Ca concentrations similarly;l calcium applications, either as nitrate or chloride, increased Ca significantly in epidermis and seed; the highest dose was required to raise significantly Ca concentrations in the pulp. K+Mg/Ca ratios in nitrate- or chloride-treated fruit were: pulp > seed > epidermis.

227

Effects of Dicyandiamide on Blueberry Uptake and Soil Transformations of Nitrogen

*Philip Throop** and *Eric Hanson*, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48912.

Absorption of ^{15}N-enriched fertilizer by young 'Bluecrop' bushes was compared following application of the nitrification inhibitor dicyandiamide (DCD). Ammonium sulfate solutions containing 7.9 g N (10.2 atom % ^{15}N) were applied to the soil surface. Treated plants received 0.6 g of DCD and were compared to fertilized untreated controls. Fruit was collected during the growing season and bushes were excavated at the end of the season. The bush was partitioned into root stems and current season's growth (shoots, leaves, fruit). Tissues were dried, ground, and analyzed for ^{15}N and ^{14}N by mass spectrometry. No significant differences in N absorption were observed. Available soil fertilizer nitrate and ammonium content is presently being analyzed for effects of DCD.

228

Phosphorus Forms for Cranberry Production

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Commercial cranberry (*Vaccinium macrocarpon* Ait.) soils are high in iron and calcium and have low pH. This soil chemistry causes conditions where phosphorus is tightly bound and is, to a large extent, unavailable to the cranberry plants. In theory, P forms that directly enter the plant (foliar), or that do not quickly dissolve to become rapidly immobilized (organic, slow-release, other insoluble forms) could be more efficient for cranberry production. To test this hypothesis, two separate sets of field plots, one comparing 19 kg P/ha from sole P sources (all received 22 kg·ha^{-1} each N and K_2O as ammonium sulfate and potassium sulfate) and the other comparing "complete" N–P–K fertilizers containing P, were established at six locations on three cranberry cultivars. Experiment #1 showed that, over all locations, there were no differences in mean yield for plots fertilized with triple super phosphate (current practice), foliar, or rock phosphate. However, fruit rot levels differed by treatment. In Experiment #2, organic forms (except bone meal) gave the lowest yields, while rock phosphate plots had the greatest yields. These field studies indicated that, while some organic P sources may not be suitable for cranberry production, low-leaching P forms such as bone meal and rock phosphate were as effective for cranberry production as the more-soluble triple super phosphate.

229

Influence of Rootstock on Bloomtime Petiole Analyses of Selected Grape Cultivars

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Petioles were gathered at bloomtime in four trials, one each of 'Chardonnay and 'Zinfadel' and two of 'Cabernet Sauvignon' over 2 years, 1993 and 1994. In each trial, scions were grafted onto 12 to 14 rootstocks. Petioles were analyzed for NO_3-nitrogen, NH_4-N, K, P, and Mg. NO_3-N levels differed among rootstocks

by as much as 16-fold (126 to 2064 $\mu g \cdot g^{-1}$), NH_4-N by as much as 4-fold (253 to 1-28 $\mu g \cdot g^{-1}$), K, P, and Mg by about 3-fold (9.7 to 30.6 $mg \cdot g^{-1}$, 1.8 to 6.3 $mg \cdot g^{-1}$, and 2.9 to 7.5 $mg \cdot g^{-1}$, respectively). 'Freedom' had the highest levels of NO_3-N. 'Salt Creek' had moderate levels of NO_3-N, but had the highest levels of NH_4-N. The rootstock 420A Mgt was consistently low in NO_3-N, NH_4-N, and K. Freedom was among the highest in K content. The rootstock 44-53 Malègue' had high levels of K and low Mg. Implications for vineyard fertilization programs will be discussed.

102 ORAL SESSION 30 (Abstr. 230–234) Growth & Development/Vegetable Crops

230

Developmental and gGenetic Differences in the Fruit-receptacle Separation Zone in Tabasco Pepper

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Two lines of tabasco pepper (*Capsicum frutescens)* were previously identified that differ significantly in ease of fruit detachment force. Greenhouse-grown plants of these lines, 'McIlhenny Select' and 'HP', were investigated for differences in cell organization in the fruit-receptacle area and the separation zone at different developmental stages. Histological examination indicated that fruit of 'HP', which requires greater force to separate, exhibited a larger region of sclerified cells within the fruit-receptacle area. In contrast, fruit of 'McIlhenny Select', the line that detaches easier, had fewer sclerified cells in this region. Cell sclerification increased for both lines with increasing fruit maturity. The fruit-pedicel separation zone in both lines is distal to the sclerified region and is composed of parenchymatous fruit tissue. The separation zone for 'HP' includes at least 10 additional distal cell layers in the fruit septal region than 'McIlhenny Select'.

231

Temperature Influences Yield, Leaf Expansion and Unfolding, and Vine Growth of Sweetpotatoes Grown in NFT

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Growth chamber studies were conducted to evaluate the effect of four diurnal temperatures (24/18C, 26/20C, 28/22C, and 30/24C) on yield, leaf expansion and unfolding, and vine length of sweetpotatoes [*Ipomoea batatas* (L.) Lam]. Four vine cuttings (15 cm in length) of 'TI-155' and 'Georgia Jet' were grown for 120 days using a modified half-Hoagland nutrient solution with a 1:2.4 N:K ratio. Irradiance at canopy level averaged 600 $\mu mol \cdot m^{-2} \cdot s^{-1}$ at an 18/6 photoperiod, and RH of 70%. Storage root number/plant for both cultivars decreased with increased temperature. Storage root fresh and dry weights for both cultivars increased with temperatures up to 28/22C and declined at 30/24C. Foliage fresh and dry weights were not influenced by temperature for either cultivar. Leaf expansion rate and vine length were highest at 26/20C and lowest at 24/18C for both cultivars. Leaf unfolding rate was not affected by temperature foe either cultivar, but was more influenced by time of measurements.

232

Growth and Metabolism of Tomato Seedlings Grown with Roots Warm during the Day and Cold at Night, or Vice Versa

*Yong-Zhan Ma** and *Martin P.N. Gent*, Dept. of Forestry and Horticulture, The Connecticut Agricultural Experiment Station, New Haven, CT 06504-1106.

Do root temperatures warm during the day and cool during the night benefit plant growth? Tomato (*Lycopersicon esculentum* Mill.) seedlings were grown at a constant 20C air temperature but with varied root temperature, either 28/12C or 12/28C day/night for 8 days. Eight seedlings were grown in troughs in continuously flowing nutrient solution containing 200 μM $^{14}NO_3^-$ excess amounts of other mineral elements. The flow rate was 0.6 liters/day per trough on the first day, when plants weighed 20 mg, and increased with plant size. After 8 days, $^{15}NO_3^-$ was provided for 12 h when roots were warm, and eight plants were harvested at the end of labeling or 12 h later. During the treatments, weight per plant increased more in leaves, 3.5 to 44 mg, than roots, 4.3 to 19 mg, and least for stem, 12 to 30 mg. The whole-plant relative growth rate did not differ among treatments, 0.17 to 0.19/day, but was less than for plants grown at a constant 20C root temperature, 0.22/day. Uptake of $^{14}NO_3^-$ from the media and exudation from the stem of decapitated plants were greater when roots were warm than when roots were cold, regardless of light. After labeling for 12 h at the warm root temperature, ^{15}N enrichment in plant tissues was greater with roots warm during the day, 0.20, 0.15, and 0.16, than in those with roots warm during the night, 0.16, 0.11, and 0.10, for roots, stems, and leaves, respectively. Enrichment with roots warm during the day was 22%, 33%, and 62% greater, for roots, stems, and leaves, respectively, than with roots warm during the night. However, uptake of NO_3^- at night by roots that were warm during the night was sufficient so that plants grown at out-of-phase root temperature grew as fast as plants grown at in-phase root temperature. Research supported in part by grant 93-37100-9101 from the NRI Competitive Grants Program/USDA.

233

Yield and Growth Responses of Asparagus to Between-row Spacing and Planting Depth

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Five between-row spacings of asparagus ranging from 60 to 120 cm were combined with five planting depths ranging from 15 to 30 cm, in a central composite rotatable design. After seven harvest seasons, the accumulated yields ($kg \cdot ha^{-1}$) declined linearly by 108 (+18) $kg \cdot ha^{-1}$ for each increase of 1 cm of depth. Accumulated yield also declined linearly by 6.6 (+4.5) $kg \cdot ha^{-1}$ with each increase of 1 cm in row width. Depth and row width did not interact. Effects of treatment on average spear weight were negligible. When the experiment was terminated, the final depth of all crowns, regardless of original planting depth, had floated to about 11.3 cm.

234

Growth Analysis of Two Pea Cultivars as Influenced by Planting Date

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'Lincoln' and 'Rondo' pea cultivars (*Pisum sativum* L. subsp. *hortense*) were planted at early, midseason, and late dates during 1989–90 and 1990–91 growing seasons. Plant growth analysis data were collected via weekly harvests throughout the growing season. Plant height, leaf area, and shoot dry weight were measured, and LAI, SLA, and SLW were also determined. Derived growth quantities such as RGR, NAR, and CGR were calculated. 'Rondo' plants were taller, larger in leaf area, had more vegetative and dry weight, and were earlier in flowering than 'Lincoln' plants. Leaf area was not significantly affected by planting date. Optimum LAI was obtained between harvests 7 and 9, which coincides with the time of highest values of NAR and CGR. Significant correlation coefficients were obtained between growth attributes in both seasons, and, in most cases, for all planting dates.

103 ORAL SESSION 31 (Abstr. 235–239) Postharvest Physiology/Vegetable Crops

235

Sites of Superoxide Production in Mitochondria Isolated from Bell Pepper Pericarp Tissue

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Reactive O_2 species produced when electron transport is disrupted have been implicated in several environmental stress-induced disorders. Superoxide (O_2^-) is produced at two or more sites in mitochondria isolated from bell pepper fruit supplied with succinate and NADH. SOD and KCN completely inhibited O_2^- production with both substrates. Antimycin A inhibited O_2^- production with succinate, but not with NADH. Insensitivity of O_2 uptake to KCN increased in mitochondria

isolated from bell peppers stored at 2C and their O_2^- production increased with NADH as substrate, but decreased with succinate. Disrupting the mitochondrial membranes enhanced O_2^- production with NADH and reduced production with succinate. Greater O_2^- production with NADH may result from the inability to transfer electrons from NADH through the alternative path. The KCN-insensitive alternative path in some plant tissues appears to reduce the potential production of O_2^-

236

Bruising Susceptibility of Green Bell Pepper Fruit Varies with N Level and Planting Time

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Green 'Jupiter' bell peppers (*Capsicum annuum* L.) were grown in the spring and fall seasons of 1994 on polyethylene mulch with drip irrigation. Seedlings were planted on three dates in each season, either 2 weeks (spring) or 1 week (fall) apart, with N applied at rates of 0, 100, 200, or 400 $kg \cdot ha^{-1}$. Primary fruit were harvested upon reaching full size (diameter) and the bioyield-point (which reflects bruising susceptibility) measured at the fruit shoulder with an Instron machine; pericarp thickness was measured adjacent to the area where bioyield-point was measured. Dry weight of the fruit tissue was measured in the fall only. Bioyield force decreased with increasing N rate and increased with later planting time in the fall, but did not change with N rate and decreased only slightly with planting time in the spring. Pericarp thickness increased with N rate in both spring and fall, but increased with planting time in the spring while decreasing in the fall. Dry matter increased with planting time, but decreased with N rate in the fall peppers. These results indicate that bioyield force is not controlled by pericarp thickness, but rather may be more closely related to cell size or cell wall thickness, as suggested by dry weight differences.

237

Tomato Locule Cell Wall Polysaccharides: Changes during Maturation and Ripening

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Softening and liquefaction of 'Solar Set' locules was studied by examining cell wall polysaccharides during fruit developmental stages (FDS) of immature green, mature green and breaker. Ethanol insoluble solids (EIS) were sequentially extracted by H_2O, CDTA, and Na_2CO_3 solutions. The chromatograms of gel filtration among the same-solution extracts of EISs from three FDS were similar. Gradient DEAE also yielded similar patterns among FDS in each extraction solvent, even though the patterns of Na_2CO_3 extracts differed from those of H_2O and CDTA extracts. The mole ratio of total polyuronides decreased for Gal, Ara, and Xyl at later FDS in both EIS and in all extracted polymers. Gal had the highest mole percentage of total neutral sugars, followed by Ara, Xyl, and Rha. While the mole percentage of neutral sugars for Gal, Rha, Ara, and Xyl were relatively similar among FDS in H_2O extracts, those in CDTA and Na_2CO_3 extracts either increased or decreased, depending on individual neutral sugar. SDS-PAGE showed increased density in locule-tissue proteins, especially one with a molecular weight of less than 20 kDa, during later FDS. Results indicate that pectin depolymerization was limited and major neutral sugars commonly composing side chains showed a net decrease.

238

Instrumental and Sensory Analysis of Tomato Flavor

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Sugars, acids, and flavor volatiles are components of flavor that have been measured instrumentally, revealing differences among tomato cultigens. For objective measurements to be useful, however, they need to relate to sensory data. In this study, objective and sensory analyses of tomato flavor were compared. Seven tomato cultigens were ranked for sweetness, sourness, and flavor and rated for overall acceptability by a panel of 32 experienced judges. Sucrose equivalents (SE), measured by HPLC, but not soluble solids correlated with sweetness at $P = 0.10$. In addition, SE highly correlated with flavor ($P = 0.03$), while titratable acidity (TA) negatively correlated with overall acceptability ($P = 0.03$). Regression analysis indicated that 2+3-methylbutanol, *cis*-3-hexenal, and 6-methyl-5-hepten-2-one significantly contributed to flavor at a 5% level of significance. It is apparent from this study that sucrose equivalents are more meaningful than soluble solids for measurement of sweetness, and that certain flavor volatiles play a role in tomato flavor.

239

Heat Treatments Extend Shelf-life of Tomato Fruit

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Mature, green tomatoes were either gassed or not gassed with C_2H_4 for 24 h, immersed in 42C water for 60 min, or held in 38C air for 48 h or not treated, and then stored at either 2C or 13C for 14 days before ripening at 20C. During ripening, the fruit were evaluated for color development, internal quality, and decay and for volatiles when full ripe. Both high-temperature treatments reduced chilling injury and inhibited decay. Days to ripen after removal from storage at 2C or 13C was not influenced by heat treatment method. Color development, lycopene content, and internal quality characteristics of fruit were similar at the ripe stage, irrespective of heat treatment. Of 15 volatiles analyzed, seven showed decreased levels of concentrations as a result of C_2H_4 gassing, nine showed decreased levels when stored at 2C prior to ripening, and most were unaffected by the heat treatments. Heat treatments appear to be beneficial for maintaining tomato fruit quality.

104 ORAL SESSION 32 (Abstr. 240–247) Culture & Management/Fruit & Nuts (Temperate)

240

Soft Sour Cherries—What's the Problem?

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Michigan growers often have severe problems with soft 'Montmorency' sour cherries. Causal factors may include weather conditions, orchard practices, harvesting methods, and conditions during hold of fruits prior to processing. In this study, efforts were concentrated on orchard practices, including shading to reduce solar radiation, irrigation, nutrient level, and application of growth regulators, especially ethephon and gibberellin. Fruit firmness decreased as maturity approached, then stabilized. Significant fruit softening occurred only during mechanical harvesting. No treatments, including sprays of calcium and potassium, consistently increased firmness, but firmness was reduced in 1993 by spraying with ethephon. Firmness varied among orchards, but no "soft" fruit, as defined by industry standards, were observed in harvested fruit. Softening appeared to be caused by excessive bruising, and was always associated with mechanical damage. Advanced maturity and heavy cropping appear to predispose the cherries to greater bruise damage.

241

Potential Relationship between Peach Tree Short Life Symptomology and Aberrant Wood Anatomy

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Peach tree short life (PTSL), a major disease complex impacting peach culture in the southeastern United States for decades, accounts for millions of dollars of losses annually. In spite of the overwhelming amount of research that has been conducted on PTSL, many uncertainties still exist regarding the factors involved in the syndrome and the true cause of tree death. As a consequence, we examined the wood structure and anatomy of 6-year-old peach trees, some showing the initial visible symptoms of PTSL, and others that appeared unaffected and healthy. Very dramatic differences in wood anatomy were observed between healthy and stricken trees. Stricken trees showed a total lack of vessel formation in some earlywood zones, a decrease in vessel formation in latewood, and a marked increase in ray parenchyma cells. Healthy trees showed normal vessel and ray formation. Preliminary results indicate that in some way PTSL may be associated

with increased gum production in the xylem and decreased earlywood vessel production, thereby significantly reducing water conduction, leading to tree death. Results of studies currently in progress to further investigate this hypothesis will also be presented.

242

Rootstock, Time, Technique, and Quantity of Nitrogen Effects on Production, Mineral Nutrition, and Postharvest Quality of 'Fuji' Apple

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The influence of three rootstocks, various levels of soil-applied nitrogen in fall, and spring spray applications with and without minimum ground nitrogen on tree growth, productivity, leaf and fruit nutrient partitioning, and postharvest quality of fruit at harvest and after storage in 'B.C. 2 Fuji' apple was studied over several seasons. Early results showed that trees on M.26 and M.9 were more precocious and had higher yield and yield efficiency. Trees on M.9 had significantly higher leaf Ca and incidence of sunburned fruit than those on other rootstocks. Trees on M.7 had larger fruit and higher leaf N, K, and Cu, but had lower fruit starch degradation pattern (SDP) and leaf Ca. Soluble solids at harvest were lower in fruit from trees on M.26 rootstock. Trees with fall nitrogen application had lower leaf N and better fruit color. Lower quantities of N application had smaller fruit but better fruit color and higher firmness at harvest. Fruit from all rootstocks did not produce ethylene for several days in the ripening chambers. After this period, fruit on M.9 rootstock produced ethylene before those from other rootstocks. Trees established with only nitrogen spray without any ground application had leaf N deficiency after they started bearing fruit. Establishment of a new 'Fuji' orchard based on only nitrogen spray produced weak trees with low yield and yield efficiency, while addition of a small quantity of ground-applied N improved tree growth and fruit quality.

243

Improvement of 'Fuji' Apple Color and Fruit Size using Reflective Materials

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Soil-applied reflective materials significantly improved the red color development, fruit size, and early harvestability of 'Fuji' apple grown under hot climate conditions of the the San Joaquin Valley of California. Red surface color was significantly improved from 7.35% in the control to 14.27% where 60-inch-wide silver polypropylene o 48-inch-wide crinkled foil on cloth backing were applied to the soil between rows of 'Fuji' apple grown on a Lincoln trellis. The weight per apple was also significantly increase where the reflective materials were used. There was no significant difference in soluble solids, acidity, pH, pounds firmness, or starch content. Packinghouse records showed a 33% increase in first harvest pack-out where the reflective materials were used. Total pack-out in the larger sizes was improved in the extra-fancy and US#1 grades, while the utility-grade fruit was reduced by using these materials. Ground color was shifted from green to yellow where the reflective materials were used.

244

Effects of Rowcover Microclimate on 'Delicious' Apples

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Plastic covers were placed over rows of 'Delicious' apple trees/M.26 to test their effect on canopy temperature and hence on bud phenology and growing season duration. In 1992, plastic covers enclosed the treated plots to within 0.5 m of the soil and the tunnel ends were left open. Average daily temperatures within the rowcovers were 0.1C cooler in April, 0.2C warmer in May, and 0.1C cooler in July than uncovered canopy temperatures. In 1993, rowcovers completely enclosed the treated plots (both ends and sides); average daily temperatures within the enclosed plots were 1.6C warmer in April, 0.1C cooler in May, 0.2C cooler in June, and 1.3C cooler in July. There was no difference in the date of anthesis in 1992; however, within the complete enclosures in 1993, anthesis occurred 7 days earlier than in the uncovered plots. Apple weight and shape were comparable in 1992, but, in 1993, apples in the covered plots average 31.1 g more than fruit in the uncovered trees and had slightly great length/width ratio. Complete and uniform red color development did not occur either year under rowcovers. In addition, rowcovers prevented sunscald and hail damage, and reduced windfall of nearly ripe fruit.

245

Influence of Environmental Factors on Pecan Oil Composition and Nut Quality

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Four cultivars of pecan [*Carya illinoinensis* (Wangenh.) K. Koch] were selected for the study ('Cheyenne', 'Mohawk', 'Pawnee', and 'Osage'). The influence of total climatic heat units, during nut filling, on nut quality was compared from 14 geographic locations over a 3-year study. Nut quality parameters included nut size by weight, kernel percentage by weight, kernel color by Hunter Color Difference Meter, fatty acid profile by GC, and total oil by NMR. Nuts were harvested at shuck split, dried to 3% moisture, and stored at –20C prior to analysis. Monounsaturated fatty acids (MUFA) and total oil increased, and polyunsaturated fatty acids (PUFA) decreased in 'Mohawk' 2 out of 3 years with increased heat units. Fatty acids in 'Pawnee' responded the same as in 'Mohawk' in 1992, but were variable in 1991. In 1993, 'Pawnee' kernel whiteness and total oil decreased with increased heat units. Higher heat units caused the testas of 'Cheyenne' to be darker in all 3 years. MUFA of 'Cheyenne' increased with increased heat units 1 out of 3 years. The PUFA content of 'Cheyenne' decreased with increased heat units in 1993. 'Osage' showed a reversal of MUFA and PUFA with increased heat units. High negative correlation between oleic and linoleic acid were obtained for all cultivars.

246

Thinning and Diametric Fruit Growth Response of Apple Trees Treated with Benzyladenine and GA_{4+7} (Accel®), Carbaryl, and NAA

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A series of seven fruit thinning experiments with benzyladenine (BA), benzyladenine and GA_{4+7} (10:1 BA:GA_{4+7}, Accel), carbaryl (CB), and NAA were conducted at the Horticultural Experiment Station, Simcoe, during the 1993 and 1994 growing seasons. In 1993, BA and Accel at 0, 100, 200, and 300 mg of BA/liter were applied to mature 'Redspur Delicious'/M.26 and 'Empire'/M.26 trees when fruit were ≈10 mm in diameter. In one set of experiments in 1994, Accel was applied at 0, 25, 50, 100, 150, and 200 mg of BA/liter to mature 'McIntosh'/M.26 and 'Empire'/M.7 trees. In a second set of experiments in 1994, Accel was applied at 0, 50, and 100 mg of BA/liter to mature 'Idared'/M.26, 'Empire'/M.26, and 'Marshall McIntosh'/Mark trees when fruit were ≈10 mm in diameter. Additional treatments included bloom sprays of Accel at 50 mg of BA/liter, and sprays of BA at 50 mg a.i./liter, NAA at 10 mg a.i./liter, CB at 1000 mg a.i./liter, and a "low" (two fruit remaining/flower cluster) and '"high" (one fruit remaining/flower cluster)rate of hand thinning. In all experiments, thinning response to BA and Accel increased with concentration. Concentrations below 50, 100, and 300 mg BA/liter were generally ineffective for thinning 'Empire', 'Idared', and 'McIntosh', and 'Delicious', respectively. Fruit size of 'Idared' and 'Empire' was increased at rates of 50 mg BA/liter, whereas rates of 100 mg BA/liter were needed to increase fruit size of 'McIntosh' . Accel applied to 'Empire' at 150 mg BA/liter decreased the number of seeds per fruit and increased fruit length:diameter (L:D) ratios. Concentrations of Accel exceeding 100 mg BA/liter in 'Red Delicious' decreased the number of seeds per fruit, while having little effect on fruit L:D ratios even though lower concentrations increased fruit L:D ratios. Diametric fruit growth measurements in 1994 indicated a temporary, but sharp, decline in growth rate immediately following treatment imposition for trees that responded positively to thinning. Additional data describing treatment effects on fruit size distribution, vegetative growth, and fruit maturity will be presented and discussed in relation to crop load.

247

GA_3, GA_{4+7}, and GA_7 Inhibit Flower Bud Formation and Reduce Alternate Bearing in Apple (*Malus domestic* Borkh.)

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A single spray of either GA_3 or GA_{4+7} at full bloom reduced the severity of the

alternate bearing cycle of 'Braeburn' apples, measured as the proportion of flowering spurs over the 2 years following treatment. Increasing the concentration of GA_3 applied in the light-flowering year linearly reduced the proportion of flowering spurs in the following year and linearly increased the proportion of flowering spurs 2 years after treatment. Application of GA_3 or GA_{4+7} at full bloom inhibited flower bud formation on spurs only, whereas, in a separate experiment, GA_3 or GA_7 applied later than 8 weeks after bloom inhibited flower bud formation on 1-year wood only. Thus, delayed GA treatments may provide suitable technology for the selective removal of fruit from 1-year wood in apple.

115 ORAL SESSION 33 (Abstr. 248–252) BioTechnology/Vegetable Crops

248

Gene Transfer for Enhancing Plant Disease Resistance to Bacterial Pathogens

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Gene transfer can provide plants with a novel source of disease resistance. Two different antibacterial peptides, Shiva-1 and lactoferrin, were tested in vitro for antibacterial activity. The former is from cecropin B in insects, and the latter from human or mammal fluids such as milk. Both peptides exhibited high antibacterial activity against all tested gram-negative phytopathogenic bacterial strains. Lactoferrin was more lethal than Shiva-1. A particular lactoferrin domain showed a much higher activity against bacterial strains. A gene encoding lactoferrin was then transferred to *Nicotinia tabacum* L. *xanthi*-nc to evaluate the gene expression using *Agrobacterium*. Stable transformation was confirmed by Southern, Northern, and Western blot analysis. Delayed wilting of the transgenic plants inoculated with *Pseudomonas solanacearum* was observed. A significant positive relationship between the gene expression levels and resistance was also found by either Northern or Western blotting. Biolistic transformation using a gene gun is currently underway to transfer this novel gene to common beans.

249

Comparison of Methods to Transform Embyrogenic Cotyledons of Melon

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Agrobacterium-mediated transformation (AMT) was compared with a particle bombardment (PB) for stable transformation of 'Eden Gem', a melon with high embryogenic potential. Pretreated cotyledonary explants were either wounded via particle bombardment prior to *Agrobacterium* infection or were bombarded with plasmid-coated gold microparticles, using a modified particle inflow-type gun. Although similar numbers of embryos initially were obtained with each method, most produced via AMT became abnormal, possibly due to the growth-regulatory effects of the antibiotic mefoxine, which was used to inhibit *Agrobacterium*. Stably transformed plants and progeny were obtained only with PB, as determined by detection of the NPTII gene in R_0 plant by Southern hybridization and, in progeny, by PCR amplification.

250

A Method for Transforming Whole Plants via the Electrophoresis of Shoot Tips

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Most methods developed to transform plants either require tissue culture to regenerate a whole plant from transformed tissue or the transformation of reproductive tissue. These approaches are not applicable to vegetatively propagated crops or crops that can not be tissue-culture propagated. We have modified a procedure that was developed to transform zygotic meristems for use with whole plant meristems. We developed a method to introduce DNA via electrophoresis into the cells of axillary meristems of whole plants growing in soil. About half of the treated meristems developed into shoots. Of those shoots, up to half had some level of GUS marker gene expression. We were able to transform *Cercis*, *Chrysanthemum*, *Capsicum*, and *Prunus*. In *Capsicum*, the GUS gene was inherited.

251

Morphological Trait QTL Mapping in Tomato Recombinant Inbred Line Population

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Quantitative trait loci influencing morphological traits were identified by restriction fragment length polymorphism (RFLP) analysis in a population of recombinant inbred lines (RIL) derived from a cross of the cultivated tomato (*Lycopersicon esculentum*) with a related wild species (*L. cheesmanii*). One-hundred-thirty-two polymorphic RFLP loci spaced throughout the tomato genome were scored for 97 RIL families. Morphological traits, including plant height, fresh weight, node number, first flower-bearing node, leaf length at nodes three and four, and number of branches, were measured in replicated trials during 1991, 1992, and 1993. Significant ($P \leq 0.01$ level) quantitative trait locus (QTL) associations of marker loci were identified for each trait. Lower plant height, more branches, and shorter internode length were generally associated with RFLP alleles from the *L. cheesmanii* parent. QTL with large effects on a majority of the morphological traits measured were detected at chromosomes 2, 3, and 4. Large additive effects were measured at significant marker loci for many of the traits measured. Several marker loci exhibited significant associations with numerous morphological traits, suggesting their possible linkage to genes controlling growth and development processes in *Lycopersicon*.

252

Analysis of Anther-derived Potato by RAPDs and SSRs

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RAPD and SSR analyses were used to characterize the genetic composition of anther-derived plants of a diploid potato clone, CP2 (*S. chacoense* 80-1 x *S. phureja* 1-3). The ploidy of anther-derived plants was first determined by flow cytometry. A total of 44 decamer primers was screened for polymorphism. The loci that segregated were selected and scored. The monoploids had only half as many loci carrying RAPD markers compared to the anther donor. Among the 13 anther-derived diploids, four were identified as homozygous by marker frequency similar to monoploids and nine as heterozygous. Five of seven SSRs obtained from published potato sequences were polymorphic in CP2. CP2 was found to be heterozygous with two alleles at four SSR loci (TC/TA, AAG, AGA, CTT), and three alleles at an ACTC locus. Primer pairs flanking each of the five polymorphic SSRs revealed that monoploids had only the allele contributed by *chc* 80-1. Homozygous diploids had only one band per SSR locus, whereas heterozygous diploids displayed more than one allele for at least one SSR locus. Results of the SSR analysis supported the findings based on RAPD markers; the same diploid clones were characterized as homozygous by both SSR and RAPD markers.

116 ORAL SESSION 34 (Abstr. 253–260) Nutrition/Cross-commodity & Ornamentals

253

Contrasting Responses of Amur maackia and Black Locust to Culture in Hoagland Solution

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Hydroponic culture of tree seedlings is commonly used to study root biology; however, we have found that species differ in their responses to this practice. Responses of 2-week-old seedlings of Amur maackia (*Maackia amurensis* Rupr. & Maxim.) and black locust (*Robinia pseudoacacia* L.) to 1%, 5%, 10%, 25%, 50%, and 100% Hoagland solution #1 were determined over 5 weeks. Dry mass of black locust increased with increasing solution concentration up to 50%. For Amur maackia, dry mass was highest in 5% solution, and dry mass declined by

≈50% in 50% solution. Purpling, chlorosis, and necrosis occurred on leaves of Amur maackia in solutions ≥10%, and symptom severity increased with solution strength. Amur maackia leaf ion content increased dramatically with increasing solution strength; for instance, leaf P content increased 688% as solution strength increased from 5% to 50%. No symptoms occurred on Amur maackia grown in a soil-based medium and irrigated with 50% solution. These data indicate that black locust can be grown hydroponically using standard methods. However, growth of Amur maackia is inhibited at high solution concentrations, suggesting a sensitivity to the availability of ions, and perhaps an enhanced ability to sequester ions from its media.

254

Root-zone Temperature Effects Onion Content of Tomato, Muskmelon, and Honey Locust

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Horticultural species vary in growth response to high root-zone temperature (RZT), but little is known about the effects of RZT on nutrient uptake. We determined P, K, Ca, Mg, Zn, and Mn total plant content of tomato (*Lycopersicon esculentum* Mill. cv. Jet Star), muskmelon (*Cucumis melo* L. cv. Gold Star), and honey locust (*Gleditsia triacanthos* L. var. *inermis* Willd.) grown in nutrient solution kept at 24, 27, 30, 33, and 36C. RZT effects on plant dry mass gain and gain in nutrient per plant varied by species. Honey locust and tomato total plant gain in P decreased linearly with increasing RZT, while melon P content increased linearly to 36C. Trends in total Mg and Mn content will be presented, as well as results from further research on correlations between supraoptimal RZT, root respiration, and shoot and root P content of tomato.

255

Effect of Different Nitrogen–Sulfur Ratios on 2-Phenylethyl isothiocyanate (PEITC) Levels in Watercress

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A study was initiated to identify cultural conditions that optimize the production of important chemopreventive agents in watercress. Chemopreventatives are chemical compounds that reduce or prevent diseases such as cancer. Watercress (*Nasturtium officinale*) contains phenylethyl glucosinolate that, on hydrolysis, yields PEITC, and PEITC is one of the most-important anti-carcinogens among the cruciferous chemopreventatives tested. Watercress was grown in closed hydroponic systems containing 200 ppm nitrogen and either 64, 128, and 192 ppm sulfur to yield N:S ratios of 1:0.3, 1:0.6, and 1:0.9. The experiment was laid out as RCBD in the greenhouse with six replications. PEITC levels in leaf and stem tissue was assayed using gas chromatograph. After 36 days in the treatment solutions, watercress grown at a N:S ratio of 1:0.6 produced 90.1% and 65.3% (in repeated experiments) more PEITC than plants grown at a N:S ratio of 1:0.3. Plants grown in nutrient solution with a N:S ratio of 1:0.9 produced 57.4% and 24.2% greater PEITC than those grown with a N:S ratio of 1:0.3. Plants grown in a nutrient solution with a N:S ratio of 1:0.9 produced 17.2% to 24.2% less PEITC than those grown with a N:S ratio of 1:0.6. Leaves contained 54% to 70% more PEITC per unit dry mass than stems, suggesting that the leaf is the major site of synthesis and storage of PEITC.

256

Nitrogen-Yield Relationships in Greenhouse Roses

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The establishment of critical tissue N (N_{crit}) for greenhouse rose production has been primarily based on visual symptoms of N deficiency, with relatively less consideration to yield parameters. This work examined the relationship between rose leaf N concentration and flower yield and quality. Microlysimeter-grown 'Royalty' rose plants were irrigated with complete nutrient solutions containing N concentrations of 30, 60, 90, 120, 150, and 220 mg·liter^{-1}. Results after 1 year indicated no significant differences in total dry weight, number of flowers, and stem length for plants irrigated with 90 to 220 mg·liter^{-1} N. Tissue N concentrations were significantly lower for plants that received 30 or 60 mg N/liter. Estimated N_{crit} for yield parameters were ≈2.7% of leaf dry weight. Chlorophyll content and color leaf attributes (hue, chroma, and value) were correlated with tissue N concentration. The results suggest that the rate of N application typically recommended for greenhouse roses is considerably higher than necessary.

257

Influence of Nitrogen and Phosphorus Rates and Soil pH on Growth and Yield of Goldenseal

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Goldenseal (*Hydrastis canadensis* L.) is a widely used medicinal herb that is commonly collected from forests in North America. An increasing demand for goldenseal has put intense pressures on wild populations and increased the interest in cultivation. Cultural information on goldenseal, however, is limited and contradictory. A 3-year study was initiated to examine the effects of soil pH (4.5, 5.5, 6.5, and 7.5) and four rates of P and N (0, 0.1, 0.2, and 0.3 kg P or N/m^3 of soil) on growth and development of goldenseal. In Spring 1993, small rhizome pieces were planted in pots of forest soil and grown under a wood-lath structure. Plant growth, flowering, and fruiting are monitored throughout each growing season. The plants are brought into an underground storage facility for overwintering. In late winter, roots are weighed, evaluated, and replanted. After one season of growth, root weights were highest with pH 5.5 and 6.5 and no additional P or N. During the second season of growth, the greatest plant growth and fruiting were obtained with pH 5.5 and 6.5 and with the two highest rates of phosphorus.

258

Screening Fine Fescues for Aluminum Tolerance

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The fine fescues are generally considered to be acid-tolerant compared to many other cool-season turfgrasses. However, there is a lack of documentation on aluminum tolerance of fine fescues at both the species and cultivar levels. A total of 58 genotypes belonging to five species or sub-species were screened under greenhouse conditions using solution culture, sand culture, and acid Tatum subsoil. This soil had 69% exchangeable Al and a pH of 4.4. An Al concentration of 640 μM and a pH 4.0 were used in solution screening and sand screening. Differences in Al tolerance were identified at both species and cultivar levels based on relative growth. The genotypes with endophyte infection generally exhibited greater Al tolerance than endophyte-free genotypes. The results indicate that fine fescues vary in Al tolerance and there is potential to improve Al tolerance with breeding and to refine management recommendations for fine fescues regarding soil pH.

259

Utilization of Aquaculture Effluent to Supplement the Water and Nutrient use of Native Plant Nursery Production

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The multiple use of water from aquaculture to supplement irrigated crop production could minimize the cost of growing fish and irrigating crops. Aquaculture effluent was utilized to supplement the fertility and irrigation of six native shrub species (big sage, fourwing saltbush, mountain mahogany, Mormon tea, rubber rabbitbrush, and winterfat). Plants were established in two container types: 20-liter standard polypot and nonwoven UV-stabilized Duon synthetic fiber growbags. The plants were irrigated with fish effluent or city water. Plants irrigated with fish effluent were not given any fertilizer treatment, while plants irrigated with city water were fertilized with Osmocote®. Fish effluent was suitable for production of fourwing saltbush, rubber rabbitbrush, big sage, and winterfat. Fourwing saltbush irrigated with effluent had the best survival rate, while mountain mahogany irrigated with effluent had the poorest growth and survival rates. Big sage, rubber rabbitbrush, and winterfat had better growth and survival rates in the growbags, while Mormon tea had better growth and survival rate in the polypot containers.

260

The Earth Box—A Sustainable Production System

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The Earth Box is made of recycled plastic and designed to maintain a water table. A nutritional gradient is initiated with N–K fertilizer applied on the surface of the soil or media contained in the box. The box is designed to facilitate the functioning of a nutritional procedure known as the gradient concept. Basically, the concept synchronizes the nutrient/water input with removal, providing stability and nutritional predictability to the ionic composition of the soil solution. Crop response (yields and, especially, quality) with the Earth Box has been most positive, indicative of an optimal nutritional precision. The positive response is also evident in the field—average tomato yields in Florida more than doubled

with the inception of the gradient-mulch system (1970s). the gradient as the dominant nutritional component eliminates the soil (type and/or quantity)–plant–season as nutritional variables. The Earth Box with minimal water, minimal pollution, minimal management, and the potential for a minimal unit cost could be the basis of a globally sustainable production system.

117 ORAL SESSION 35 (Abstr. 261–268) Growth & Development/Vegetable Crops

261

Multiplication of Bigger Potato Tubers by Sprout Cutting can Produce More Than 140 Cuttings in 16 Days

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The multiplication technique by sprout cutting has been improved at St-Jean-sur-Richelieu in 1994. The tuber size has been increased to medium-large tubers and two different pre-sprouting periods has been extended to 190 days. In one trial, potatoes of 20 seedlings were warmed up after 4 to 8 weeks of storage at 3C and were placed under dry conditions under light or not, for more than 6 months. They were planted in flats (28 x 53 cm) filled with a soil mixture at 16 h of light 22–24C. When 50% of the sprouts had 3 to 4 cm, they were placed in the dark for 3 days or less. The sprout cutting was done the day after returning to the initial lighting condition. The tubers were sprout-cut after 6, 10, 16, 20, 24, and 32 days after planting. A yield of more than 90 sprout cuttings in 26 days was obtained with seven seedlings. LP86065 gave 140 cuttings in 16 days. In another trial, tubers with 7 months of cold storage were tested with the technique. In 23 days, 'Superior' and LP85619 gave an average of 68.4 sprout cuttings in 23 days with only three steps of multiplication. A third trial with different periods of storage and pre-sprouting will be discussed. The multiplication rate depends on may factors, such as: firmness, number of sprouts by eye and eyes by tuber, sprouting conditions, and cultivar.

262

Accumulation of Possible Potato Tuber-inducing Factor in Continuous-use Recirculating NFT sSystem

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Potatoes (*Solanum tuberosum* L.) have been grown successfully with a recirculating nutrient film technique (NFT) when a fresh nutrient solution is used for each planting. During the past year, we conducted two studies in which the same nutrient solution was used for successive plantings (EC and pH were maintained at 0.12 $S \cdot m^{-1}$ and 5.8). Results showed that successive plantings became prematurely induced (tubers initiating near 20 days after planting–DAP), causing stunted shoot growth and reduced yields per plant. When "old" nutrient solution from a continuous production system was regularly added to a newly started plant system maintained under a non-inductive environment (12-h photoperiod with night break of 6 h into dark), tubers formed on "old" nutrient solution plants (24 DAP), but not on "new" solution plants. When charcoal water filters were placed on the systems, plants grown on either "old" or "new" nutrient solutions showed no tuber initiation (plants harvested at 42 DAP). Results suggest that a tuber-inducing factor(s) emanating from the plants accumulates in the nutrient solution over time and that the factor(s) can be removed by charcoal absorption.

263

Continuous Production of Potato in an AFT System

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An experiment was conducted in the Biomass Production Chamber (BPC) at Kennedy Space Center to determine the feasibility of continuous steady-state production of potato (*Solanum tuberosum* L.). Plants were grown in a "batch" or continuous production mode using either 0.5 x modified Hoaglands or effluent from aerobically processed inedible potato biomass as a nutrient source. EC and pH were controlled to 0.12 $S \cdot m^{-1}$ and 5.8, respectively. The batch harvest occurred after 104 days and continuous harvest occurred every 26 days, with replanting occurring in the same solution. Continuous production on "aged" solution resulted in earlier tuber initiation, reduced plant height, and smaller canopies than the "batch" treatment. Planting density of the continuous treatment was increased from eight to 16 plants/m^2. Because one quarter of the planting area was harvested and replanted every 26 days, a steady-state of canopy coverage between 60% to 75% of the chamber was maintained. Steady-state of CO_2 fixation was also maintained in the continuous treatment. There was no effect on either quantum efficiency, tuber yield, or harvest index of the plants grown in continuous production. Although replanting into "aged" nutrient solution resulted in earlier tuber initiation and reduced plant size, the system reached a steady state of production, which is desirable for advanced life support system.

264

A Heat Unit Model to Predict Growth and Development of Muskmelon (*Cucumis melo* var. *reticulatus* Naud.) to Anthesis

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Plant dry weight of muskmelon transplants to anthesis could be predicted from a multiple linear regression based on air and soil temperatures prevailing under 11 mulch and rowcover combinations. The two dependent variables of the regression model consisted of a heat unit formula for air temperatures with a base temperature of 14C and a maximum-reduced threshold at 40C, and a standard growing-degree-day formula for soil temperatures with a base temperature of 12C. Based on 2 years of data, 86.5% of the variation in the dry weight (on a log scale) could be predicted with this model. The base temperature for predicting time to anthesis of muskmelon transplants was established at 6.8C and the thermal time ranged between 335 and 391 degree-days during the 2 years of the experiment.

265

Weather Parameters Affecting Dry Bean Yields in Western Nebraska

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A phenological approach was used to test the effect of weather parameters upon yield of dry beans. A time series (1940 to present), cross-section of western Nebraska bean-growing counties coupled with weather variables taken from respective weather stations was used to estimate regression equations. Weather parameters in context of the phenological development of the dry bean were tested in predicting yields. Analysis of the error was used to explain unique historical events that impact yield outside of weather. The predictive ability of the equation can then be used by producers, Ag. Lenders, and other industry personnel to predict yield and thus total production for the western Nebraska dry bean industry.

266

The Maintenance of Charge Balance and pH in Hydroponic Solutions by Stock Nutrient Addition: A Possibility?

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The maintenance of pH in unbuffered nutrient solutions has important consequences for the hydroponic industry and proposed nutrient delivery systems for plants in space. The requirement for charge balance by a model plant system, dwarf wheat (*Triticum aestinum* cv. Yecora rojo), is largely a function of the uptake ratio of four cation species ($NH_4^+ K^+$, Ca^{2+}, and Mg^{2+}) and two anion species (NO_3^- and SO_4^{2-}) up to anthesis. The change in electrical conductivity (EC) and pH of the nutrient solution over time integrates the overall influx:efflux process of the plants. Solutions with three different NH_4:NO_3 ratios were sampled at 15-min intervals over a 12-h period at 9, 10, 16, 17, 23, 24, 37, and 38 days after planting. Exhaustion of N in the solution at all stages of ontogeny resulted in a 2- to 3-fold reduction in $\Delta pH/\Delta t$, despite high plant tissue N and irrespective of the concentration of other charge balance ions in solution. These data, combined with a plant nutrient uptake database (normalized for plant relative growth rate per mole PPF), suggest that a system can be developed to control pH by direct supply of various alternative nutrient stock solutions, rather than by the addition of H^+ or OH^- from acid or base.

267

Tissue Nutrient Content Dynamics of Wheat and Potato Grown under Highly Productive Field and Hydroponic Conditions

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Tissue nutrient (element) content profiles were determined for wheat and potato plants grown hydroponically (NFT) in NASA's Biomass Production Chamber (20 m^2) using a complete nutrient solution with electrical conductivity maintained at 0.12 $S \cdot m^{-1}$. Profiles were compared to patterns of nutrient accumulation during vegetative stages reported for highly productive wheat and potatoes grown in the field under a wide range of conditions. Among the essential elements, differences between the hydroponically and field-grown crops were observed only for Ca, Mg, and Mn in the recently mature leaves, and these differences were related to changes in growth phase and/or consistency of nutrient supply during plant growth. Nutrient profiles for both hydroponically and field-grown crops were also compared to deficiency and toxicity critical levels compiled by various workers. As expected for high-yielding crops, the profiles for both crops were well within the sufficiency ranges for all evaluated nutrients.

268

Development of Diagnostic Nutrient Sufficiency Criteria (Homeostatic Level) from High-yielding Wheat and Potato Plants

W.L. Berry[*1], *A. Matar*[1], *C.L. Mackowiak*[2], *G.W. Stutte*[2], *R.M. Wheeler*[3], and *J.C. Sager*[3], [1]UCLA/DOE Lab., Los Angeles, CA 90024; [2]Dynamac Corp., and [3]NASA Biomedical Operations and Research, Kennedy Space Center, FL 32899.

Elemental analysis of tissue is very useful in determining when plants are nutrient-stresses, but has less diagnostic value when concentrations are within the poorly defined sufficiency range. It has been postulated that, within the sufficiency range, there is a homeostatic, or equilibrium, level for each element. As a first approximation, we utilized the nutrient profiles of non-nutrient-limited, high-yielding wheat and potato crops during the vegetative growth phase. Plants were grown hydroponically (NFT) in NASA's Biomass Production Chamber (20 m^2) using a complete nutrient solution with the electrical conductivity maintained at 0.12 $S \cdot m^{-1}$. These profiles were compared to critical deficiency levels found in the literature for both field- and controlled environment-grown plants. The homeostatic concentrations for the various nutrients were found to be 3 to 8 times that of their respective deficiency critical levels, suggesting that nutrient status can be defined even within the sufficiency range.

118 ORAL SESSION 36 (Abstr. 269–276) Postharvest Physiology/Fruits

269

Ripening Physiology and Storability of Saskatoon Fruit

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Saskatoon (*Amleanchier alnifolia* Nutt.) fruit were stored into nine maturity stages based on color and size. Fruit color ranged from green (stages 1–4) to pink (5 and 6) to red (7 and 8) to purple (9). Fruit diameter of 'Smoky' increased linearly as maturity advanced from 1 to 9. Fresh weight increased by 46 mg/fruit for each stage between 1 and 6, and then increased by 141 mg/fruit for each stage between 7 and 9. Firmness declined linearly from maturity 1 to 5, then remained relatively constant through maturity 9. The ability of fruit of maturities 3, 5, and 7 to ripen after harvest was assessed over 6 days (23C). Color measurements of maturities 3 and 5 indicated a change from green to pink, but no further change to purple. Color of maturity 7 changed to equal that of fully ripe (purple) maturity 9 fruit. After 6 days, fruit firmness of maturities 5 and 7 was equal that of freshly harvested maturity 9 fruit; however, maturity 3 fruit were incapable of softening to the same degree as fully ripe fruit. While fruit harvested at stage 7 appear to ripen normally, a significant lower fruit fresh weight precludes harvesting at this stage. Internal C_2H_4 concentration of fruit, and production by fruit in an open air-flow system, were monitored for 'Northline', maturities 1–9. Internal C_2H_4 concentration of maturity 6 fruit was about 8-fold higher than that of maturity 4 fruit. Moreover, C_2H_4 production rate of maturity 5 fruit increased 3-fold from 10 to 25 h after harvest and then fell, reached the initial rate by 45 h after harvest. The respiration of these fruits also increased (by ≈70%) from 15 to 30 h after harvest, and then declined. Fruit color had changed from mostly green to red by 45 h after harvest. Collectively, these results indicate that saskatoon fruit exhibit a climacteric ripening patter. Results on the efficacy of controlled-atmosphere and hypobaric storage to delay physiological and pathological deterioration of saskatoon fruits will be presented.

270

Strawberry Fruit Temperature Affects Sensitivity to Bruising from Impact and Compression Forces

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Individual strawberry *(Fragaria xananassa* Duch.) fruits at cooled or ambient pulp temperatures were subjected to compression or impact forces to determine sensitivity to bruising. Fruits were more resistant to compression bruising at lower temperatures, but were more resistant to impact bruising at ambient temperatures. 'Chandler' fruits at 1C or 30C were compressed (9.8 N for 2 s); after 24 h @ 24C, bruise volumes were 0.27 cm^3 and 0.65 cm^3, respectively. Following a single impact from 13 cm, fruits at 1C or 24C had bruise volumes of 0.21 cm^3, and 0.10 cm^3, respectively. Increasing impact height to 38 cm caused bruise volumes of 0.31 cm^3 and 0.16 cm^3 for fruits at 1C and 24C, respectively. The potential exists to improve packout quality and efficiency for value-added strawberry packs. Due to greater resistance to impacts at ambient temperatures, strawberries could be bulk-transported to a central facility, and graded and packed on an appropriately designed packing line. Care must be taken to avoid compression bruising at harvest.

271

Hydrocooling as an Alternative to Forced-air Cooling for Maintaining Strawberry Quality

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'Sweet Charlie' strawberries *(Fragaria xananassa* Duch.) harvested at full ripe stage were 7/8-cooled by forced-air or hydrocooling to 4C, then held with or without a PVC film wrap in one of three storage regimes: 1) 7 days at 1C plus 1 day at 20C; 2) 7 days at 1C plus 7 days at 7C plus 1 day at 20C, or; 3) 7 days at 1C plus 5 days at 15C plus 2 days at 7C plus 1 day at 20C. Quality attributes, including surface color, firmness, weight loss, soluble solids and ascorbic acid content, pH, and titratable acidity, were evaluated after storage. Hydrocooled berries were better in overall quality, with better color retention, less weight loss, and lower incidence and severity of decay compared to forced-air-cooled berries. Strawberries wrapped in PVC film retained better color and had less weight loss and greater firmness, but greater incidence and severity of decay than berries stored uncovered. These results indicate good potential for using hydrocooling as a cooling method for strawberries.

272

Ethylene Evolution, Respiration, and Mold Development Studies in Some Selected *Rubus* Genotypes

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In 1993, we studied the postharvest behavior of 25 *Rubus* genotypes. Included in the study were named cultivars from Europe and North America, advanced selections from the Univ. of Maryland Cooperative Breeding Program, species and raspberry interspecific hybrids, with *R .phenicolasius, R. pungens oldhamii R sumatranus*, and *R parvifolius.* Wide variation exists in the ethylene production rates of these genotypes. The difference between the lowest ethylene producer, *R. phenicolasius*, and the highest ethylene evolver, HTCC-6t (*R. lasiostylus*), was four orders of magnitude. Ethylene evolution rate and percentage mold were not correlated. Ethylene production and respiration rates were also measured using a flowthrough system. No single pattern was characteristic of all genotypes. Red raspberries were the highest ethylene producers and showed an ethylene and respiratory climacteric. Blackberries were low ethylene producers. Interspecific hybrids showed varied postharvest behaviors. The behavior observed in these interspecific hybrids may explain some of the conflicting reports on the postharvest behavior of blackberries and raspberries. In general heat-tolerant species such as blackberry, *R. occidentalis, R. parvifolius* exhibited lower

rates of respiration and ethylene evolution than species from cool, temperate areas like *R. idaeus.*

273

Postharvest Quality of 'Thompson Seedless' Grapes after Insecticidal Controlled Atmosphere Treatments

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Nonfumigated 'Thompson Seedless' table grapes were stored in air or one of four atmospheres: 0.5% O_2 and 35% CO_2; 0.5% O_2 and 45% CO_2; 0.5% O_2 and 55% CO_2; and 100% CO_2. Grapes were stored at 5C and 20C for 6 and 4.5 days, respectively. The fruit were evaluated for weight loss, berry firmness, soluble solids, titratable acidity, berry shattering, rachis browning, berry browning, and volatiles (acetaldehyde and ethanol). Fruit quality was not affected at 5C; however, at 20C, controlled atmosphere (CA) treatments had a detrimental effect on rachis browning and soluble solids. CA at both temperatures induced the production of high levels of acetaldehyde and ethanol. After treatment at 5C, volatile concentrations were two-thirds lower than at 20C. A consumer taste panel evaluated fruit 3 days after removal from CA. Consumer preference was negatively affected by the CA treatments at 20C; however at 5C, consumer preferencewas not affected by the treatments. Preliminary data for mortality of Omnivorous Leafroller pupae (*Platynota stultana*), Western Flower Thrips adults (*Frankliniella occidentalis*), and Pacific Spider Mite adults (*Tetranychus pacificus*) indicate that many of these treatments would provide quarantine security.

274

Reducing Superficial Scald of Apples and Pear with Naturally Occurring Triterpenoid Compounds

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Superficial scald is a physiological skin disorder of apples and pears that develops in cold storage and that often increases in severity after the fruit is removed. It is thought to be associated with the accumulation of farnesene in the epithelial tissue. Currently used methods of controlling scald are diphenylamine (DPA) drenches, and controlled atmosphere (CA) to a limited extent. In order to expand the methods available to control scald, we have been investigating the potential of a number of naturally occurring compounds applied to the fruit surface by drenching or by topical application. Fruit were treated either by wiping the fruit surface with technical-grade material and then removing the excess, drenching whole fruit in aqueous emulsions, or drenching fruit in combinations of heat plus emulsion. After treatment, the fruit was air-dried for 30 min and then placed either in regular or CA storage for 6 months, after which time they were placed in a dark room at 68F for 7 days. Scald was evaluated and fruit condition assessed. Results from 3 years indicate farnesene and squalene reduce scald in apples and pears.

275

Effects of Postharvest Prestorage Hold Temperatures Followed by Cold or CA Storage on the Quality of 'Bartlett' Pears

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'Bartlett' pears were harvested from four commercial orchards at their optimum harvest date and 3 or 7 days later (depending on grower orchard). Samples were held for 3 or 7 days before stored in cold storage and two controlled-atmosphere conditions: 1) cold storage at 1C; 2) regular CA storage (2.5% O_2 + 1.0% CO_2 at –1C); 3) low-oxygen CA (1.0% O_2 + 0.2% CO_2 at –1C). After 2 months of cold and CA storage, pears showed that postharvest prestorage holding temperature, affected the rate of change in weight loss, firmness, ground color, and senescent breakdown. After 4 months of CA storage, 'Bartlett' pears maintained their quality at about 53–58 N of firmness. Firmness loss, peel ground color change, and senescent breakdown of 'Bartlett' pears were affected by the holding temperature and the length of the holding period between harvest and storage. In conclusion, pear quality was reduced depending on the holding temperature and holding period between harvest and storage. CA storage maintained better pear quality than cold storage. Fast oxygen pulldown in order to establish CA condition sooner was essential to maintain better pear quality.

276

Postharvest Cullage of 'Anjou' Pears

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Fruit cullage due to postharvest-expressed diseases and disorders of 'Anjou' pear amounted to $1.4–2.4 million annually to northwest growers in 1991–93. Fungal diseases, including *Penicillium* spp., *Botrytis cinerea*, and *Mucor* spp. accounted for the majority of losses. Scald, skin speckling, and scuffing are listed by packinghouse managers as major contributing disorders. A 3-year study has examined reasons for losses and methods to reduce losses through improved postharvest handling. Maturity at harvest, fruit nutrient status, time of packing, temperature management, and improved handling practices provide the basis for cullage.

119 ORAL SESSION 37 (Abstr. 277–284) Culture & Management/Fruits & Nuts (Temperate)

277

Early Response of High-density Peaches in Sod to Different Irrigation and Fertilizer Treatments

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Seven high-density (606 trees/ha) management systems for peach [*Prunus persica* (L.) Batsch cv. Harrow Beauty/Bailey] were compared on Fox sand in southwestern Ontario. Each system had an irrigation component (N = none D = drip, M = microsprinkler) and a fertilizer placement component (B = banded, L= low-rate fertigation, H = high rate fertigation). NB (nonirrigated, banded fertilizer) and DB (drip-irrigated) are commonly used systems in Ontario, while the other five treatment combinations were experimental. Trunk cross-sectional area (TCA) was generally greatest for DH and DB systems, smallest for ML and NB systems, and intermediate for the other three. No symptoms of N or K deficiency or excess were noted for any of the fertilizer treatments. The seven management systems each had similar cumulative yield efficiencies for the first 4 cropping years However, total marketable yields for the 4 years were highest for MB (58.7 $t \cdot ha^{-1}$), followed in descending order by DB (56.8 $t \cdot ha^{-1}$), DH (56.6 $t \cdot ha^{-1}$), MH (53.9 $t \cdot ha^{-1}$), DL (50.6 $t \cdot ha^{-1}$), ML (49.8 $t \cdot ha^{-1}$), and NB (47.5 $t \cdot ha^{-1}$). Each of the irrigated treatments outyielded the nonirrigated check (NB) and ranged from 4.8% to 23.6%. Only one of the irrigated treatments (MB) outyielded the irrigated check (DB), and by only 3.3%. There was no clear advantage for either the drip or microsprinkler system of irrigation. Banded application of N and K appeared to promote higher yields than by fertigation equivalent to the banded rate, while yields at the low rate of fertigation were lower than for either the high rate of fertigation or the banded application. It appeared that banded fertilizer combined with either microsprinkler (MB) or drip irrigation DB provided the most-effective of the management systems in the first 4 cropping years.

278

Early Performance of Four Apple Cultivars on Mark and M.26 Rootstocks

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To evaluate the interactions between cultivar and rootstock, four apple (*Malus domestica* Borkh.) cultivars, 'Pioneer Mac', 'Marshall McIntosh', 'Ginger Gold', and 'Empire' on two rootstocks, M.26 and Mark, were planted in a split-plot design. After 5 years, 'Pioneer Mac' and 'Ginger Gold' had larger trunk cross-sectional area (TCSA) on M.26 than on Mark. 'Marshall McIntosh' and 'Empire' had larger TCSA on Mark than on M.26. Precocity, expressed as both number of flower clusters and yield, was greater for trees on Mark for all cultivars except 'Ginger Gold', which had greater flower cluster numbers and yield on M.26. Fruit size was variable from year to year, depending on crop load; however, 'Pioneer Mac' and 'Ginger Gold' usually produced the largest fruit, while 'Empire' consistently produced the smallest fruit—'Ginger Gold' appears to be incompatible on Mark. The results of this study demonstrate that cultivar x rootstock interactions

can be significant and need to be considered when rootstock and planting density recommendations are made.

279

Performance of 'Gala' Apple Grown on Seven Rootstocks in Illinois

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Yield performance and postharvest quality of 'Gala' apple on Mac.39, P.1, Mark M.26E, M.9E, B.9, and M.27E were evaluated. Trees on B.9 and Mark had the highest yield efficiency, while trees on P.1 and M.9E had the lowest yield efficiency. Trees on P.1 were most vigorous, while trees on B.9 and M.27E were least vigorous. Trees and fruit buds survived a –32C during Jan. 1994. Fruit firmness, soluble solids, starch, and ethylene production rate were similar in fruits from all seven rootstocks at harvest. However, after 3 months in storage, fruits from trees on M.27E, P.1, and Mark rootstocks were less firm than fruits from trees on the other four rootstocks. Glucose, fructose, sucrose, and sorbitol levels at harvest and after storage were similar in fruits from all rootstocks.

280

Studies of the Vigor and Productivity of Micropropagated Trees

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A planting to compare budded apple trees (M7a, MI11) and tissue-culture-(TC) propagated trees was established in 1985. 'Golden Delicious' and 'Gala' trees were more productive than other cultivars and appeared better-suited to micropropagation. High cumulative yields per tree were harvested regardless of rootstock. 'McIntosh', 'Delicious', 'Mutsu', and 'MacSpur' trees were less precocious and more responsive to size-controlling rootstocks. To control tree size prior to bearing and minimize propagation time, trees were set as containerized transplants in a subsequent trial begun in 1986. Small containerized trees were set directly into the orchard. Setting trees in this manner has restricted tree size without delaying bearing. 'Oregon Spur II' trees and 'Empire' trees are now about 4 m tall. Trees have wide branch angles and numerous spurs. To further control tree size, trees were root-pruned with a Vermeer tree spade in 1991. In the year following, treated trees flowered profusely but did not fruit. Since then, cropping has controlled tree size. Ten years ex vitro 'Granny Smith', 'Oregon Spur II', and 'Empire' trees can be managed without ladders. The goals of this study were: 1) to avoid "short life" problems and 2) develop a management scheme that would allow rapid entry of "bioengineered" cultivars into commercial orchards. Based on our research, selecting precocious cultivars or spur-type clones, in combination with transplanting 3 to 4 months ex vitro and root pruning show promise toward accomplishing these goals.

281

Evaluation of Commercial Potential of Asian Pear Cultivars in South Carolina

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An Asian pear variety trial consisting of 13 cultivars replicated 12 times was planted in 1989 near Columbia, S.C. For 6 years, cultivars were evaluated for commercial fruit production. The Chinese types 'Ya Li' and 'Shin Li' bloomed earliest (early March), whereas Japanese types such as 'Twentieth Century' and 'Choju' bloomed 10 to 12 days later. The largest trees were 'Ya Li', 'Shinsei', and 'Shin Li', and the smallest were 'Shinko', 'Shinsui', and 'Twentieth Century'. All cultivars on *P. betulaefolia* rootstock had suckers, with 'Chojuro' and 'Shinko' trees having the fewest. 'Kosui' and 'Shinsui' defoliated first each fall. Average fruit yields in kg/tree were largest for 'Ya Li', 'Shinsui', 'Shin Li', and 'Twentieth Century'. Fruit size was large (>200 g) for the Chinese types such as 'Ya Li', 'Shin Li', and 'Daisu Li', but small (<100 g) and non-commercial for 'Twentieth Century'. Fruit maturity dates were consistent year to year, with 'Choju' and 'Shinsui' ripening first (early July) and the Chinese types ripening last (mid-August). Low return bloom (i.e., alternate bearing) was observed after a heavy crop year. Winter injury, as evidenced by bark cracking on the southwest side of the trunk, was severe in 1993–1994. However, 'Ya Li' suffered no cold damage. Fireblight was first observed in the 1992, and increased in 1993 and 1994. 'Choju', 'Shinseiki', and 'Kosui' were the most-susceptible cultivars, while 'Ya Li', 'Shinsui', and 'Shinko' were the most tolerant.

282

Nimblewill Ground Cover for Biocontrol of Ring Nematode in Peach Orchards

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Benefits of nimblewill (Ms = *Muhlenbergia schreberi*), a warm-season, perennial grass, as an orchard ground cover are: 1) it is not competitive with tree growth and 2) it reduces ring nematode (Cx = *Criconemella xenoplax*) soil population, even in the presence of a tree fruit host. Ms is difficult to establish in orchards in warm fruit-growing regions. In field studies, we found that Ms establishment was decreased by chemical mowing relative to seeding only. Successive years of reseeding at 22 kg seed/ha per year, mechanical mowing, and control of winter annuals gave best establishment of Ms in peach orchards. An orchard microplot study was established to evaluate effects of five Ms densities and two Ms sources on Cx population and on growth of 'Redhaven'–Lovell trees (10 replications). Cx numbers were reduced hyperbolically in response to Ms density. Ms cover of 5 g dw/m^2 (planted at 9 kg seed/ha) reduced Cx from 200 (control) to the accepted threshold of 50 Cx/100 cc soil. Maximum Cx reduction to 26 Cx/100 cc was obtained at 34 g dw/m^2 Ms (planted at 40 kg seed/ha). Cx response to Ms density was not affected by Ms source.

283

Mystery Spot of 'Enterprise' Apples Appears to Be a Low-calcium Disorder

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The apple cultivar Enterprise is a product of the Purdue–Rutgers–Illinois (PRI) disease-resistant apple breeding program. It has field immunity to apple scab, has a high level of resistance to cedar apple rust and fire blight, and is moderately resistant to apple powdery mildew. This resistance to these diseases makes the production of this cultivar desirable, especially on the popular fire blight-susceptible M.26 rootstock. Compared to many other scab-resistant cultivars, 'Enterprise' has performed well in the mid-Atlantic area. However, this cultivar has been reported to be susceptible to low-Ca disorders when grown in New Jersey and Virginia. The mid-Atlantic area is notorious for the production of fruit with high levels of corking and bitter pit. This may be due to factors such as vigorous tree growth and low transpirational flow, which may be weather-related. Circumstantial evidence based on the production of clean 'Enterprise' at Biglerville, Pa., where moderately high rates of $CaCl_2$ have been applied in cover sprays, indicate that this disorder may be a Ca deficiency symptom. A replicated trial of many scab-resistant cultivars was established in 1990, 1991, and 1992. Due to the common incidence of low-Ca disorders, $CaCl_2$ has been added to the cover spray program that is applied for insect control. Low-Ca disorders have never been seen in fruit produced at Biglerville, and the cover spray program applied 67 and 73 kg·ha^{-1} of $CaCl_2$ (77% to 80% $CaCl_2$, flake) in 1993 and 1994, respectively.

283

Intermittent $CaCl_2$ Sprays during Rain to Prevent Sweet Cherry Cracking

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Fruit of sweet cherry *(Prunus avium* L.) crack during or after rain due, in part, to absorption of water through the fruit surface driven by the water potential gradient. In 1972, J. Vittrup-Christensen suggested that overhead misting of calcium salts during precipitation may be an effective way to prevent cherry cracking by reducing the water potential gradient. We tested this hypothesis by designing a computer-controlled irrigation system to intermittently spray a 10% $CaCl_2$ solution on trees during rain events. Spray emitters were placed in the middle and at the top of the canopy. The program turned the system on for 90 s at each 0.3 mm of rain and monitored daily rainfall and accumulated mist times. Two 'Emperor Francis' and two 'Ulster' were treated with equal number of controls. Intact and cracked cherries were counted on four branches per tree at three times when cherries were susceptible to cracking. Overall, cracking was reduced from 33% to 11% by the $CaCl_2$ spray at the end of the experiment. Treated 'Ulster' had 9% cracked fruit, while control had 43% cracked fruit. Differences for 'Emperor Francis' were not significant. Phytotoxicity was estimated at about 15 % of leaf area. This system will be reevaluated in 1995 with the added objective of quantifying and reducing phytotoxicity.

129 ORAL SESSION 38 (Abstr. 285–291) Culture & Management/Woody Ornamentals & Landscape

285

Growth Comparison of Trees Produced under Three Production Methods and Two Irrigation Treatments

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Patmore green ash (*Fraxinus pennsylvanica* 'Patmore'), Bur oak (*Quercus macrocarpa)*, and Austrian pine (*Pinus nigra*), were used to measure growth differences of trees produced using three different production methods: balled and burlapped, plastic container, and fabric container (grow bag). Two irrigation frequencies were also established. A pressure chamber was used to measure the xylem water potential and to determine tree water requirements and irrigation scheduling. The balled and burlapped trees showed the least new growth of the three production methods across all three tree types. The production method showing the most new growth varied by genera. Plastic container ash trees grew considerably more than the fabric container ash; fabric container oak grew significantly more than plastic container oak; and there was no measurable difference between the new growth of the plastic container and fabric container pines. The fabric container transplants required more frequent irrigation than did the balled and burlapped trees. Under high temperature and drought conditions, fabric container trees showed stress earlier than did the balled and burlapped or plastic container trees.

286

Utilization of MSW for Nursery Container Stock Production

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Five composted Municipal Solid Waste (MSW) (garbage) products and a composted manure were evaluated as container growing media components on eight woody and herbaceous plants. Plant growth response to the different composts and to the quality of compost used was species-specific. Media UM Manure 100 provided the greatest increase in plant height across all species during the first year. However, only one species, *V. lentaga*, actually ranked number one in UM Manure 100. J.h. 'Blue Chip' and *A. tuberosa* both grew the tallest in Control I. The remaining five species grew tallest in five different media. Therefore, several amended media can provide increased plant height for specific species; however, the top three media for plant height across all species were: #1 UM Manure 100, #2 Prairieland 50, and #3 Pennington 50. Plant height was the lowest in Recomp 100 media. Pennington 50 provided the greatest increase in plant volume. Media producing the highest plant dry weights across all species were: #1 Prairieland 50, #2 Pennington 50 and #3 UM Manure 50. Plants grown in Recomp 100 had the lowest plant dry weight. Media physical properties such as media drainage and aeration were affected by amendment quality and quantity.

287

Evaluation of Incorporated Slow-release Fertilizers for Two-year Container Production Systems.

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Media fertility, nutrient availability, and subsequently plant nutrition are critical factors that can be modified by growers to produce quality container-grown plants. The trend in container fertility has been toward incorporation of slow-release fertilizers; however, fertility release curves are variable and fertilizer longevity for many fertilizers is limited. Seventeen slow-release fertilizers were compared for longevity and plant performance over a 2-year production cycle using deciduous and evergreen plant materials. Plant growth was quantified based on height, volume, branching, dry weight, and quality. Soil fertility levels based on leachates were followed. Nutrient release for the incorporated fertilizers evaluated was variable. Fertility treatment effects were species-dependent. Several incorporated, slow-release fertilizers, especially those high in nitrogen and having extended release curves, including Nutricote 20–7–10, Scotts Experimental 24–6–10 and 26–6–11, Scotts Prokote Plus 20–3–10, Sierra 17–6–10, Sierra High N 24–4–6, Sierra Experimental 24–4–8, Woodace 21–4–10, Woodace 23–7–12, and Woodace Briquettes 23–2–0, show promise for use in 2-year container production systems.

288

Leaching Characteristics of P From Four Fertilizer Sources in a Container Nursery Growing Medium

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A 3 pine bark : 1 peatmoss: 1 sand (by volume) medium was amended with 7.7 g P as superphosphate, triple superphosphate, ammonium phosphate, or controlled-release ammonium phosphate per 1000 g medium (3.8 liters). The medium was then leached with 250, 350, or 450 ml distilled, deionized water daily for 25 days. Phosphorus leaching curves were then generated for each fertilizer. A subsequent study determined the effect of these four P fertilizers on growth of marigold seedlings in the greenhouse. Superphosphate, triple superphosphate, and ammonium phosphate rapidly leached from the medium, while the controlled-release ammonium phosphate was retained for a longer time. Marigold growth was not affected by fertilizer type; however, marigolds grown in P-amended media were larger than those grown without P. These studies indicate that amending container growing medium with superphosphate or triple superphosphate prior to planting may not be cost-effective.

289

Optimum Soluble and Slow-release N Rates for Rhododendrons and the Fate of Such N Applied to Various Potting Media

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Two year-long, factorial experiments were conducted on *Rhododendron catawbienses* (cv. Roseum elegans) grown in 2.3-liter plastic pots. I) Annual N rates of 0, 0.4, 0.8, 1.6, and 3.2 g/pot were applied as NH_4NO_3 (SBL) or sulfur-coated urea (SR) to plants potted in a composted hardwood bark (CHB)/peatmoss (P)/sand (S) medium. Plant growth and quality was best at 0.8 g N/pot for SBL and 1.6 and 3.2 g N/pot for SR. II) Annual N rates of 0.8 (SBL) and 2.4 (SR) g/pot were chosen as optimum rates and applied to plants potted in the following media: pine bark (PB)/P/S; CHB/P/S; P/S; and PB/CHB/P/S. Plant growth and N uptake was best in PB/PS. Plant quality was best in P/S. NO_3 in leachate did not differ among media, but was greater in SBL. Total N immobilized in media was greater in PB/CHB/P/S. N recovered from SR-treated pots as unused fertilizer did not differ among media. Total applied N recovered was 90% for SBL and 51% for SR.

290

Growth and Potential of Root Regeneration of Trees Grown in Cupric Hydroxide-coated Fabric

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The most widespread deformation observed in container production is root circling. Consequently, root circling often reduces growth, root regeneration, and tree anchorage at transplanting time. The objectives of this study were to test the effectiveness of $Cu(OH)_2$ lined containers on restriction of root tips, tree growth, and potential root regeneration (PRR). Two species were used in this study: *Fraxinus pennsylvanica* and *Acer saccharinum.* Species were grown for one season in containers lined with one of six combinations of polymer (P) (0, 30, and 60 $g \cdot m^{-2}$) and copper (Cu) (0%,0.4%, and 0.8%) -coated fabric. Two other treatments were included as controls: a plastic container and a fabric container. Seedlings of each species were harvest twice: at the first season and after being transplanted from 10- to 75-liter containers. Treatments were randomized in complete blocks with six repetitions. Results of root circling length and dry weight indicate good restriction of root tips for two combinations (30 g of P/m^2–0.8% Cu; 60 g of P/m^2–0.8% Cu) for all species. However, treatments did not cause any reduction in stem height, trunk diameter, or stem and root dry weight. At the end of the transplanting season, PRR was greater for two combinations (30 g of P/m^2–0.8% Cu; 60 g of P/m^2–0.8% Cu), especially for green ash. No significant differences were observed between a plastic fabric and the two treatments cited for the other growth parameters. No phytotoxic symptoms were observed throughout the experiment.

291

Production System and Copper Hydroxide Influences on Growth and Photosynthesis of *Magnolia grandiflora* 'St. Mary'

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A study was conducted with *Magnolia grandiflora* 'St. Mary' to evaluate the effects of a pot-in-pot production system compared to a conventional above-ground production system and containers treated with or without copper hydroxide (Spin Out™). At 4 and 12 months after beginning the study, plants grown pot-in-pot were taller than plants in the conventional system. Stem diameters of plants grown pot-in-pot were also larger at 12 months. Production system influenced root dry weight in the outer 50% of the container, total root dry weight, percent root dry weight in the inner 50% of the container, percent root dry weight in the outer 50% of the container, and total biomass. Production system had no effect on shoot dry weight. Treatment with copper hydroxide had no effect on root or shoot growth. Production system and copper treatment influenced degree of root coverage. Plants grown pot-in-pot had higher rates of Ps and g_s with increased C_i levels compared to plants above-ground. Production system had no effect on calculated transpiration rates.

130 ORAL SESSION 39 (Abstr. 292–297) Breeding/Fruits & Nuts (Tropical Subtropical)

292

Freezing Tolerance of Citrus Hybrids USDA 17-11 and USDA 119 Compared to 'Hamlin' Orange and Satsuma Mandarin

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Citrus hybrids USDA 17-11 [*Citrus grandis* L. x (*C. paradisi* Macf. 'Duncan' x *Poncirus trifoliata* (L.) Raf. 'Gotha Road')] and 119 [(*C. paradisi* Macf. 'Duncan' x *P. trifoliata* (L.) Raf. 'Gotha Road') x *C. sinensis* (L.) Osb. 'Succory'], 'Hamlin' orange [*C. sinensis* (L.) Osb.], and satsuma mandarin (*C. unshiu* Marc.) were planted March 1993 and 1994. Trees were irrigated and fertilized in an identical manner. In 1993, electrolyte leakage readings were taken monthly using 17-11, 119, and satsuma leaf discs. Leaf killing point (LKP) LT_{50} averaged from –8 to –9C by mid-November for all selections. In 1994, leaf discs from 17-11, 119, and 'Hamlin' orange were sampled weekly to determine LKP. USDA 119 had the lowest LKP and acclimated the fastest during the fall. By the end of November, there was no significant difference in LKP (–6.5C) between USDA 119 and 17-11, although both selections were significantly more freeze-tolerant than 'Hamlin' orange (LKP –40C), which showed no significant decrease in LKP until the 6 weeks after the hybrid selections began acclimating. Citrus hybrids 17-11 and 119 can survive in freeze-susceptible areas that are marginal for other commercial citrus.

293

The Effect of Avocado Clonal Rootstock on Productivity and Tree Vigor of 'Hass' Avocado

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A project evaluating the performance of cv. Hass on eight clonal avocado rootstocks—G755A, G755B, G755C, Duke 7 (D7), Borchard (BR), D9, Toro Canyon, and Topa Topa was established in southern California in 1986. Two additional rootstocks, Thomas and G1033, were added in 1987. Of the trees planted in 1986, the BR and D7 rootstocks have consistently had the highest total yields for all rootstocks, whereas the three G755 selections have had the lowest productivity. No differences in productivity between the two rootstocks planted in 1987 have been detected. The influence of rootstock on the magnitude of alternate bearing will be discussed, although the oscillation in yield is greater for the higher-yielding rootstocks. Tree size has been measured throughout the study. The BR selection has consistently produced a larger tree, even though it has continued to have high productivity. There are no consistent differences between the other rootstocks. Yield efficiency, measured as the kg fruit/m^3 of canopy volume has been calculated. In selections that are prone to severe alternate bearing, the swing in yield efficiency is also the greatest. The data thus far suggests that a yield efficiency of ≈2.5 kg fruit/m^3 canopy volume is the maximum yield possible for California 'Hass' avocado.

294

Performance of Arizona and California Guayule Lines in Southern Texas

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Guayule (*Parthenium argentatum* Gray) is a promising alternative to (*Hevea brasiliensis* Muell. Arg.) for rubber production in semiarid regions. Substantial improvement in yield is needed to establish guayule as a competitive source of natural rubber. A 4-year field study was conducted on a dryland site in southern Texas to evaluate productivity of selected guayule breeding lines from Arizona and California. Plants were harvested at the age of 22, 34, and 46 months and analyzed for dry weight, resin content, rubber content, resin yield, rubber yield, and percent mortality. While significant differences ($P = 0.05$) were found for dry weight, resin content, and rubber content within the harvest dates and among the guayule lines, no significant differences were found for rubber content between the harvest dates for each genotypes. Phytomass was highly correlated ($r = 0.94$) with rubber yield. Survivorship of all the guayule lines decreased progressively over the experimental period and mortality rates ranged from 38% to 67 % . Guayule lines 'UC102' from California and 'N6-5' and 'P3-1' from Arizona were ranked highest for all traits measured.

295

Genotype-by-environment Interaction in *Musa* Germplasm Revealed by Multi-site Evaluation in Sub-saharan Africa

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Two multilocational trials, one comprising 18 *Musa* clones in three locations and another of 20 genotypes across 11 locations, were set up in 1991 and 1992, respectively, to assess the genotype-by-environment interaction (GxE) for important traits and to select stable high-yielding and black sigatoka (BS)-resistant genotypes. Combined ANOVAs showed significant differences among environments and among genotypes for all traits. GxE affected all growth and yield parameters, except fruit girth. Host response to BS disease also showed significant GxE, but there was no cross-order season-by-year interaction. Hence, genotypic response to BS can be assessed in 1 year during the rainy season, when disease pressure is highest. Genotype-by-location effects were more important than the nonsignificant genotype-by-year effects, supporting the need for multilocational trials. Stability analysis showed that full-sib plantain hybrids ($TMPx^1$) exhibited different host responses to BS as well as different interaction patterns, suggesting that selection for stable BS resistance is possible. The BS-resistant TMPx genotypes had higher yields than the plantain landraces, but showed differences in yield stability. TMPx 1658-4, 2796-5, 5511-2, and 6930-1 have been selected as stable high-yielding hybrids, while the initial best selections (TMPx 548-4 and 548-9) were top yielders only in good environments. [Vuylsteke, D., R. Swennen, and R. Ortiz. 1993. Registration of 14 improved tropical *Musa* plantain hybrids with black sigatoka resistance. HortScience 28:957–959.]

296

Genetic Diversity in *Nephelium*

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Fifty-six accessions involving five taxa of *Nephelium* (*N. lappaceum* varieties *lappaceum* and *pallens*, *N. hypoleucum*, *N. ramboutan-ake,* and *N. cuspidatum*) were fingerprinted and evaluated for genetic diversity using isozyme polymorphism. All five taxa were polymorphic for most of the enzymes encoded by 10 putative loci. Number of alleles per locus ranged from three for *Pgi-1* to nine for *Pgi-2* with a total of 57 alleles. Thirty-eight accessions out of 56 possessed unique isozyme genotypes, indicating a high level of diversity in the collection. On average, 80% of the loci were polymorphic and the expected and observed heterozygosities were 0.374 and 0.373, respectively. The cluster analysis of the isozyme data revealed five distinct clusters representing the five taxa included in the study. Genetic differentiation within *N. lappaceum* var. *lappaceum* was evident from the cluster analysis. Isozyme data indicated that *N. ramboutan-ake is* the closest relative of *N. lappaceum* var. *lappaceum,* followed by *N. hypoleucum*, *N. lappaceum* var. *pallens*, and *N. cuspidatum*. Interestingly, the varieties of *N. lappaceum* exhibited genetic divergence far beyond that of the congenerics, *N. hypoleucum* and *N. ramboutan-ake* and may require a taxonomic revision.

297

Isozyme Variation in Lychee (*Litchi chinensis* Sonn.)

*F. Zee**[1], *K.M. Aradhya*[2], and *R.M. Manshardt*[2], [1]U.S. Dept. of Agriculture (USDA/ARS), National Clonal Germplasm Repository, Hilo, HI 96720; [2]Dept. of Horticulture, Univ. of Hawaii at Manoa, Honolulu, HI 96822.

A genetic diversity analysis involving 49 lychee (*Litchi chinensis* Sonn.) accessions using eight enzyme systems encoding 12 loci (*Idh-1*, *Idh-2*, *Mdh- 2*, *Per-1*, *Pgi-2*, *Pgm-1*, *Pgm-2*, *Skdh*, *Tpi-1*, *Tpi-2*, *Ugpp-1*, and *Ugpp-2*) revealed moderate to high levels of genetic variability. Cluster analysis of the isozyme data from 40 genetically different accessions of the total 49 identified three groups at the 50% level of genetic similarity, the largest of which contained 32 of the 40 accessions distributed in three sub-groups. The groups including the three subgroups differed in frequency and composition of alleles at different loci. Polymorphism was observed in 77% of the loci, with an overall mean of 2.2 alleles per locus and an observed heterozygosity of 0.387. The unbiased genetic identities (I) between groups ranged from 0.809 to 0.937. Summing over all 11 polymorphic loci, 16% of gene diversity was due to differentiation between groups and 84% within groups. Comparison of isozyme fingerprints revealed that some accessions with identical names, particularly of 'No mai tsz', 'Kwai mi', and 'Hak ip', possessed different isozyme genotypes, while other accessions with different names displayed identical isozyme genotypes. Isozyme fingerprinting will be useful in revealing and resolving questions of clonal identity, which are common in lychee germplasm collections.

131 ORAL SESSION 40 (Abstr. 298–305) Breeding/Vegetable Crops

298

Genetic Structure of Pejibaye Heart of Palm Yield Precocity at an Ideal Site in Hawai'i

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The pejibaye *(Bactris gasipaes* Kunth) is being evaluated in Hawai'i for its fresh heart of palm, a gourmet vegetable. Seven half-sib progenies of the Putumayo land race were planted in a split-plot design, with densities (3333, 5000, 6666 plants/ha) as the main plots, progenies as the sub-plots, three replications, and nine plants/plot. Precocity was defined as "days from planting to harvest"; relative growth rate (RGR) and unit leaf rate (Ea) are possible causes of precocity and were estimated for the period from 6 months after planting to harvest. Density effects were never significant, suggesting that competition is not significant before harvest. Mean precocity ranged from 610 to 712 days; V_a accounted for 14% of the phenotypic variance (V_p), with $h^2 = 0.57$, similar to fruiting precocity in African oil palm (*Elaeis guineensis* Jacq.). Mean E_a ranged from 1.89 to 2.21 g/m^2 per day, V_a accounted for 8% of V_p, with $h^2 = 0.33$ Mean RGR ranged from 0.0086 to 0.0102 d^{-1}; V_a accounted for 9% of V_p, with $h^2 = 0$ 35 Neither RGR (r = 0.20) nor E_a (r = 0.19) are significantly correlated with precocity. Heart, edible stem, and total edible product weights did not present significant progeny effects, probably because of the criterion used to determine harvest (height = 1.3 m). Precocity is easiest to work with and should give acceptable genetic gains.

299

Breeding Lettuce for Big Vein Resistance

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Big vein is a disease of lettuce; symptoms include vein clearing and delayed head formation. Big vein virus is vectored by a fungus that inhabits lettuce roots. We developed a greenhouse screening procedure to evaluate cultivars and breeding materials for resistance, which is relative and based on the proportion of plants in a population that show no symptoms at an arbitrary time after inoculation. We have screened 744 cultivars in preliminary tests. Of these, 49 showed promise for resistance. Eleven of the promising cultivars showed consistent resistance in replicated greenhouse and field trials. In breeding populations, reaction of single plants is not as reliable an indicator of resistance as the reaction of plant groups. Therefore, F_3 families are more useful than the F_2 for screening. Field test rankings of materials selected with this method are consistent with greenhouse evaluations.

300

Genetic Parameters for Traits Related to Mechanized Harvesting in a Cucumber (*Cucumis sativus* L.) Population

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Sex expression (SE), stem length (SL), and number of laterals plant (NL) are important morphological traits of a cucumber plant ideotype adapted for machine harvesting. Two inbred lines, the determinate, gynoecious G-421, possessing high fruit quality, and the monoecious H-19, with multiple lateral branching and sequential fruiting habit, and their F_1 and F_3 (100) progenies were planted in Wisconsin and Georgia. Data on SE, SL, and NL were recorded on individual plant basis. Genetic parameters were estimated using all generations. Phenotypic correlations were calculated from the trait means, and genotypic correlations were estimated from the analysis of variance of F_3 progeny. The additive genetic variance was the highest of the variance components for SL and NL. Dominance genetic variance was more important than the additive variance for the control of SE. Narrow-sense heritability were 0.41, 0.83, and 0.85 for SE, SL, and NL, respectively. The genotypic (g) and phenotypic (p) correlation coefficients (r) indicated negative association between SE and SL (r_g = –0.57, r_p = –0.45**) and between SE and NL (r_g = –0.56, r_p = –0.27**). The association between SL and NL was positive (r_g = 0.63, r_p = 0.35**). Results suggest that gain from selection can be made for this plant ideotype.

301

Inheritance of Resistance to Root-know Nematode (*Meloidogyne arnaria*) in Cucumber (*Cucumis sativus*)

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The inheritance of resistance to *M. arenaria* races 1 and 2 in *Cucumis sativus* var. *hardwickii* (R.) Alef. line LJ 90430 was studied in several crosses with cultivated cucumber (*C. sativus* L.). Initially, parents, F_1, F_2, and BC_1 to both parents of 'Sumter' x LJ 90430 tested in a split-root experiment showed that resistance was quantitative. In addition, it appeared that the same genes were controlling resistance to race 1 and race 2 of *M. arenaria* (genetic correlation of 0.97 and 0.99 for gall index and egg mass data, respectively). In later greenhouse experiments, two other families were evaluated ('Addis' x LJ 90403 and 'Poinsett 87' x LJ 90430) for inheritance of resistance to *M. arenaria* race 1. In all crosses using gall index data, additive variance was the largest component of genetic variance, and estimates of narrow-sense heritability ranged from 0.50 to 0.85 (0.57 to 0.81 for broad-sense heritability). Estimates of the minimum number of genes (effective factors) using gall index data ranged from 1.1 to 2.7 (0.2 to 0.3 for egg mass data).

302

Ccreening Onions (*Allium cepa* L.) and Other *Allium* spp. for Botrytis Leaf Blight Resistance

Thomas W. Walters[1], Leroy A. Ellerbrock*[1], *Jan J. van der Heide*[1], *James W. Lorbeer*[2], and *David P. LoParco*[2], [1]Dept. of Fruit and Vegetable Science, [2]Dept. of Plant Pathology, Cornell Univ., Ithaca, NY 14853.

Greenhouse and field methods were developed to screen *Allium* spp. for resistance to Botrytis leaf blight (caused by *Botrytis squamosa* Walker). In the greenhouse, plants were sprayed with laboratory-grown inoculum and incubated in a temperature-controlled enclosure containing an atomizing mist system. For field inoculations, a portable misting system with windbreaks was erected, and the plants were sprayed with laboratory-grown inoculum. Greenhouse and field incubation conditions maintained leaf wetness without washing inoculum from the leaves. Botrytis leaf blight symptoms in greenhouse and field evaluations were identical to symptoms in commercial onion fields. A total of 86 selected USDA *Allium* collection accessions were evaluated using these methods. All *A. fistulosum* accessions and *A. roytei* were highly resistant to immune, as were most accessions of *A. altaicum*, *A. galanthum*, *A. pskemense*, and *A. oschaninii*. Nearly all of the *A. vavilovii* and *A. cepa* accessions were susceptible. However, one *A. cepa* accession (PI 273212 from Poland) developed only superficial lesions, which did not expand to coalesce and blight leaves. This work confirms previous reports of Botrytis leaf blight resistance in *Allium* spp., and suggests that strong resistance exists with *A. cepa*.

303

Cryopreservation of Tomato Pollen

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We have developed a method for cryopreserving *Lycopersicon esculentum* pollen to facilitate the timing of crosses and for long-term germplasm conservation. Gelatin capsules containing pollen were wrapped in tissue paper and placed in air-tight glass tubes with anhydrous calcium sulfate desiccant. Tubes containing pollen were stored at –80C. In one experiment, we stored the pollen of LA359 and T5 at –80C for 37 days. Pollen predesiccated overnight at 4C then stored at –80C, pollen put in a tube with desiccant then immediately stored at –80C, and fresh pollen were compared by pollinating 10 flowers of LA359 with each of the six pollen treatments and counting the number of seed per fruit. Average seed counts ranged from 127 for fresh, T5 pollen to 172 for predesiccated LA359 pollen. In another experiment, cryopreserved pollen of UC82B and VFNT Cherry was given from 0 to 6 cycles of freezing and thawing. Ten flowers of LA359 were pollinated with each of the 12 treatments. Average seed counts ranged from 125 to 152. The data from both experiments suggest that cryopreservation of tomato pollen to facilitate efficient plant breeding is feasible.

304

Variation for Calcium Concentration among 64 Genotypes of Snap Bean (*Phaseolus vulgaris*)

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Calcium is an essential element for human nutrition. The lack of it causes various problems, such as osteoporosis. Snap beans rank as good sources of calcium among vegetables and are well-liked by most teenagers. In this study, pod yield and Ca concentration were analyzed for 64 genotypes of snap beans, plus four checks. The experimental design was a 8 x 8 double lattice, repeated at two locations (Arlington and Hancock, Wis.). Snap beans were planted in June 1993 and machine-harvested 67 days later, in Aug. 1993.Calcium analyses were made using an Atomic Absorption Spectometer. Results indicated significant differences for pod Ca concentration and yield. Pod size and Ca concentration showed a strong negative correlation (R = 89.5). Clear differences among the locations were also observed. Results were consistent—high-Ca genotypes remained high regardless of location or pod size. Selected genotypes appeared to have the ability to absorb Ca easier than others, but this factor was not related to yield.

305

Breeding Tomatoes for Attractiveness to Pollinating Insects

*Richard W. Robinson**, Horticultural Science Dept., Cornell Univ., NY Agricultural Experiment Station, Geneva, NY 14456.

Bumblebees are commercially used to improve fruit set of greenhouse tomatoes, but they seldom pollinate tomatoes outdoors if not confined in a no-choice situation. Bumblebees frequently pollinated *L. peruvianum* and other self-incompatible (SI) *Lycopersicon* species, but not tomato plants, in the field at Geneva, N.Y. Bumblebees were very efficient pollinators of SI *Lycopersicon* species, averaging only 5 s to pollinate one flower and fly to the next. Transfer of this attractiveness to pollinating insects to the tomato could improve fruit set of tomatoes grown in greenhouses with introduced bumblebees. It could also improve fruit set in the field, especially when conditions are poor for pollination. It has potential use for producing F_1 hybrid seed, but associated problems make hybrid tomato seed production by insect pollination impractical now. Attractiveness to pollinating insects is being introgressed from *L. peruvianum, L. hirsutum,* and *L. pennellii* in the tomato breeding program at Geneva, N.Y. Several floral characteristics were found to be of importance for attracting pollinators, including the reaction to ultraviolet light. Flowers of SI species absorbed UV, whereas tomato flowers reflected UV light.

132 ORAL SESSION 41 (Abstr. 306–313)
Water Stress–Utilization/Cross-commodity

306

Deficit Irrigation in 'Braeburn' Apples: Fruit Water Relations and Plant Growth

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Information on fruit water relations is scant for apple trees, especially under deficit irrigation. Here we discuss plant and fruit responses to deficit irrigation. Three-year-old potted 'Braeburn' trees were studied in a glasshouse. The treatments were: well-watered control (C), early deficit (D1), and late deficit (D2). The latter two were, respectively, water stressed during 61–183 and 109–183 days after full bloom (DAFB). The final harvest was at 183 DAFB. Photosynthesis, stomatal conductance, and trunk circumference were lower in D1 and D2 than in C. Leaf area and shoot growth was reduced only in D1. Root length remained the same for all treatments. Fruit were smaller in D1 than in C; however, fruit growth was less sensitive to deficit irrigation than was vegetative growth. Fruit growth in D2 was the same as in C. Fruit concentrations of K^+, fructose, sorbitol, total sugars, and titratable acidity were higher in D1 than in D2 and C. Total soluble solids were higher in D1 and D2 than in C. Although fruit water potential was lower in D1 than in C, a concomitant lowering of osmotic potential in D1 fruit led to maintenance of turgor potential, indicating osmotic adjustment. This could have been effected, at least partially, through accumulation of K^+ and soluble sugars. Water relations of D2 fruit were not affected by deficit irrigation, although leaf water potential was lower than in C. Fruit water relations and fruit growth are therefore less sensitive to deficit irrigation than are those of vegetative parts.

307

Determination of Cavitation Response in Stems of Apple Rootstocks and Hawthorn Seedlings with a Pressure Chamber

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Stems of 1-year seedling Washington hawthorn (*Crataegus phaenopyrum*) and 1-year layers of apple rootstocks M.9 and M.26 EMLA were subjected to positive air pressures in a double-open-end pressure chamber to determine the cavitation response of each taxon. Inferences regarding relative desiccation tolerance of the taxa can be made by comparing the range of applied pressures over which air-seeding and subsequent reduction of water flux through xylem conduits is induced. M.9 rootstock maintained higher levels of water flux relative to M.26 EMLA or Washington hawthorn at pressures between 3.0 to 4.0 MPa, suggesting greater resistance to water stress-induced air-seeding in the former compared to the latter two taxa. The cavitation responses of M.26 EMLA and Washington hawthorn were indistinguishable from each other. Inferences regarding water stress-induced cavitation response will be discussed relative to this technique.

308

Effects of Irrigation with Reclaimed Water on Citrus Tree Performance

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'Hamlin' oranges and 'Orlando' tangelos on four rootstocks have been irrigated since planting in 1987 with highly treated reclaimed effluent water at application rates of ≈500, 1250, and 2500 mm/year. Reclaimed water treatments have been compared to a well water control at 500 mm/year. Tree growth, yield, and fruit quality have been satisfactory for all irrigation treatments. Growth and yield of 'Orlando' tangelos was greatest at the 2500 mm rate and yield was highest on 'Swingle' citrumelo and 'Carrizo' citrange rootstocks. 'Orlando' tangelos benefited more from the high irrigation rates than 'Hamlin' oranges. Dilution of soluble solids in the juice by high irrigation rates has diminished as trees matured. Leaf nutrient content was influenced by irrigation, variety, and rootstock. Reclaimed water supplied all the phosphorous and boron needed for citrus production. Soil pH increased due to irrigation with reclaimed water. No disease problems have resulted from the high irrigation rates. Irrigation with high rates of reclaimed water on deep well-drained sands is not detrimental and has benefited citrus production.

309

Influence of Irrigation System and Frequency on Plant Growth, Root Distribution, and Water-use Efficiency

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Euphorbia pulcherrima 'Gutbier V-14 Glory' were grown with 220 mg·liter^{-1} N (20N–4.4P–16.6K) using ebb-and-flow (EF), capillary mat (CAP), microtube (MIC), and hand-watering (HAN) and were irrigated either daily (pulse - P) or as needed (regular - R). For all irrigation systems, pulse irrigation produced the greatest total dry weight. HAN-R produced lower total dry weight than all other irrigation systems and frequencies. Root dry weight was highest with pulse subirrigation (EF and CAP). MIC-P, EF-P, and EF-R were the most water-efficient treatments. The experiment was repeated twice with similar results. In a second experiment, *Pelargonium* x*hortorum* 'Pinto Red' root balls were sliced into three equal segments; top, middle, and bottom. For all irrigation systems, root counts were lowest in the top region. EF root counts were greatest in the middle region, while MIC root counts were greatest in the bottom region. The two subirrigation systems had higher average root counts than the two top-irrigated systems (HAN and MIC). In general, there was less difference in EC between regions for top-irrigated than for subirrigated root balls. The EC was lowest in the bottom and middle regions of EF and the bottom region of MIC and CAP. For subirrigation, the highest EC was in the top region. For all systems, pH was lowest in the bottom region.

310

Zoysiagrass Rooting and Drought Tolerance are Reduced by Frequent Irrigation

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Textbook recommendations suggest that turf should be watered deeply and infrequently to encourage drought resistance. Data supporting this recommendation are lacking, however. Studies were done to determine the influence of irrigation frequency on 'Meyer' zoysiagrass (*Zoysia japonica* Steud.) rooting and drought resistance. Turf was established on a silt loam soil in 27-cm-diameter by 92-cm-deep containers in the greenhouse. Irrigation was performed daily or at the onset of wilt with a water volume equal to daily or cumulative evapotranspiration of well-watered turf in small weighing lysimeters. After 90 days of irrigation treatments, a dry-down was imposed during which no additional water was applied for >50 days. Compared to turf irrigated daily, turf watered at the onset of wilt exhibited: i) lower (more-negative) leaf water and osmotic potentials prior to the onset of drought; ii) higher leaf water potential and better turf quality at the end of dry-down; and iii) deeper rooting as indicated by lower soil moisture content at 50- and 70-cm depths at the end of dry down.

311

Direct Turgor Measurements in Cells of Cherry and Other Fruit and Vegetable Tissues, and Its Relation to Tissue Physical Properties

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The pressure microprobe has been used to measure cell turgor and, in addition, to sample vacuolar tissues. In carrot, a rapid initial loss of tissue firmness (instron technique) occurred when the tissue was heater (cooked), and this could be entirely attributed to a loss in cell turgor. Turgor was well-correlated to firmness over the range of turgor measurements (0–0.8 MPa). In cherry and other fruits, turgor is typically 1 to 2 orders of magnitude lower than that expected based on cell osmotic potential, indicating the presence of apoplastic solutes. Cherry fruit firmness and cell turgor were well-correlated during the first 2 h of hydration at 20C, but, as fruit began to crack, tissue decreased, whereas turgor continued to increase.

312

Paraheliotropic Leaf Movement of Bush Bean in Response to Water Availability and Air Temperature

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Paraheliotropic leaf movements of bush bean were studied in relation to water availability, ambient temperature, leaf water potential, and stomatal conductance in a growth chamber. Unifoliate leaf angle from the horizontal (LA), stomatal conductance (G), and leaf water potential (WP) were measured at noon to minimize the effect of leaf movements due to circadian rhythm. Photoperiod and light intensity on the foliage were kept constant at 14 h, and 200 μmol·m^{-2}·s^{-1}, respectively, throughout the measurements. Negative correlations were obtained between water availability (WA) and LA (R = –0.93), and WP and LA (R = –0.85), whereas positive correlations were shown between WA and WP (R = 0.90), WA and G (R = 0.90), and WP and G (0.84) at 35C air temperature. Similar correlations were observed at 25C between WA and LA (R = –0.91), WP and LA (R = –0.79), WA and WP (R = 0.91), WA and G (R = 0.68), and WP and G (R = 0.76). Air temperature significantly ($P \leq 0.01$) affected leaf movements.

313

Comparison of Drought-induced Chitinase Expression Between Wild and Cultivated Tomatoes

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We have carried out a comparative study on chitinase gene expression and enzyme activity in *Lycopersicon chilense* (a drought-tolerant wild tomato) and *L. esculentum* under water stress. Both enzyme assay and Northern blot analysis revealed that chitinase expression was differentially induced by drought among the different genotypes. Higher induction of chitinase was found in tolerant species compared to the sensitive one. Among genotypes examined, *L. chilense* LA2747 presented the highest level of the chitinase induction, while the lowest level was found in *L. esculentum* HR86. Leaves of drought-stressed plants showed the highest expression and roots showed the lowest, with stems being intermediate. Chitinase activity was detected in flowers of both drought-stressed and control plants. The measurement of leaf water potentials of different genotypes revealed a correlation between drought tolerance and the level of chitinase expression during water stress. Our results suggest that the chitinase might be involved in drought tolerance of *L. chilense.*

143 ORAL SESSION 42 (Abstr. 314–321) Culture and Management/Woody Ornamentals & Landscape

314

Effect of Site Preparation on Seeding of Wildflower or Prairie Mixtures in Ontario

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The effect of site preparation on the establishment of a perennial wildflower and a prairie mixture was compared on five highway rights-of-way in southwestern, central, and northern Ontario. The site preparation treatments of the existing perennial cover were: 1) control, 2) broadcast glyphosate herbicide application, or 3) broadcast glyphosate herbicide application plus cultivation. The sites were mown prior to drill seeding. The experiments were planted in 1990 and 1992 and evaluated for total cover, cover of seeded species, and noxious weeds. The wildflower mixture established more rapidly than the prairie mixture. The wildflower seed mixture established better with either site preparation treatment compared to the control regardless of the type of vegetation present prior to planting. By 3 years after treatment the original vegetation had reinvaded to a greater degree with the herbicide treatment, indicating that the herbicide plus cultivation provided better control of the original perennial cover. Four years after seeding, neither seed mixture had established in the control, indicating that control of perennial vegetation was crucial for establishment of these seed mixtures on existing sites.

315

Evaluation of Four Herbaceous Perennials under Increasing Levels of Drought Stress

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Four herbaceous perennials *Aquilegia caerulea* 'McKana's Giant', *Gaillardia aristata*, *Gypsophila paniculata* 'Fairy's Pink', and *Callirhoe involucrata* were sub-

jected to increasing levels of drought stress and evaluated for ornamental quality and performance in the landscape. Drought stress was imposed by irrigation treatments of 100%, 75%, 50%, 25%, and 0% of reference evapotranspiration (ET_0) in 1994. Irrigation treatments resulted in *Aquilegia* exhibiting a decline in plant growth and appearance below the 50% ET_0 treatment. *Callirhoe* grown at the 100% ET_0 irrigation treatment were larger than the plants in any other treatment. *Gaillardia* receiving some irrigation (25% to 100% ET_0) were generally larger than those that received no supplemental irrigation (0% ET_0). A decline in plant appearance and growth was observed with *Gypsophila* with lowering irrigation treatments.

316

Influence of Irrigation Scheduling on Groundcover Performance

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The performance of six landscape groundcover species was evaluated when irrigated at 30% of ET_0 at irrigation schedules of three times per week, once per week, once every 2 weeks, and once every 4 weeks. *Potentilla tabernaemontani* could not be sustained under any of the treatments. For the other species (*Baccharis pilularis*, *Drosanthemum hispidum*, *Vinca major*, *Osteospermum fruticosum*, and *Hedera helix*) there were no season-long differences in a species' performance or density due to irrigation frequency, but there were significant differences among species across irrigation treatments. *Drosanthemum* and *Osteospermum* provided good overall appearance and density consistently through the season. *Baccharis* maintained acceptable performance most of the irrigation season, while *Vinca* and *Hedera* became unacceptable in appearance in mid-season. Soil moisture content differed among species, but was not consistently different between irrigation treatments.

317

Nitrate-Nitrogen Concentrations in the Soil Profiles Beneath Containerized Rhododendron Provided High or Low Irrigation Volumes

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Uniform *Rhododendron* 'Roseum Elegans' plants were potted into 3-gal plastic containers and place atop eight identical 1-m^3 soil-filled boxes (six per box). The bottomless boxes were recessed into a grassed field and filled with Woodbridge fine sandy loam. Soil samples were taken in 30-cm layers to 90 cm from each box and analyzed for NO_3-N. Samples were taken at 14-day intervals from 9 June 1994 to 10 Nov. 1994. All plants received 40 g of Sierrablen 17N–6P–10K 8–9 month controlled-release fertilizer as a topdressing on 13 June 1994. Half of the boxes received a high irrigation rate of 5 gal/min for 4 min and half received a low rate of 5 gal/min for 1 min. Irrigation was provided every other day from above the plant canopy to simulate typical irrigation practices. For the low irrigation treatment, NO_3-N levels reached 19.5 mg of NO_3-N/kg of soil in the first 28 days of the study, while increases in the deeper layers lagged behind. For the high treatment, NO_3-N levels followed a similar pattern, but only reached 8.9 mg of NO_3-N/kg of soil in the same time period. These results suggest that the high irrigation volumes cause NO_3-N to leach at a faster rate, posing a threat to water resources.

318

Use of Paper Sludges as a Partial Constituent of Substrate Mixtures in Horticulture

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Waste residues arising from paper production, either from recycled (deinking) or virgin wood (primary) fibers, are composed primarily of lignin, cellulose and hemi-cellulose. Large quantities of such residues are usually landfilled or burned. In a joint project with the company "Les Composts du Quebec Inc.'," this study examined the use of deinking and primary paper sludges as partial constituents of substrate mixtures, used as organic soil amendments for the growth of several grass and tree species. In a strip-split-plot design, mixtures of paper sludge (0% to 50%), sand (50%) and organic soil (0% to 50%) were prepared with or without a base-fertilization (strip-plot) before planting. Base fertilizations were given to improve N, P, and K availability and C/N and C/P ratios based on the nutrient status of substrate mixtures before incorporation into the soil. Results over both years indicated that unfertilized treatments with a higher percentage of paper sludge (by dry volume) generally displayed poorer growth. Grass plots exhibited decreased ground cover and stand quality. Shrubs showed some deficiency symptoms, but not until late in the season of each year. However, few differences were found between sludge treatments for grass or shrub species if substrates were given a base-fertilization of N, P, and K (to 0.5%, 0.13%, and 0.33%, respectively). Again, during the 2nd year, few differences were found between sludge-amended plots that were base-fertilized the year before. In short, our results indicate that paper sludge amendments can maintain or improve the growth of grass and shrub species if an adequate base fertilization is given to overcome nutrient immobilization. Several, more-precise base-fertilizer treatments are currently being examined for turfgrass culture.

319

Aeration Criteria and Plant Response in Peat Substrate Amended with Six Sources of Organic Wastes

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Increasing rates (5%, 10%, 25%, and 40%, v/v) of six sources of organic wastes were substituted for peat to assess changes on the physical properties of peat–perlite media and the subsequent plant response. Wastes were both fresh and composted bio-filter, sewage sludge, and de-inked paper sludge. Geranium plants (*Pelagornium* x*hortum* 'Orbit Hot Pink') were grown in the media. Saturated hydraulic conductivity (K_{sat}) and air-filled porosity (AFP) were successively measured with a Cote infiltrometer and by time-domain reflectometry. Pore space tortuosity (PST) and gas relative diffusivity (D_p/D_o) were calculated. Both physical and plant growth parameters were significantly affected by the source and rate of application of waste. K_{sat} ($P = 0.0001$, $r = 0.937$), AFP ($P = 0.001$, $r = 0.984$), PST ($P = 0.0001$, $r = 0.935$), D_p/D_o ($P = 0.0001$, r - 0.872) linearly increased as the rate of waste increased in the media. However, plant height ($P = 0.0001$, $r = 0.856$), root dry weight ($P = 0.0001$, $r = 0.994$), and shoot dry weight ($P = 0.0001$, $r = 0.963$) either linearly or quadratically decreased as the rate of waste increased. Decreases in plant growth parameters were most likely due to high salinity of organic wastes.

320

Effects of Three Organic Residues on Growth of Woody Ornamental Plants Produced in Containers

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Three ornamental species (*Spiraea japonica* 'Little Princess', *Physocarpus opulifolius* 'Nanus', and *Prunus* x *cistena*) were potted in seven different substrates. The control substrate contained peatmoss, composted conifer bark, and fine crushed gravel (5:4:1, by volume). In the other six substrates, peatmoss was partially or completely substituted by different proportions of three organic residues (10% or 50% of the mixture made up of fresh bio-filters, 5% or 10% in composted sewage sludges, and 10% or 40% in composted deinking sludges). Four fertilization regimes (0, 200, 400, and 600 mg N/liter in the form of soluble fertilizer 20–20–20) were applied weekly onto containers. The experimental design was a split-plot with six replications. Physical and chemical analysis of the organic residues proved that the composted sewage sludges were richer in minerals than the other residues. Moreover, fresh bio-filters and composted deinking sludges were less granular than composted sewage sludges. The 10% proportion of each organic residue, combined with the other materials, was the most-adequate proportion and did not reduce the growth of plants (height, aerial and root dry matter). In addition, a dose of 400 $mg \cdot liter^{-1}$ generally gave good results, especially for fresh bio-filters and for composted sewage sludges. However, it is preferable to use a higher dose (600 $mg \cdot liter^{-1}$ if composted deinking sludges are used.

321

Root Penetration in Heavily Compacted Soil Systems

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In the development of a street tree planting medium for use as a sidewalk base, we have been testing a series of limestone gravel and soil media with varied amounts of clay loam suspended within the matrix voids. *Tilia cordata* and *Quercus alba* seedling roots quickly penetrated and grew in these systems when compacted to densities in excess of 2000 $kg \cdot m^{-3}$, while they were severely impeded in clay loam soil compacted to 1300 $kg \cdot m^{-3}$. Limestone mixes of the same design had variable, but consistently acceptable, California Bearing Ratios (>40)

when compacted to similar densities; demonstrating their strength as a pavement base. *Tilia* root growth, based on the volume collected from total root excavations after two growing seasons, increased a minimum of 300% in the limestone mixes over the compacted clay loam control when the treatments were compacted to ≈80% Standard Proctor Optimum Density. Root penetration of *Quercus* increased >400% in the limestone mixes over compacted loam in a 6-month trial compacted to 95% Standard Proctor Optimum Density.

144 ORAL SESSION 43 (Abstr. 322–329) Culture & Management/Small Fruits & Viticulture

322

Chilling Affects Flowering of Fall-bearing Red Raspberries

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Tissue-cultured raspberry plants are not exposed to low temperatures during the propagation phase, yet the primocane that grows from the crown will flower terminally after developing 20 to 25 nodes. We studied the effect of duration of chilling (hours) (CH) on days to flower (DTF) in primocanes arising from root suckers of previously cropped fall-bearing 'Heritage' and ''Summit' raspberries. Growth of 'Heritage' plants with 0 or low CH was either short with rosetted leaves or indeterminate. Plants with 0 CH remained vegetative for >240 days, while plants with >750 CH flowered in <4 months when the primocane had 25 to 30 nodes. These results suggested that low-temperature exposure prior to shoot emergence was necessary for flower bud initiation in 'Heritage' red raspberry. In contrast, all 'Summit' flowered; DTF ranged from 120 days for 0 CH plants to <70 days for plants with 1000 CH. Low-temperature treatment affected flower bud development. Plants with 0 CH developed 15 flowering laterals, while plants with >750 CH had 25 flowering laterals. Although 'Summit' needs no CH to flower, low temperature treatments definitely accelerated DTF and increased the number of fruiting laterals.

323

Effect of Plant Density and Cultivar on the Fruiting Response of Strawberry using the Winter Annual Hill Culture System

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Four strawberry (*Fragaria xananassa*, Duch.) cultivars were grown in a winter strawberry fruiting study using the annual hill cultural system and polyethylene-mulched beds during two seasons. Plants were set on 15, 30, 45, and 60 cm in row-plant spacing with two rows per bed spaced at 45 cm. Increasing plant density in the fruiting field generally increased early fruit yield and sometimes total fruit yield during two seasons. Yields of cull fruit were also increased with increased plant density. Daughter plant production decreased with increased plant density. Growers should consider planting costs, fruit rot, and harvesting problems when selecting the plant density for fruit production.

324

Effect of Soil Fumigation and Soil Solarization on Annual Hill Strawberry Production

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The use of soil solarization on 20-cm raised beds 30, 60, and 90 days prior to fall planting of 'Chandler' strawberries was compared with soil fumigation with 269 kg·ha^{-1} 98/2 methylbromide/choropicrin and with 562 liters·ha^{-1} metam-sodium (Busan). The clear plastic mulch was painted with white latex paint prior to planting on 15 Oct. Methylbromide/choropicrin treatment gave the best yields, followed by the metam-sodium treatment. Soil solarization on raised beds was complicated by weed growth on the top edges and sides of the bed. Soil solarization is a useful alternative for flat bed culture, but is practically limited on raised beds due to insufficient weed control.

325

Renovation of Strawberries Grown on Plastic Mulch to Obtain Multiple Years of Harvest

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Chandler strawberries were planted on plastic mulch in September and renovated at various times after harvest during the next summer. Renovation treatments included mowing, thinning to three crowns/plant, and mowing plus thinning. These treatments were applied to 1-year-old and 2-year-old beds of 'Chandler' strawberries. We conducted this study over two harvest seasons to compare winter conditions and the influence of polyester rowcovers. The second harvest season had severe winter temperatures (–5F), along with frequent ice accumulation. Marketable yields, culls, and fruit size were determined from each treatment. Yields varied with the time of treatment and with the degree of winter severity. Fruit size of renovated berries was smaller than first year berries, but still marketable. Polyester covers increased early yields.

326

Blueberry Production in a High-density, Evergreen System

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Blueberry plants fertilized at 3-week intervals with nitrogen (N) throughout the year and protected from freezing temperatures avoid dormancy and produce an off-season "winter" crop. Southwestern Florida offers a climate where this production system can be implemented without undue fear of freezes. 'Sharpblue', 'Gulfcoast', and 'Warmabe' southern highbush blueberry cultivars have been planted at high density (10,000 plants/ha) to determine the feasibility of successfully establishing an evergreen production system for blueberry. Three rates of N fertilization (84, 168, and 252 kg·ha^{-1}) and the use of peat or municipal solid waste (MSW) compost as soil amendments are being evaluated in this study. Initial data on plant growth indicate that, during the first 9 months of the planting, 168 kg N/ha will produce plants similar in height, but with significantly less volume, to those receiving 252 kg N/ha. MSW compost appears to be a beneficial soil amendment for blueberry establishment despite an increase in soil pH associated with the compost amendment.

327

A Reevaluation of Mechanical Harvester vs. Hand-raking for Wild Blueberries

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Improvements in the Bragg harvester and the introduction of a new Nimco harvester warranted a reevaluation of new technologies. Four technologies: the Bragg harvester, a modified Bragg harvester, the Nimco prototype, and hand-harvesting were evaluated at two locations: a land-leveled field (T-19) and a field without land leveling (Deblois). The experimental design was a randomized complete block with eight replications. A 150-ft strip was harvested with each technology, with strips directly adjacent to each other to minimize field variability. Time to harvest and berry weights were measured. Poor maintenance, adjustment and skill of the operator contributed to a 69% recovery relative to hand-harvest by both the Bragg and modified Bragg harvesters. The Nimco harvester has great potential, but only if it is properly mounted to allow it to cover the fields at a speed similar to the Bragg harvesters. The land-leveled field allowed for greater recovery for the Bragg and Nimco harvester, indicating that smoother fields are more efficient for machine-harvesting.

328

Response of 'Chardonnay' Grapevines to Training and Crop Control

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Growing conditions in Michigan can threaten the yield and acceptable fruit quality of 'Chardonnay' grapevines. Three grapevine training systems, mid-wire cordon (MWC), umbrella kniffin (UK), and a combination of the two (MWC-UK) were evaluated under Michigan growing conditions to determine their influence on yield, fruit quality, cluster compactness, incidence and severity of Botrytis bunch rot, and trellis fill. Vines were grown on C3309 rootstock and pruned to 44

nodes per kilogram of cane prunings. The MWC-UK treatment had an additional 30 nodes per vine retained, and the crop level on these nodes was removed after fruitset. Over a 2-year period, UK and MWC-UK trained vines had fruit soluble solids about 1 °Brix higher and yields were 48% and 63% higher than MWC trained vines, respectively. MWC-UK trained vines consistently out-performed MWC trained vines for all variables measured, while UK-trained vines provided an intermediate response.

329

Do Chemical Treatments that Influence Inflorescence Necrosis Severity affect Grape Flower Cluster NH^{4+}?

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A fruit-set disorder of grape, called Inflorescence Necrosis (IN), causes death of flower cluster tissue near bloom. Various chemical treatments have been reported to increase IN severity. Separate studies show that high flower cluster NH^{4+} is related to naturally occurring IN. We designed a field trial to determine if treatments thought to influence IN severity also affect flower cluster NH^{4+}. One week before first bloom, flower clusters were dipped in solutions of either methionine sulfoximine (MSO, an inhibitor of NH^{4+} assimilation), α-keto glutarate, $(NH_4)_2HPO_4$, KNO_3, NAA, GA, or an emulsion solution reported to increase transpiration. Also, ethephon was sprayed on whole vines 1 week before first bloom. Flower clusters were collected 5 days after treatment. MSO increased tissue [NH^{4+}] by almost 2-fold over that of controls. NAA and GA reduced [NH^{4+}] a small amount, possibly due to their slightly higher fresh weights. Other dip treatments did not affect [NH^{4+}]. Despite high [NH^{4+}] in MSO treated clusters, there were no visual differences in IN between treatments. Ethephon increased cluster [NH^{4+}] 20% over that of controls, but caused more severe IN. These data show that flower cluster [NH^{4+}] is not always coupled with IN symptoms.

145 ORAL SESSION 44 (Abstr. 330–337) Weed Control & Pest Management/ Cross-commodity

330

Genetic Analysis of Acylsugar Production in Intraspecific Populations of the Wild Tomato, *Lycopersicon pennellii*

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Acylsugars produced by many accessions of wild tomato (*L. pennellii*) mediate resistance to a number of important pests of tomato. The highly resistant *L. pennellii* accession LA716 accumulates high levels of acylsugars, of which 85% are in the form of acylglucoses, the rest being acylsucroses. In contrast, *L. pennellii* accession LA1912, which does not show the insect resistance of accession LA716, accumulates very low levels of acylsugars, of which 55% are represented by acylglucoses. The intraspecific F_1 derived from crosses between the accessions LA716 and LA1912 accumulates moderate levels of acylsugars, of which, like its LA716 parent, 85% are in the form of acylglucoses. Intraspecific F_2 and backcross populations derived from crosses between the accessions LA716 and LA1912 were surveyed for acylsucrose and acylglucose production. These populations segregated for the ability to produce acylsugars, levels of total acylsugars produced and amount of acylglucoses as a percentage of total acylsugars. The genetic control of these traits will be discussed.

331

Breeding for Acylsugar-mediated Multiple-pest Resistance in Cultivated Tomato, *Lycopersicon esculentum*

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Acylsugar mediates the resistance of *Lycopersicon pennellii* LA716 to several important insect pests of cultivated tomato, including potato aphid, green peach aphid, leaf miner, fruitworm, armyworm, and silverleaf whitefly. Incorporation of acylsugar-mediated multiple pest resistance could result in a significant reduction in the use of pesticidal sprays in cultivated tomato. Development of a reliable assay for acylsugar production and confirmation of the association between the resistance and acylsugars allowed us to try to breed for the trait by selecting for acylsugar-producing plants. The breeding cycle allows us to progress by one backcross generation per year. The breeding program was faced by several challenges, including interference in gene transfer by interspecific crossing barriers, and the oligogenic nature of the acylsugar-mediated resistance trait. Despite these challenges, the breeding program has produced BC_3F_2 plants that produce effective levels of acylsugars, are tomato-like in vine appearance, and produce seed-bearing fruit in the field without manual pollination. The current status of the program and future plans will be discussed.

333

Pest Control with Proteinase Inhibitors: Is It Compatible with IPM Strategies?

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In recent years, several studies have demonstrated the potential of proteinase inhibitors (PIs) for the control of various pests and pathogens. Used as a component of an integrated pest management program, such an approach must, however, be carefully considered, given the possible risks of interference with other control methods. For example, we are analyzing the effect of oryzacystatins (OCI and OCII), two cysteine PIs naturally occurring in rice grains, against digestive proteinases of *Amblyseius californicus* (AC), a native predator of the two-spotted spider mite (SM; *Tetranychus urticae*). Electrophoretic analyses have shown the existence in SM extracts of a major cysteine proteinase form strongly inhibited by OCI, indicating the potential of this inhibitor for SM control. However, similar analyses revealed a strong affinity between proteinases from AC extracts and OCs. Thus, despite their potential for SM control, plant cystatins may represent growth-suppressing compounds for AC. Work is currently underway to determine the usefulness of OCI-expressing transgenic plants for SM control, and to assess the compatibility of this control with an AC-based biological control strategy.

335

Cover Crop Effects on Weed Control and Growth of First-year Grapevines

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Four cover crops were evaluated for weed control and effects on first-year vine growth. Winter wheat (cv. Cardinal), rye (cv. Wheeler), oats (cv. Ogle), and hairy vetch (no cultivar name) were either fall- or spring-planted and compared to cultivated and weedy control plots. Cover crop and weed biomass dry weight was collected twice during the growing season. Vines (*Vitis labrusca* cv. Steuben) were planted in the spring and destructively sampled at the end of the growing season for analysis of leaf area, leaf number, shoot length., shoot number, top growth dry weight, and root system dry weight. None of the vines in cover crop treatments had growth as good as vines in the weed-free check. Vines in the best cover crop treatments had ≈70% as much leaf area, 75% as many leaves, 50% as much shoot dry weight, and 40% as much root dry weight as vines in the weed-free check. Cover crop biomass dry weight and vine growth was greater in fall-planted plots than in spring-planted plots. Despite low cover crop biomass dry weight, spring-planted plots had few weeds (low weed biomass dry weight). However, vine growth in spring-planted plots was not significantly different than vine growth in the weedy check.

336

Preemergence Weed Control with Sulfentrazone (F 9285) and Sulfentrazone Combinations in Field-grown Ornamentals

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Sulfentrazone is a promising new herbicide now under evaluation for use in agronomic and ornamental cropping systems. Sulfentrazone selectively controls yellow nutsedge, morningglories, and other annual grasses and broadleaf weeds. Research was conducted to evaluate the efficacy of sulfentrazone in combination with other labeled products for preemergence weed control in nursery crops. Treatments included sulfentrazone at 0.56 and 1.12 kg a.i./ha and sulfentrazone at 0.37 kg a.i./ha in combination with the following; dithiopyr at 0.37 kg, oxyfluorfen at 0.56 kg, metolachlor at 3.36 kg, isoxaben at 0.56 kg, norfluorazon at 2.64 kg, and isoxaben plus oryzalin at 2.24 kg a.i./ha. Combinations of sulfentrazone with isoxaben or metolachlor provided superior control of morningglory spp., honeyvine

milkweed, Carolina horsenettle, and yellow nutsedge. Sulfentrazone plus oxyfluorfen or isoxaben plus oryzalin also provided good control. Poorest overall control was obtained with sulfentrazone plus dithiopyr. Viburnum and deciduous holly were slightly injured 4 WAT with sulfentrazone plus metolachlor. Sulfentrazone plus dithiopyr treatments resulted in serious injury to burning bush 4 WAT and slight injury at 8 WAT.

337

Orchard Groundcover Management Systems Influence Surface Runoff and Subsoil Leaching of Agrichemicals

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Non-point source water pollution by agrichemicals is a recognized problem that has been studied in agronomic crop systems, and simulated using computer models or artificial soil columns, but rarely measured at field scale in orchards. For three growing seasons, we monitored the movement of nitrate and pesticide analogs and a widely used fungicide (benomyl) in two apple orchards under four different groundcover management systems (GMSs), including turfgrass, woodchip mulch, residual pre-emergence herbicides, and post-emergence herbicide treatments. In subsoil lysimeter samplers at one orchard, we observed that nitrate and pesticide analogs leached more rapidly and in higher concentrations under herbicide plots compared with turfgrass plots. At another orchard where subsoil leaching and surface runoff of benomyl and nitrate-N were monitored in replicated GMS plots, we observed higher concentrations of benomyl (up to 30 $\mu g \cdot liter^{-1}$) and nitrate-N up to 50 $\mu g \cdot liter^{-1}$) leaching under herbicide GMS. The highest benomyl concentrations (375 $\mu g \cdot liter^{-1}$) and most frequent runoff of this pesticide were observed in the residual pre-emergence herbicide plots. Yearly weather patterns, irrigation, and development of different soil physical conditions under the four GMSs determined the relative magnitude and frequency of agrichemical leaching and runoff in both orchards. The agrichemicals apparently leached by mass flow in preferential flowpaths such as old root channels and soil cracks, while surface chemical runoff occurred mostly adsorbed on eroding soil sediment. These observations indicate that orchard GMSs can have a significant impact on leaching and runoff of pesticides and nutrients.

146 ORAL SESSION 45 (Abstr. 338–343) Growth Regulators/Cross-commodity

338

Effect of Spray Additives on Cuticular Transfer of NAA

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Foliar application of plant growth regulators (PGR) is an established horticultural practice. We are using a finite dose system to examine diffusion of ^{14}C-labeled PGRs, primarily napththaleneacetic acid (NAA), from aqueous droplets and deposits through enzymatically isolated plant cuticles (CM) as affected by spray adjuvant chemistry, solution pH, and epicuticular wax. Recent studies have focused on a nonbuffered aqueous medium, which approximates field application conditions. Despite the negligible buffering capacity of the spray solution, there were significant differences in NAA diffusion with solution pH. At pH 3.2, NAA (pK_a = 4.2) diffusion was two-fold greater than at pH 5.2. Additives (surfactants, urea, and urea:NH_4NO_3, 1:1 mixture) in the spray solutions increased the initial rate and absolute amount of NAA diffused. The polyethoxalated octylphenol surfactant (Triton-X) TX-45 (EO 5.5) enhanced rate and quantity of NAA diffusion. This enhancement was observed with CM, but not after removal of the epicuticular waxes, implicating an interaction between surfactant and waxes. Urea, over a four-fold concentration range, increased NAA diffusion 5% to 31% after 144 h. The urea:NH_4NO_3 mixture increased NAA diffusion to a greater extent at pH 5.2 (+136%) than at pH 3.2 (+8.4%) after 144 h.

339

Plant Growth Regulators for Crop Management in Tea

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Growth regulators are used in tea plantations from planting to productivity. Paclobutrazol at 500 ppm applied on foliage, 1 month after planting, promotes lateral production, besides feeder root proliferation. Triacontanol at 2 ppm applied in mature tea improves productivity through enhanced photosynthesis, favorable partition of assimilates, and water-use efficiency. Hydrogen cyanamide applied on the pruned frame at 0.5% improves budbreak. Antitranspirants based on long-chain polymers impart drought-tolerance in young and mature tea. Thus, use of PGR for cost-effective management of tea plantations, without affecting the quality of made tea or bush health, has been standardized.

340

The Effect of Slow-release Polymeric Derivatives of Auxins (NAA and 2,4-D) on Regeneration of *Achimenes* in Vitro

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Polymeric formulations of plant growth regulators (PGR) are high-molecular weight systems in which the PGR unit can be slowly released providing prolonged action and effectiveness in a wide range of concentrations. In this study, *Achimene* explants were used for testing the biological activity of polymeric derivatives of NAA and 2,4-D. Shoots of *Achimenes* 'Bella', obtained from leaf segments cultured in vitro, were transferred for 8 weeks on Murashige and Skoog (MS) medium supplemented with different levels of conventional or polymeric NAA (0, 0.01, 0.05, 0.1, 0.5, 1.0, 1.5, 2.0, 2.5 $mg \cdot liter^{-1}$) and 2.4-D (0, 0.01, 0.05, 0.1, 0.5, 1.0, 1.5 $mg \cdot liter^{-1}$), each combined with three levels of BAP (0, 0.1, 0.5 $mg \cdot liter^{-1}$). Compared to conventional NAA, twice as many shoots proliferated with higher dry weight, at 0.5 0.1, 1.0, or 1.5 $mg \cdot liter^{-1}$ polymeric NAA with 0.5 $mg \cdot liter^{-1}$ BAP. In another trial, the combination of 0.05 or 0.1 $mg \cdot liter^{-1}$ polymeric 2,4-D with 0.1 BAP gave more shoot and vigorous growth without callus formation, compared to conventional 2.4-D These results suggest that the polymeric derivatives of auxins used in this study enhance regeneration and growth of *Achimenes* in vitro more effectively than conventional formulations, at greater concentrations, without causing toxic or inhibitory effects.

341

Growth of Begonia as Influenced by Paclobutrazol Residue in Compost-amended Media

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Paclobutrazol was applied as soil drench to potted petunia, and the treated plants were shorter than untreated ones. Three types of compost were then made from the treated and untreated plants: the shoots, the medium (including roots), and both shoots and medium. They were mixed with Vergro Klay Mix at the ratios of 0%, 5%, 10%, 20%, and 40% (v/v). In a factorial experiment, plugs of *Begonia semperflorens* cv. Gin were planted in the media with compost. Plants grown in media containing paclobutrazol residue were shorter and had less dry weight compared to those grown in media containing no paclobutrazol residue. Compost ratios at 5% and 40% reduced plant height to 65% and 42% and shoot dry weight to 55% and 20% of the control plants, respectively. These results indicate that residues from plants treated with paclobutrazol may carry over in soil of landscape beds and affect the growth of subsequent crops grown in that soil.

342

Effects of Nutrient and Growth Regulator Treatments on Growth and Development of Zinnias

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Two cultivars of *Zinnia elegans*, 'Big Red' and 'Sunrise Red', were grown hydroponically in two different nutrient solutions. The experiment was implemented in the greenhouse to assess affects of growth regulator treatments on growth and development of the plants. Heights of seedlings germinated in peat pellets were measured prior to placement in the hydroponic units. Plants were sprayed with five rates of either paclobutrazol or uniconazole. The experiment was laid out as a randomized complete-block design with four replicates of the treatments, which were factorial combinations of variables. Days to first flower were recorded for each plant. After 90 days, measurements were made of plant heights, flower bud numbers, and dry weights of shoot and root systems. Nutrient treatments affected all parameters observed. Growth regulator treatments affected plant heights. 'Sunrise Red' produced more flower buds and earlier flowers than 'Big Red'.

343

Distribution of Paclobutrazol in Media Following Drench Applications

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Drench applications of paclobutrazol (PBZ) are becoming increasingly popular as a means for controlling height in potted plants, and research is being conducted to quantify the distribution of PBZ following applications. In one trial, 120 ml of 0 or 1 mg 1-1 PBZ were applied to 15-cm pots filled with either Vergro Klay Mix (no bark) or Metro Mix 500 (bark). A bioassay using broccoli (*Brassica oleracea* L. *Italica*) seedlings was used to quantify PBZ in leachates and media following treatment drenches. Leachate PBZ concentrations were lower for Vergro than for Metro Mix 500; however, leachates for both media were <0.1 mg•liter^{-1}. Concentrations of PBZ in media decreased with depth and were four to 10 times higher in the uppermost 2.5 cm than in lower horizons. For the uppermost 2.5 cm of media, higher PBZ concentrations were recovered in Metro Mix 500 than in Vergro. A follow-up study will compare surface vs. subsurface application methods on the movement of PBZ into pots.

162 ORAL SESSION 46 (Abstr. 344–350) Genetics/Vegetable

344

Nodal Propagation Reduces Genetic Variability in Sweetpotato Clones

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Our research examined whether plants originating from adventitious sprouts from fleshy sweetpotato roots are genetically more variable than plants that arise from pre-existing meristematic regions, i.e., nodes. Our study compared one plant each of 'Jewel', 'Sumor', and L87-95 clonally propagated for seven generations both nodally and through adventitious sprouts. PCR-based analysis of 60 samples (10 nodal and 10 adventitiously derived plants/genotype) showed 20% polymorphism among adventitious materials vs. 6% among nodally derived plants. An "analysis of molecular variance" showed that differences between propagation methods accounted for 30% of the total marker variability. Our results support previous findings that, relative to non-meristematic materials, meristematic regions strictly control cell division and DNA synthesis that exclude DNA duplication and other irregularities.

345

Paternity Analysis in Higher Polyploids

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The breeding of new sweetpotato varieties is a highly inefficient process, confounded by incompatibility, poor fertility, open-pollination, and its hexaploid nature. Upwards of 12 to 20 lines are currently combined in open-pollinated nurseries based on good horticultural characteristics. Most progeny after several years of selection can be traced back to just three or four maternal lines. A method that would identify the paternal parent of superior progeny would enable breeders the ability to combine parents that exhibit superior combining ability in more-efficient, smaller nurseries. The objective of this work is to explore by means of computer simulation the application of genealogy reconstruction techniques on hexaploid individuals with PCR-based data. The progeny obtained on each female parent is fractionally assigned to each male with non zero exclusion probability proportional to its paternity likelihood. Computer simulations show that at least five different alleles per loci are needed to reach a reasonable discriminatory level. Also, the number of loci scored should not be less than 20. An increment in the number of alleles or loci increases the discriminatory power; but, the number of alleles produces a far more important effect than the number of loci.

346

RNA Populations in Tomato Seeds Imbibing in the Presence or Absence of Abscisic Acid

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The RNA content of tomato seeds was shown to increase when the seeds were imbibed in water. This increase was due mainly to an increase in nuclear RNA, the polysomal content declining and the ribonucleoprotein fraction remaining constant. The poly(A)+RNA population also showed a gradual increase, again due to a high de novo synthesis rate in the nucleus. In the presence of 200 µM abscisic acid (ABA), the total nuclear DNA failed to increase in the manner seen with water imbibition, leading to an overall decline in RNA during the first 1.5 h. The polysomal and ribonucleoprotein fractions were unaffected by ABA. The decline in total nuclear RNA was due primarily to a major decrease in the nuclear poly(A)+ content of seeds imbibing with ABA. This reduction in de novo transcription may be a factor responsible for the inhibitory effect that ABA has on germination of tomato seeds.

347

juvenile albino, a Virescent Mutant in Watermelon: Inheritance and Expression

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juvenile albino (*ja*) is a spontaneous mutant, first observed in 1992. Hypocotyls, new young leaves, shoot tips, tendrils, and flowers on the main shoot of the *ja* mutant are all albino during early spring and late fall. The interior of the albino leaves gradually become green, while the margins remain albino. Fruit rind color of the mutant is variegated. Growth of the *ja* mutant is severely impaired in the early spring and late fall. However, the mutant grows almost normal in the summer, and produces fruits of almost normal size. Genetic analysis of F_1, F_2, and BC_1 populations derived from the *ja* mutant showed that *ja* mutant is inherited as a single, recessive, nuclear gene. The segregation ratios in the F_2 and BC_1 progenies derived from the cross between the previously reported *dg* virescent mutant and the *ja* mutant indicated that both are inherited independently. Experiments with temperature (3–5C vs. 20–22C at night), day length (8 vs. 15 h), and red and/or far-red light (15 vs. 0 min) at the end of an 8-h day were performed to investigate the regulation of *ja* trait expression. Temperature and red/far-red light had no differential effect on mutant and wild-type plants. However, significantly increased fresh weight and chlorophyll content were observed in the *ja* mutant over the wild-type when grown under long-day conditions. In addition, chlorophyll synthesis or accumulation in the mutant is severely impaired under short-day conditions. To our knowledge, this is the only virescent mutant in Cucurbitaceae whose expression is regulated by day length.

349

A Genetic Model for Resistance to Root-knot Nematode (*Meloidogyne hapla* Chitwood) in Carrot (*Daucus carota* L.)

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The genetics of resistance to root-knot nematode (*M. hapla* Chitwood) was studied in crosses of three carrot inbred genotypes, two resistant genotypes (R_1 and R_2) and one susceptible genotype (S_1) identified in previous screening tests. Seedlings of three parental genotypes, six F_1 crosses including three reciprocal crosses, two BC_1 populations, and three F_2 populations were evaluated for their resistance and susceptibility to infestation of *M. hapla* Chitwood based on gall number per root, gall rating per root, and root rating per root in a greenhouse experiment carried out in 1994. All six F_1 plants were susceptible, which indicated a lack of heterosis for resistance in these F_1s. The $R_1 \times S_1$ cross segregated 3 susceptible : 1 resistant in the F_2, 1 susceptible : 1 resistant in the BC_1R_1, and did not segregate in the BC_1S_1.The $R_1 \times R_2$ cross yielded 44 susceptible : 36 resistant seedlings in the F_2 (R_1R_2), and 48 susceptible : 32 resistant in the reciprocal cross of R_1 and R_2, both of which closely fit a 9 : 7 ratio ($P \leq 0.001$). These results indicate these two resistant genotypes carry two different homozygous recessive genes conditioning root-knot nematode resistance. We propose a model of duplicate recessive epistasis control the reactions of host plants and nematode in these crosses.

350

Differential Effect of Population Density on Shape and Size of Cylindrical Red Beet Genotypes

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The use of cylindrically shaped red beet cultivars for production of processing beets has increased in recent years. Yield and shape of globe-shaped red beet cultivars are determined in part by population density and within-row spacing; thus, it is thought cylindrical cultivars are similarly affected by these factors. The objective of this investigation was to evaluate the effects of population density on shape and size of cylindrical red beet cultivars. Two F_1 hybrids and two open-pollinated cultivars were planted in replicated trials consisting of three population densities during 1993 and 1994. Ten traits were measured on a randomly selected sample of beets from each plot. Averaged over genotypes, significant differences among densities were found for percent harvestable beets per plot, length x width , harvest weight, length, and mid-width. Average over genotypes, greater harvest weight, higher percentage of harvestable beets, and greater length, mid-width, and length x width values were found at low density. Average over densities, open-pollinated cultivars exhibited a greater degree of straightness along with lower yield, harvest weight, and percent harvestable beets than their hybrid counterparts. These data demonstrate population density has a differential effect on shape and size of cylindrical beet genotypes.

163 ORAL SESSION 47 (Abstr. 351–357) Postharvest Physiology/Fruits & Nuts (Tropical & Substropical)

351

Packingsheds Harvest Date and Seasonal Effects on Texas Grapefruit Destined for Fresh Market

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Uniform samples of Texas grapefruit, harvested in December, January, February, and March, were run through five Rio Grande Valley packingsheds, then stored for 30 days at 65C and 80% RH. The tests were done in 1987, 1988, and 1989 (December only). Data evaluated were degreening effectiveness, water loss, spoilage, and juice analysis. There were no degreening differences between sheds. Analyses of the parameters of time in storage x water loss regressions for sheds and harvest dates showed fruit harvested in the warmer months tended to have the higher percentage of water loss. Water loss differences between sheds was inconsistent, varying with month and season. The correlation between average fruit weight and percentage of water loss was very inconsistent. Harvest date rather than sheds had the most influence on spoilage. While the variations in the physical characteristics and chemical treatments of each packing line probably underlay the packingshed x harvest date interaction for water loss, no simple cause and effect hypothesis involving all these factors could be constructed.

352

Physiological Responses of Citrus to High-pressure Washing

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High-pressure washing (>689 to 3446 kPa or 100 to 500 psi at the spray nozzle) has been used recently in citrus packinghouses to improve the action of surfactant solution and brushing on the removal of dirt and superficial molds. Although high-pressure washing has no obvious detrimental effect on citrus fruit (e.g., no cellular breakage), its effects on physiology have not been fully examined. In this study gas samples were taken from the fruit core of 'Orlando' tangelos, 'Hamlin' oranges, and 'Ruby Red' and white 'Marsh' grapefruit prior to and following washing. An apparent wound ethylene response was measured for all varieties and was a function of prolonged exposure (>20 s) and excessive pressure (>2067 kPa). For the responding fruit, internal ethylene was initially detected about 3 h after washing, reached a maximum around 24 h (range: 0.1 to 0.6 ppm), and diminished to near background levels (0.0 ppm) after 48 h. No wound ethylene was observed when fruit were washed for the recommended exposure time (10 s) and pressure (1379 kPa). Concurrent decreases in internal O_2 and increases in CO_2 were observed for white and red grapefruit. High-pressure washing (1379 or 2757 kPa) did not affect water loss and water, O_2, and CO_2 exchange. The effects of subsequent waxing of the fruit (increased internal ethylene and CO_2 levels and reduced of internal O_2 levels) were amplified by washing at the higher pressure (2757 kPa).

353

Effects of Enzyme Infusion on The Processing and Storage Quality of Peeled Citrus

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An enzymatic peeling process is currently used to produce peeled citrus fruit that are convenient for consumption. By this process, fruit are scored and infused with pectinase or pectinase and cellulase solution and are incubated at 20 to 45C for 0.5 to 2 h. While enzyme solution apparently weakens of the albedo and thus improves separation of the fruit from its peel, we expect that enzyme infused into the flesh reduces storage quality. In these studies, fruit were vacuum- or pressure-infused with or without pectinase in water. The time required to peel white 'Marsh' and 'Ruby Red' grapefruit infused with solution containing enzyme were only 10% to 20% less than for fruit infused with water alone. 'Hamlin' orange and 'Orlando' tangelo peeling times were not improved by enzyme treatment. This suggests that water is the primary operative component of the enzyme solution and that the enzyme is an active, but nonessential, supplement. For white grapefruit and oranges stored at 5, 10, 15, or 25C, nonenzyme-treated fruit had significantly less juice leakage than enzyme-treated fruit. For example, 0.2% and 5.0% of the peeled fruit weight was lost by non-enzymatically and enzymatically peeled fruit, respectively, for vacuum-infused oranges stored at 5C for 7 days. Moreover, the enzyme treatment significantly reduced firmness, as determined by a sensory panel. Microbial levels and rates of respiration and ethylene emanation during storage were not significantly affected by enzyme treatment. Similar results were found for vacuum- and pressure-infused fruit.

354

Growth Temperature Influences Postharvest Tolerance of Lemon Fruit to Hot Water, Cold, and Methyl Bromide

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Lemon trees [*Citrus limon* (L.) Burm.[grown outdoors were moved into three greenhouses in Sept. 1993 before hot summer temperatures waned. Greenhouse (grh.) temperatures were 22 to 28C min./35 to 40C max. to maintain the hot growing condition effect. In late October, one grh. was set to 5 to 10C min./20C max. (cool), one to 20C min./33C max. (warm), and one to 25 to 30C min./35 to 40C max. (hot). Fruit was harvested after 1-, 2-, and 4-week exposures. Postharvest treatments applied 1 day after pick were hot water immersion (HWI) (55C/5 min.), cold (CT) (2C/3 weeks), or methyl bromide (MB) fumigation (60 g/m^3/2 h/21C). Fruit was stored at 10C for 4 weeks after treatment and evaluated weekly. HWI caused more peel injury to fruit from cool (82%) and warm (60%) grhs. than from the hot grh. (32%). The incidence and severity of injuries increased with time fruit were held in the cooler grhs. CT caused more peel injury in fruit from the hot (94%) grh. than from the warm (48%) or cool (16%) grh. Severity of injury decreased with longer exposure in the cooler grhs. MB injury was least in fruit from the cool and warm grhs. (2% to 3%) and most from the hot grh. (14%). MB injury increased slightly with fruit age. In HWI, CT and MB tests 'Eureka' fruit were injured more than 'Lisbon'.

355

Elevated CO_2 Atmosphere for Storage of Mature-green and Tree-ripe 'Tommy Atkins' Mangoes

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Mangoes for long-distance markets are harvested at the mature-green stage and shipped in refrigerated containers. Shipment under controlled atmosphere is still tentative, and the CO_2 concentrations used are relatively low (maximum 10%), although mangoes have been reported as being less-sensitive to elevated CO_2 than other tropical fruits. In the present study, CO_2 concentrations of 10%, 15%, 25%, 35%, and 45% combined with 5% O_2 were used to store mangoes. Mature-green 'Tommy Atkins' were stored for 21 days at 12C, followed by air storage at 20C for 5 days. Tree-ripe mangoes were stored at 8 or 12C under the same

conditions. Ethanol production rates increased along with increasing CO_2 concentrations. However, only 35% and 45% CO_2 atmospheres inflicted damage. Color development was severely inhibited under those treatments. Lower CO_2 treatments, up to 25% in the storage atmosphere, inhibited skin color development and ethylene biosynthesis but, after 5 days in air at 20C, skin color and ethylene production reached control levels. Fruit flesh firmness did not differ among treatments at 12C. Tree ripe mangoes stored in CA at 8C were only significantly firmer than control fruit at transfer from CA to air.

356

Physiological and Chemical Changes during Ripening of Costa Rican Bananas Harvested at Four Different Seasons

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Mature-green 'Grande Naine' bananas (Musa AAA) were harvested 13 weeks after flowering, in June and Sept. 1993, and Feb. and Mar. 1994. Fruit were 1) held in storage for 36 days at 14C and 80% to 90% RH, or 2) after 8 days of storage, fruit were treated with ethylene, and held at 17C until color 6 of the standard color scale was observed. Although a similar grade and age, the length of the preclimacteric phase was different among months, which reflected different physiological maturities at harvest. Rate of respiration, pulp pH, and soluble solids were the most-useful variables to characterize the fruit. Increases in respiration after ethylene treatment varied from 4- up to 14-fold the respiratory level under storage conditions. The climacteric occurred at any point during ripening, ranging from color 2 to 5, except at very early stages. Ethylene increases were short in duration and magnitude, and occurred earlier than the respiratory peak. Sometimes, internal and external ripening stages did not match. The most dramatic seasonal effects were observed in CO_2 evolution, pulp-to-peel ratio, and starch conversion.

357

Changes in the Respiratory Activity of Papaya Fruit Following Storage in Low-oxygen Atmosphere

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Controlled-atmosphere (CA) storage of fruits employing low O_2 and/or elevated CO_2 have been used to reduce respiration and other associated metabolic activities. Papaya fruit cv. Eksofika were exposed to 2%, 5%, and 21% (air) O_2 for 4 weeks at 12C. The CO_2 production rates of fruit previously stored in 2% and 5% O_2 were suppressed during storage, but increased upon transfer to air at 20C. Carbon dioxide production rates of low-oxygen stored fruits were slightly lower than the air-stored fruit during transfer to air, indicating a slight residual effect of low O_2 on the respiratory activity of the fruit. This was highly evident in fruit stored in 2% O_2 for 4 weeks. Ethylene production rates were not affected by prior storage of fruit in low-O_2 atmosphere. Anaerobic metabolism did not occur in fruit stored in 2% O_2 for 4 weeks, as evidenced by the RQ values close to unity and the absence of ethanol from the headspace of the respired gas. The total sugar content of ripe fruit at color score 5, previously stored in low-O2 atmosphere for 4 weeks, were not significantly different from the air-stored fruit.

164 ORAL SESSION 48 (Abstr. 358–362) Propagation/Woody Ornamentals

358

Using Subirrigation to Root Stem Cuttings: Comparison to Mist and Effects of Nutrition

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Use of subirrigation to root stem cuttings was compared to using mist, and effects of fertilization during subirrigation were determined. All cuttings of *Dendranthema* x*grandiflorum* (Ramat.) Kitamura 'Charm' and *Coleus* x*hybridus* Voss. rooted, but misted *D.* x*grandiflorum* 'Charm' had a higher mean root mass than subirrigated cuttings. Percentage rooting and mean root mass of subirrigated *Acer rubrum* L. 'Franksred' were 95% and 321 mg, whereas mean root mass of the 21% of cuttings that rooted with mist was 38 mg. Percentage cuttings with callus, mean callus diameter, rooting percentage, and mean root mass of *Syringa reticulata* (Blume) Hara were 77%, 124 mm, 21%, and 52 mg with subirrigation and 45%, 63 mm, 0%, and 0 mm with mist. Subirrigation with <7 mol N/m^3 improved rooting of *Impatiens hawkeri* Bull. 'Celebration Bright Scarlet' and *A. rubrum* 'Franksred'. Subirrigation can replace mist, and effects of fertilizer in subirrigation solution vary among taxa.

359

Influence of Stock Plant Nitrogen Fertilization on Rooting Stem Cuttings of Loblolly Pine

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Containerized, 1.5-year-old, hedged stock plants of four full-sib families of loblolly pine (*Pinus taeda* L.) were fertilized daily with a complete nutrient solution containing 9 ppm P, 38 ppm K, and either 0, 5, 10, 20, or 40 ppm N. Softwood cuttings were removed in May and July 1994, and placed under intermittent mist at two locations: Raleigh and Summerville. Overall rooting was significantly greater at Summerville (49%) than in Raleigh (37%). Cuttings taken in May rooted at significantly greater percentages than the July cuttings (57% vs. 29%). Overall rooting (56%) and root area (12 cm^2) were greatest at 40 ppm N, whereas root number (two), root dry weight (66 mg), and total root length (108 cm) were maximized at 20 ppm N. Although family was not significant, a family x nitrogen interaction occurred. For both rooting trials, maximum rooting (83%) was noted for May cuttings rooted in Summerville, which were taken from stock plants of one family fertilized with 20 ppm N.

360

Penetrating Agents for Liquid Quick-dip Rooting Hormones

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Fifteen-cm terminal cuttings of *Ilex* x 'Nellie R. Stevens' were harvested 28 Nov. 1993. Basal leaves were stripped with five to six terminal leaves remaining. Groups of 10 cuttings were treated with a 5-s quick-dip by inserting stem bases to a depth of 2.5 cm into the treatment solution. Treated cuttings were immediately inserted into 12-cm-deep nursery flats containing moist 40% Pro-Mix/60% perlite. Hormone treatments were dilutions of Dip'N Grow formulation (10,000 ppm IBA + 5000 ppm NAA). IBA/NAA levels were set at 3000, 6000, and 9000 ppm and combined in a factorial arrangement with penetrating agents of 20% dimethylformamide and 20% triethanolamine with water as a control for nine treatment combinations. Ten replications were placed on a propagation bench with bottom heat (25C) and intermittent mist. When most cuttings were well-rooted, each cutting was rated on a scale of 1 (no or little rooting) to 5 (heavy rooting). Analysis of variance showed each level of rooting hormone to be different from every other level, with best rooting at 9000 ppm (3.80) . Penetrating agent treatments were different from each other, with best rooting in triethanolamine treatments (3.54), followed by dimethylformamide treatments (3.29), and controls (2.65).

361

A Propagation and Reintroduction Strategy for the Neches River Rose Mallow, *Hibiscus dasycalyx*

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Hibiscus dasycalyx is known from less than 10 locations along the Neches River. A many-stemmed, woody-based, narrow-leafed perennial to 4 ft, the species displays showy white-petaled, 3-inch blooms in summer and fall. The species is federally endangered due to loss of habitat and interspecific hybridization with the Soldier Rose Mallow, *Hibiscus militaris*, a species that encroaches into the range of the Neches River Rose Mallow. A 1994 seed propagation study included nine collection dates (late July to late October) and stratification at 0, 2, 4, and 6 weeks prior to planting. Germination percentages were low; only the 7/22 and 9/10 collection dates exhibited a germination rate above 25% and stratification did not improve germination percentages. In late Fall 1994, container-grown plants exhibited an almost universal tendency to enter dormancy in a greenhouse maintained above 70F and provided with long-days via supplemental lighting. In two cutting propagation trials, cuttings collected 8/23 rooted at 65%; a 11/22 cutting collection failed to root. Seedling variation in leaf shape and growth rate is high. The results of 1995 cutting propagation trials will be presented. A reintroduction strategy for the species under the umbrella of the Stephen F. Austin

State Univ. Arboretum includes establishing a sustainable planting of the species in the Arboretum and reintroduction into Mill Creek Gardens, a Nacogdoches county conservation easement.

362

Bare-root Shade Tree Whip Production in Containers

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A method is described for producing bare-root shade tree whips in containers. Whip production is begun in February in heated greenhouses by sowing seed. Seedlings are transplanted to copper-treated containers and grown in a greenhouse until May, when they are moved outdoors and transplanted to No. 3 copper-treated containers. In October (8 months after seeding), plant heights range from 1 to 2 m. Several media have been developed that result in rapid growth, while separating readily from the root system by hand-shaking. Bare-root plants placed in refrigerated storage for 6 months and repotted, retained high survival and regrowth potential. The system combines the handling ease of bare-root stock with the high survival and regrowth potential of container stock.

165 ORAL SESSION 49 (Abstr. 363–370) Sustainable Agriculture/Cross-commodity

363

Yield, Earliness, and Fruit Weight of Fresh-market Tomatoes Grown in Synthetic and Organic Mulches

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Fresh-market tomatoes (*Lycopersicon esculentum* Mill) cvs. Sunny and Sunbeam were grown in bare soil (BS), Horto paper (HP), black polyethylene (BP), hairy vetch (HV), crimson clover (CC), and hairy vetch plus rye (HVR) mulches. Yields were highest in HV (85.8 $t \cdot ha^{-1}$), followed by HVR 69.3 $t \cdot ha^{-1}$) and CC (65.7 $t \cdot ha^{-1}$), and averaged 47% above BP for the 3-year period. A 5- to 9-day earliness was exhibited by BP over other treatments. Fruit weight was significantly higher in all three organic mulch treatments than in the other three treatments. Mulch biomass was highest in HVR (5.91 $t \cdot ha^{-1}$), whereas N fixation was highest in HV (188 $kg \cdot ha^{-1}$). Tomato harvest was extended by the HV treatment over the BP treatment by 3 to 4 weeks, during which tomato prices were higher than those in early or mid-season.

364

Influence of Velvetbean on Southern Root-knot Nematode When Used As Part of the Crop Rotation in Low-input Vegetable Production in Southern Georgia

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Velvetbean (*Mucuna deeringiana* L.) has been used as part of the crop rotation in low-input vegetable production in southern Georgia to help suppress populations of root-knot nematode (*Meloidogyne incognita*) for the past 2 years. Overwintering cover crops of crimson and subterranean clovers were used the low-input plots and rye was the plow-down cover crop in the conventional plots. Tomatoes, peppers, and eggplant were the vegetable crops grown in these production systems. Following the final harvest in 1992, use of nematicides in the low-input plots was discontinued and velvetbean was then planted into the low-input plots and disked in after 90 days. Results from the 1993–94 soil samples taken before and after velvetbean showed a continuing trend of reduced nematode numbers where velvetbean had been, while most conventional plots that had nematicides applied resulted in increases in nematode populations.

365

Insect Pests, Beneficial Insects, and Cover Crops of Biological Vegetable Farmers

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Eighty-two vegetable growers responded to a survey on pests, beneficial insects, and cover crop use sent in Winter 1993–94 to 314 members of the Virginia Assn. for Biological Farming (VABF) and participants at the 1993 Virginia Sustainable Agriculture Conference. Respondents reported 68 occurrences of insect pests on 99 vegetable crops and herbs. Six insects (flea beetle, squash vine borer, stink bug, cucumber beetles, and Mexican bean beetle) comprised 70% of the occurrences. Squash vine borer and cucumber beetles on cucurbits comprised 24% of all pest occurrences. Insect pests attacked summer squash on 57% and cucumber on 49% of the farms. Average severity of squash vine borer damage was 3.8 (range 0–4, where 0 = no damage and 4 = death or destroyed). Average severity of cucumber beetle damage was 3.0 (severe). Squash vine borer was not observed by farmers on non-cucurbit alternate hosts. Cucumber beetles were observed on horse nettle (10%) and wild nightshades (6%), but on no other plants in most cases (61%) when found on cucurbits. The most frequently observed beneficial insects were lady beetles (64% of the farms), preying mantises (42%), wasps (29%), assassin bugs (18%), and spiders (15%). Only 29% of the farms had purchased beneficial insects, with assassin bugs (10%) and lady beetles (7%) the most common types. Vetches, clovers, rye, and buckwheat comprised 69% of the responses on 23 types of cover crops and mulches used.

367

Response of 'Thompson Seedless' Grapevines to Sustainable Viticultural Practices

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Consumer concerns about pesticide residues and environmental degradation are having a significant impact on the California grape industry. Growers are using a variety of practices, from integrated pest management to certified organic production, to reduce the amount of pesticides and other synthetic inputs used in vineyards. This experiment was established to test selected sustainable cultural practices in a mature 'Thompson Seedless' vineyard. Treatments included in the experiment were row middle management (cultivated vs. perennial legume cover crop) and nitrogen fertilization (compost vs. synthetic). Vine nutritional status, yield, fruit composition, pruning weight, and population levels of the variegated leafhopper were monitored each season (1992–1994). In addition, efforts were expanded during the 1994 season to include assessment of spider, herbivorous mite, and beneficial arthropod densities. Conventional cultural practices (cultivation and synthetic fertilizer) produced the highest yields during the 1992 and 1993 seasons. This result may have been due to the nutritional status of vines, which was generally better for the cultivation and synthetic fertilizer treatment, especially in 1992. In 1994, significant treatment effects on yield were not observed, indicating that legume cover crop plots had become fully established. Sustainable cultural practices had little impact on growth, fruit composition, or insect pest pressure. 'Thompson Seedless' grapes were grown for three seasons without the use of insecticides or herbicides. Vine diseases were managed by cultural practices and application of sulfur.

368

Towards a Sustainable Fruit Industry in Europe: Research and Strategies

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The European Union's fruit industry is currently beset by marked surplus output, formidable market competition from non-EU countries, and strong consumer demanded for enhanced quality. This latter issue is particularly complex because it involves not only the fruit's genetic, esthetic, sensory, and taste characters, but also pre- and postharvest produce management practices and their impact on the environment and human health. The main thrust of the response to the challenges posed by these quality factors is integrated fruit production (IFP), a policy sustainable crop growing that the EU can support financially. Research has been directly involved in IFP and the directions in which it is moving. It has developed the first EU guidelines (OILB-ISHS), which initially covered pome crops and were later extended to cover all fruits, and the field, harvest, handling, storage, and market monitoring and quality-control techniques needed to implement them. These methods include biological and integrated disease and pest control, the introduction of plant material resistant to biotic and abiotic stresses, the development of field management practices to enhance plant defense and cropping-control mechanisms, the use of energy-saving irrigation and nutrient input techniques, the modeling of plantations, training systems and tree-bearing control, and advanced fruit storage, packaging, and transport methods. The updated advances in these areas are reported and discussed.

369

The Organic Cultivation Practices in Tea and Coffee

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Traditionally, the tropical plantation crops such as tea and coffee are intensively cultivated. The increasing concern about the environment, ecology, and the realization that the continued use of chemical inputs is causing the starvation of soils are forcing us to look into alternatives such as sustainable farming. Being perennial crops, there are no examples to follow in the case of plantation crops. By trial and error, we have switched over to organic cultivation of 340 ha of tea and 34.5 ha of coffee. The produce from these, i.e., black teas and arabica and robusta coffees, are being cultivated, processed, and packed conforming to most-stringent organic standards and world-renowned certification authorities, such as IMO, IFOAM, MOA, et. al. have vouchsafed their authenticity. The strategies adopted, methodologies of farming, economics, and the benefits accruing from such farming will be discussed.

370

Evaluating Fall Cover Crops Following Early Harvested Vegetables

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Vegetable growers in the northeastern United States who want to use cover crops are limited by the relatively short growing season and by a lack of cover crop species options. Seven cover crops that winter-kill under NE US conditions were evaluated in on-farm trials for their suitability for following early harvested vegetables. Plots of oilseed radish (*Raphanus sativus*), white senf mustard (*Brassica hirta*), phacelia (*Phacelia tanacetifolia*), oats (*Avena sativa*), and a bare control were planted on 25 Aug. and 8 Sept. 1993, following a lettuce crop. In the early planting, oilseed radish, white senf mustard, and phacelia produced more than 3000 kg·ha^{-1} dry matter in 11 weeks, while oats produced just more than 2000 kg·ha^{-1}. A smaller proportion of the accumulated biomass from these cover crops remained on the surface in the spring compared to oats. In the first planting, 80–107 kg·ha^{-1} N were accumulated in the above-ground biomass of the cover crops. On 3 and 16 Sept. 1994, plots of oilseed radish, white senf mustard, oats, yellow mustard (*Brassica hirta*), forage kale (*Brassica oleracea*), forage turnip (*Brassica rapa*), canola (*Brassica napus* cv. Sparta), and a bare control were established following potatoes. All cover crops except kale produced more than 3800 kg·ha^{-1} dry matter by late November in the early planting.

166 ORAL SESSION 50 (Abstr. 371–377) Culture & Management/Cross-commodity

371

A Success Story of Commercialization of Pineapple in Pakistan

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From 1950 until the 1980s, pineapple cultivation in Pakistan met with limited success because of a number of constraints. These included saline soils, brackish water, and a poor understanding of the requirements for nutrition, irrigation, growth and varietal adaptation, pest, disease, weather stress, overall crop management, and cultural practices. A new approach was attempted in late 1970 to the early 1980s, when a group of organizations in the Karachi metropolitan area developed a pot culture technique replacing local saline soils by river sand, and providing city city water instead of brackish underground irrigation. This pot culture system was limited by cost, unpredictable performance of survival, growth, and development, yield, and production of planting material. Thus, it could not be adapted on a commercial basis. These limitations were investigated in a 4-year study (1987–1990) at the Plant Introduction Centre, Karachi, of the Pakistan Agricultural Research Council, and technology was developed that led to the successful introduction, adaptation, and commercialization of pineapple production in Pakistan. Under the harsh arid conditions of Karachi, field trials were conducted with the pineapple var. Queen as an intercrop under a coconut canopy with trench and double-row system of planting. The best fertilizer management treatment consisted of the application of 4 kg gypsum and 5 kg cow manure on a per-plant basis, incorporated during land preparation and followed by the application of 56 g N and 60 g K per plant per annum in six split dosages. Fruit weighing 1000 g or more were harvested during 12 to 15 months following planting. Fruits were of high quality, with 13.6 % sugars, 1.5 % acidity, and TSS value of 4.7. Five suckers and slips were produced by each plant. The application of these soil amendments reduced soil pH from 8.5 to 6.9 and ECe by 80%. This regime enabled the use of slightly brackish underground water (ECe 2.7 mmhos) for irrigation. Weekly intervals of irrigation during summer and fortnightly intervals during winter were optimum. The crop was free of serious pest and disease. Mealy bugs and scale insects were controlled by Sumithion, rodents by Raccumin, while physical damage by squirrels and birds was avoided by covering the fruit with perforated paper bags. Through the development of this integrated production technology, Pakistan is now able to grow pineapples commercially.

372

Early Development of a Free-standing Tree Wall for 'Mcintosh' and 'Empire' Apples

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Spur-type growth habit, among other factors, is known to reduce vigor in apple trees. High-density orchards can, therefore, be designed with more vigorous rootstocks, which do not require support systems. Trees were planted in a latin square design and trained to modified vertical axis system which, encouraged maximum limb development. Growth response of the spur McIntosh strains; 'MacSpur', 'Hartenhof', 'Stirling', 'Chick-a-dee'; and for 'Empire' are compared for each of the five rootstocks MM.106, Alnarp 2, MM.111, KSC13, and KSC3. 'Empire' on KSC13 grew the largest, the smallest were 'Stirling', 'Chick-a-dee', and 'Empire' on KSC3.

373

Prebloom Treatments to Alleviate Cold Injury in Apple

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Damage to xylem subtending apple buds is often observed following very low winter temperatures. Reports suggest that prebloom application of boron, zinc, and urea facilitate recovery. Prebloom nutrient treatments were applied to 'McIntosh' and 'Empire' at three sites in Spring 1994. The following treatments were applied to drip at half-inch green: boron (22.8 mM, solubor); Zn-EDTA (0.75 mM); boron and Zn-EDTA; boron, Zn-EDTA, and urea (59.4 mM). Another treatment used boron and Zn-EDTA at half-inch green, followed by boron, Zn-EDTA, and urea at pink. Spur leaf area, fruit set, fruit size, and seed number were determined. There were no clear treatment effects at the warmest site (mid-winter low –32C); however, this orchard was more variable than other treatment sites. The intermediate site (mid-winter low –37C) had a strong trend of increasing fruit set in 'Empire' and 'McIntosh' as more nutrients were applied. The combined half-inch green and pink treatment significantly increased fruit set by 23.8% compared to the untreated control. At the coldest site (mid-winter low –42C), 'Empire' again displayed a strong trend of increasing fruit set with additional nutrients. All treatments combining boron and zinc significantly increased fruit set. The combined half-inch green and pink treatment increased fruit set by 43%. At this site 'McIntosh' did not respond to treatment. However, 'McIntosh' trees had continued active growth into late Fall 1993 and sustained severe cold injury in November. Data suggest that, when they were effective, nutrient treatments resulted in increased retention of flower buds on damaged spurs.

374

Fruiting and Ripening Characteristics of *Actinidia arguta* Hardy Kiwi

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In 1989, 2-year-old *A. arguta* varieties Geneva, Annaysana, Dumburton Oaks, Fairchild, National Arboretum, 74-7', 74-8, and the self-fertile variety Issai, were planted in Agassiz, B.C., on a well-drained soil site. The plants were grown with a single trunk to 1.8-m with permanent cordons, and fruiting laterals trained on a 2.1-m-wide winged T-bar trellis support. Plant spacing was 2.75 m within the row and 4.8 m between rows. Staminate varieties (Meader and 74-6) were planted at a 1:6 ratio of male : female for pollination. Fruiting canes were renewed every 2 years by winter pruning. All plants began to bear harvestable yields by 1991. *A. arguta* vine required 622 heat units from bud break to full bloom and the average flowering date was 29 May. Fruit begin to mature during September, depending on the variety. 'Geneva', 'Annaysana', and 'Issai' were the most suitable for com-

mercial production. In 1993, they produced a yield of 26, 38, and 26 kg/vine, with average fruit weight of 7.7, 6.3, and 4.8 g, respectively. 'Geneva' was the earliest to mature, followed by 'Annaysana' and ''Issai'. *A. arguta* ripen very unevenly and, at harvest, a certain proportion of the fruit are over-ripe. Fruit are best harvested early when they are firm. Storing the fruit at 1C improved ripening uniformity.

375

Cold Protection of Leatherleaf Fern in Shadehouses Using Water and Crop Covers

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Six shadehouses were used in tests of irrigation rates and crop covers for cold-protecting leatherleaf fern [*Rumohra adiantiformis* (Forst) Ching]. Each shadehouse was equipped with two irrigation systems—one over-the-crop to supply heat and one over-the-shadehouse to supply water for sealing the openings in the shade fabric with ice. The over-the-crop irrigation system consisted of frost protection wedge-drive impact sprinklers providing water application rates of 0.30, 0.56, and 0.76 cm/h. Six-m x 9-m spunbonded polypropylene crop covers weighing 20 and 51 $g \cdot m^{-2}$ were tested. During radiation freezes, all water application rates protected immature fronds from damage. Damage during advective freezes decreased with increasing water application rate, but ,even when crop covers were used in conjunction with irrigation, some damage still occurred. Temperatures under the lighter-weight cover were higher than under the heavier-weight one, probably because more water passed through the lighter cover to the crop. Water application rates had no effect on frond yield.

376

Nitrogen Mineralizations as Affected by Container Substrate Temperatures

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The N release patterns of composted turkey litter, composted yard waste, and composted municipal waste amended pine bark substrates were measured under simulated diurnal temperature variations [25C, 45C, and 45/25C (14/10 h)] found in container substrates. Temperature regime, compost, and the interaction between temperature and compost affected the NH_4 and NO_3 availability and the total N released from the composted waste products over the 16-week experiment. Within each temperature regime, the composted turkey litter released greater amounts of NH_4 and more total inorganic N than the municipal and yard wastes. The turkey litter yielded the highest NO_3 concentrations at 25C, while the municipal waste produced the highest NO_3 concentrations at the 45C and the 45/25C temperatures. Temperatures higher than 25C inhibited nitrification in the turkey litter-amended substrates; however, the 45C and the 45/25C treatments resulted in greater total N mineralization than the 25C treatment.

377

Constant Water Table: A New Technique for Hydroponic Lettuce Production

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Lettuce was produced using a new concept of hydroponics. The system is based on maintaining a constant water table (CWT). Plants grew on a flat surface and obtained the nutrient solution from capillary matting. One end of the mat was suspended in a trough containing the nutrient solution. The distance between the nutrient solution in the trough and the bench top was kept constant with a water level controller. The nutrient solution was resupplied from a larger reservoir. A ground cover on top of the capillary mat provided nutrient movement to the roots but prevented root penetration. Lettuce seedlings, germinated in small plug trays, were placed in holes cut in a 2.5-cm-thick styrofoam sheet. The styrofoam provided seedling support as well as protected the roots. Roots grew on the surface of the ground cover and were easily removed at harvest. The CWT could be adjusted by changing the height of the water level controller. The CWT concept of hydroponic production does not require pumps nor large storage reservoirs. No runoff occurs; the only nutrient solution used is that required by plants and a minimum amount of evaporation from the ground cover surface. Disease potential should be less than in other systems.

175 ORAL SESSION 51 (Abstr. 378–383) Genetics/Fruits, Nuts, & Small Fruit

378

Meiotic Behavior and RAPD Segregation in a Tetraploid Hybrid (*Vaccinium darrowi* x *V. corymbosum*) Suggests Genomic Divergence in Blueberry

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Vaccinium darrowi (D) is a wild blueberry species with low chilling requirements for budbreak, and heat and drought tolerance. Breeding efforts to incorporate these desirable traits into cultivated blueberry (*V. corymbosum*) (C) would be facilitated with a better understanding of the genomic homology between the two species. An interspecific tetraploid hybrid (CCDD, 2n=4x=48) was used to evaluate genome homology and interspecific recombination. Pollen mother cells examined at diakinesis and early metaphase I exhibited an average of 4.6 chain bivalents, 11.4 ring bivalents, 1.0 chain quadrivalent, and 3.0 ring quadrivalents. This data most closely fits a chromosome pairing model in which there is a greater pairing affinity between homologues than homoeologues. An analysis of the inheritance of 14 RAPD markers unique to *V. darrowi* in 72 backcross progeny of the *V. darrowi–corymbosum* hybrid also supported the pairing model: Seven of the 14 markers deviated significantly from tetrasomic inheritance ratios, expected if chromosome pairing was totally random. On the basis of the cytogenetic and RAPD analyses, the genomes of *V. darrowi* and *V. corymbosum* are divergent from one another, with preferential pairing within genomes. This outcome suggests there may be difficulty in breaking undesirable linkages when introgressing desirable traits from *V. darrowi* to *V. corymbosum*.

379

Nature of 2n Gamete Formation and Mode of Inheritance in Interspecific Hybrids of Diploid *Vaccinium darrowii* and Tetraploid *V. corymbosum*

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RAPD markers were used to determine the level of heterozygosity transmitted via 2n gametes from *V. darrowi* cv. Florida 4b (Fla 4B) to interspecific hybrids with tetraploid *V. corymbosum* cv. Bluecrop. The tetraploid hybrid US 75 was found to contain 70.6% of Fla 4B's heterozygosity, a value consistent with a first division restitution (FDR) mode of 2n gamete production. Crossovers during 2n gamete formation were evidenced by the absence of 16 dominant alleles of Fla 4B in US 75, and direct tests of segregation in a diploid population involving Fla 4B. RAPD markers that were present in both Fla 4B and US 75 were used to determine the mode of inheritance in a segregating population of US 75 x *V. corymbosum* cv. Bluetta. More than 30 homozygous pairs of alleles were located that segregated in a 5:1 ratio, indicating US 75 undergoes tetrasomic inheritance.

380

Influence of Pollination on Peroxidase Activities and Isozymes during Southern Highbush Fruit Development

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Five-year-old 'Sharpblue' southern highbush (*Vaccinium corymbosum*) plants were self- and cross-pollinated ('O'Neal') to study peroxidase activities and isozyme patterns during fruit development. Both soluble and bound peroxidase activities were present throughout development. Activities were very high during early fruit development, with peaks at 10 and 20 days after self- and cross-pollination, respectively. Activity was much higher for cross-pollinations. During rapid fruit development, peroxidase activities were low. During ripening, the activity of soluble peroxidases increased, then declined in both treatments. Bound peroxidase activity increased during the color transition from blue to dark blue, with the increase being much greater in self-pollinated fruits. Banding patterns of both soluble and bound isoperoxidases varied by pollination treatment as well as fruit developmental stage. Pollen sources alter peroxidase isozymes and activities in developing fruits. During fruit ripening, soluble peroxidase activity appears to be associate with the color transition from light blue to blue, while bound peroxidase activity appears to be associated with the color transition from blue to dark blue.

381

Isozyme Variability in Wild and Cultivated *Carica papaya*

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Populations of wild *Carica papaya,* previously designated as *Carica peltata*, were sampled from its native range on the Caribbean coast of Central America (Mexico, Belize, Guatemala, Honduras) and cultivated *Carica papaya* from both Central and South America were examined for isozyme variability. Thirteen loci from nine enzyme systems (Pgm, Pgi, Idh, Mdh, 6Pgd, Ugpp, Skdh, Aco, Tpi) were scored for all populations. Ten loci were polymorphic and a total of 31 alleles were detected. Isozyme genotypes as determined through segregation analysis were used in the genetic interpretation for eight loci and 18 alleles while six additional loci and 13 alleles were postulated on the basis of phenotypic variation found throughout the species. Nei's genetic identity, *I*, for both cultivated and wild *Carica papaya* was >0.9, which is consistent with conspecific populations. Wild papaya populations from different geographic areas appear more related to one another than to domesticates in the same geographic region.

382

Inheritance and Linkage Studies in Peach

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Inheritance of male sterility in peach [*Prunus persica* (L.) Batsch] Plant Introduction (PI) 240928 was investigated. Crosses of PI 240928 with five wild-type clones yielded all male-sterile offspring, indicating dominant gene action. Inheritance of the sweet kernel trait in peach was studied in F_1 and F_2 progeny of 'Summer Beaut' nectarine (sweet kernel) x 'Biscoe' peach (bitter kernel). All four F_1 progeny were bitter. Segregation in an F_2 of 80 progeny fit a ratio of 3 bitter : 1 sweet. We propose that the gene controlling the sweet kernel trait be designated *sk.* Sweet kernel (*sk*) was linked to nectarine (*g*) at a map distance of 17 cM. Evaluation of the peach PI collection showed that PI 129678 ('Stanwick' nectarine) and PI 34685 ('Quetta' nectarine) were the only clones with a sweet kernel. Crosses between 'Davie II' and 'Honeyglo' nectarine (*dwdw*) confirmed that the gene conferring the dwarf phenotype in progeny of 'Davie II' is non-allelic to *dw.*

176 ORAL SESSION 52 (Abstr. 384–389) Postharvest Physiology/Cross-commodity

384

Effects of Light Quality on Growth and Quality of in Vitro Plantlets during Low-temperature Storage

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Broccoli 'Green Duke' plantlets, which were ready for transplanting after 2 weeks of photoautotrophic (sugar-free) culture under the conditions of 1100 $\mu mol \cdot mol^{-1}$ CO_2 (outside the vessel), 22±4C air temperature, and 140 $\mu mol \cdot m^{-2} \cdot s^{-1}$ photosynthetic photon flux (PPF), were stored for 6 weeks at 5C in darkness or in white, red, or blue light at 2 $\mu mol \cdot m^{-2} \cdot s^{-1}$ PPF. Photoperiod was set at 24 h/day during storage. Spectral quality significantly affected plantlet quality: stem length was longer and chlorophyll concentration of leaves was lower in red or in blue light than in white light or in darkness after 6 weeks in storage. Regardless of the spectral quality, light in storage maintained plantlet dry weight at a level comparable to that before storage, while dry weight was reduced significantly in dark-stored plantlets. Spectral quality did not significantly affect the photosynthetic and regrowth potential of plantlets. All plantlets stored in light, regardless of light spectra, showed comparably high photosynthetic ability after storage and had similar dry weight, number of leaves, and stem length after 9 weeks of transplanting to the greenhouse under natural light.

385

Respiration of 'Hass' Avocados in Response to Elevated CO_2 Levels

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Stress levels of carbon dioxide can be effective in the retardation of ripening and control of decay-causing pathogens and insect infestation of some horticultural perishables. Our objective has been to identify key mitochondrial enzymes and pathways that regulate the fruit's response to CO_2 actions. Oxygen uptake of fruit stored in air + 20% CO_2 (16.8% O_2) was depressed compared to the air-stored fruit, whereas the fruit stored in air + 40% CO_2 (12.6% O_2) had an elevated respiration rate. Climacteric fruit treated with 20% CO_2 at 10C had increased pyruvate dehydrogenase (PDH) activity, decreased cytochrome oxidase (CytOx) activity, and double the alternative oxidase (AltOx) activity compared to air-stored fruit. Air + 40% CO_2-stored fruit had reduced PDH and CytOx activities, and 50% more AltOx activity than the control fruit. Mitochondria were treated directly with the same CO_2-enriched atmospheres to measure the catalytic effects of CO_2. Total O_2 uptake was decreased in both CO_2 atmospheres and the cytochrome/alternative pathway ratio was greater than with mitochondria held in air. Nuclear magnetic resonance analysis of whole fruit confirmed that these CO_2 atmospheres decrease the intracellular pH several 0.1 pH units with 2 h.

386

Biochemical Bases for Controlled-atmosphere Effects on Reducing Chilling Injury of 'Hass' Avocado Fruit

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California-grown 'Hass' avocado fruit were stored at 5C, in air or a controlled atmosphere (CA) of 2% oxygen and 5% carbon dioxide. Fruit were evaluated at 0, 2, 4, 6, 8, 10, and 12 weeks, both immediately upon removal from storage and after ripening at 20C. Severe chilling injury (flesh browning) developed in the air-stored fruit after 6 weeks, while only moderate symptoms were observed in CA-stored avocado fruit after 12 weeks. Lipid peroxidation breakdown products increased during storage and ripening in both air and CA treatments. Sterols, steryl esters, steryl glycosides, glycolipids, and phospholipids were analyzed. Quantity of acylated steryl glycoside in ripe fruit changed from 34 nmoles initially, to 51 or 27 nmoles after 6 weeks at 5C in air or CA, respectively. Glycolipid fatty acid unsaturation in air-stored fruit decreased with the development of chilling injury. Fatty acid unsaturation in phospholipids (phosphatidylinositol, phosphatidylcholine, phosphatidylglycerol, and phosphatidylethanolamine) of air-stored avocados decreased with the development of chilling injury. CA storage delayed the development of chilling injury and the loss of fatty acid unsaturation.

387

Software for Design of Modified-atmosphere Packages for Fruits and Vegetables Incorporating Respiration Rate Variation

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Modified-atmosphere (MA) packages for fruits and vegetables are traditionally designed by matching product respiration rate with permeation of the packaging film to achieve a desired gas composition in the package. However, this design procedure is adequate only in ideal situations. We have previously shown that actual O_2 partial pressures were distributed around targeted levels due to variation in product respiration rate and film permeability. In some cases, injurious levels of O_2 were generated as a result of this variation. We have developed a procedure that incorporates variation of product respiration rate and uses a statistical approach to predict appropriate target levels. This approach includes a user-based decision as to how many packages with O_2 partial pressures below the lower O_2 limit for product injury can be tolerated. We have incorporated this approach into a user-friendly computer software using turbo pascal in MS DOS environment. This software is menu-driven and has graphical support. Use of the software will be demonstrated with examples.

388

Modeling the Accumulation of Volatiles in the Interstices of Fruit Interiors and the Fruit Cuticle

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A theoretical model was developed that predicts how volatiles synthesized by

fruit accumulate in the fruit interior and the fruit cuticle. Model inputs include temperature, rates of volatile synthesis, solubility of the volatile in the cuticular material, and the permeability of the volatile through the cuticle. The model indicated that the accumulation of volatiles was highly temperature-dependent and dependent upon the nature of the interaction between the volatile and the cuticle. For volatiles whose cuticular permeability declined rapidly with temperature, the concentration in the fruit and fruit cuticle tended to increase with decreasing temperature. This accumulation of volatiles in the fruit and fruit cuticle with decreasing temperature was enhanced by a decrease in the heat of solution (i.e., temperature sensitivity of solubility) and diminished by an increase in the Q_{10} Of the rate of volatile synthesis (i.e., the temperature sensitivity of the rate of synthesis). The model suggests that storage temperature can influence volatile retention and, hence, the volatile profile.

389

Application of an Ethanol Biosensor to Identify Low-O_2 Injury of Fruits and Vegetables in MA Packages

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In modified-atmosphere (MA) packaging of fruits and vegetables, there is a risk of generation of excessively low, injurious O_2 levels due to improper package design, temperature abuse, and/or product respiration rate variation. When exposed to injurious O_2 levels, product quality deteriorates and off-flavors develop. Also, there is increased production of ethanol and other fermentative volatiles. For blueberries, off-flavors were positively correlated with tissue ethanol level when the product was exposed to a range of O_2 partial pressures (0 to 18 kPa) and temperatures (0 to 25C). A biosensor that measures ethanol level in package headspace will be useful for easy identification of the packages containing injured products. Biosensors that measure ethanol in aqueous solutions by a color change reaction are commercially available. We have found a positive correlation between the color (hue) of the sensor and headspace ethanol levels in packages containing cut broccoli at 22C. The utility of the biosensor in quality assurance (QA) based on the identification of low-O_2 injury of the packaged products will be discussed.

177 ORAL SESSION 53 (Abstr. 390–395) Growth & Development/Vegetable Crops

390

Leaf Appearance Rate of Summer Squash as a Function of Thermal Time

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Different planting dates were used to study the influence of thermal time on leaf appearance rate of four summer squash (*Cucurbita pepo* L.) cultivars. During the first year (1991), thermal time or growing degree days (GDD) were calculated using a base temperature of 8C and a ceiling temperature of 32C for several planting dates. Leaf numbers per plant were determined every 2 to 3 days. Leaves that were beginning to unfold with a width of 2 cm or greater were included in the counts. The relationship between leaf number and GDD was established from the initial data set, and data from subsequent years were used for model validation. Results indicated that single equation could be used to predict leaf appearance of all four cultivars in response to thermal time. The response of leaf appearance to GDD was curvilinear, with a lag over the first five leaves. After five leaves, the increase in leaf number per plant was linear with increased GDD. Segmented regression with two linear functions also fit the data well. With this approach, leaf 5 was the node, and a separate linear function was used to predict the leaf number below five leaves and above five leaves. The results of this model should prove to be useful in developing a model of leaf area development, and eventually a crop growth model, for summer squash.

393

Root Development in Sweet Corn Inoculated with the Biocontrol Fungus *Trichoderma harzianum*

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Production of *shrunken-2* sweet corn is often limited by poor establishment. Good root development is necessary for establishment, and it can be limited by stress or disease. *Trichoderma harzianum* strain 1295-22 was developed as a biocontrol fungus with particularly strong root-colonizing ability. In addition to acting as a biocontrol agent, it stimulates root growth. In greenhouse experiments using field soil, root dry weight 21 days after planting was 500 mg, greater compared with 320 mg in uninoculated controls, an average increase of >50%. The thoroughness of soil exploration more than doubled, from 31% (control) to 70% (*Trichoderma*) of the soil being within 1 cm of a root. The difference in performance was not attributable to disease: no disease symptoms were evident, the occurrence of disease organisms was low, it was the same in both treatments, and it was not associated with smaller plants. Furthermore, the greatest differences were noted in steam-sterilized soil. Colonization of the roots by *Trichoderma* was related to the age of the root. The oldest part of the radicle had 10^6 cfu/g root DW. Branched seminal roots had $10^{5.5}$ cfu/g. Even the rapidly growing tips of the first-whorl roots were well-colonized ($10^{4.7}$ cfu/g). The mechanism of increased root growth has not been identified, but colonized roots acidify about 0.1 pH units more than control roots, which could cause both faster acid-growth and increased ion uptake. Ion leakage into distilled water is about 25% lower in colonized roots.

394

Growth Analysis of Tomatoes Grown in Black Polyethylene and Hairy Vetch Mulches

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Dry weight and leaf area of tomato (*Lycopersicon esculentum* Mill.) plants grown on raised beds with black polyethylene (BP) or hairy vetch (*Vicia villosa* Roth) (HV) mulches were measured at weekly intervals during 1993 and 1994. Leaf area and foliage, fruit, and total weight of tomato plants grown in BP were greater early in the season, but less later in the season than plants grown in HV. The relative growth rate of tomatoes in HV was higher throughout most of each year than that in BP. There was little difference between treatments in unit leaf rate (rate of weight gain per unit leaf area). The growth rate of fruit per unit of tomato foliage was greater in BP than HV, whereas the leaf area to weight ratio was greater in HV than BP. These results suggest that tomatoes grown in BP produce greater early yield because of greater early foliage growth and greater partitioning to fruit than HV. However, tomatoes grown in HV eventually outgrow and outyield those in BP because of greater partitioning to and maintenance of leaf area throughout the season.

395

Peanut Production using Recirculating Nutrient Film Technique (NFT)

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As part of NASA's effort with bioregenerative life support systems, the growth of candidate crops is being investigated in controlled environments. Peanut (*Arachis hypogaea* L.) was selected for the high oil and protein content of its seed. Peanut cvs. Pronto and Early Bunch were grown from seed, using recirculating nutrient film technique (NFT) in 6-cm-deep, trapazoidal culture trays. The trays were fitted with slotted covers, which allowed developing pegs to reach the root zone. Use of a separate moss-filled pegging compartment above the root zone (tray within a tray) had little effect on seed yield, but resulted in a 60% increase in the nitric acid requirements for pH control. Yields from both cultivars were equivalent to field values on an area basis; however, harvest indices were lower than field values due to the luxuriant canopy growth under controlled environment conditions. Proximate analysis of seeds was similar to field values, with the exception of fat, which was ≈15% lower, and ash, which was ≈30% greater under controlled environment conditions, regardless of cultivar.

178 ORAL SESSION 54 (Abstr. 396–399) Food Science/Vegetables (Tropical & Subtropical)

396

Evaluation of Iron Nutritional Quality of Two Amaranth Species sing Hemoglobin Repletion in Rats

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Studies have been underway to evaluate the genetic variation in iron nutritional quality of the green leafy vegetable *Amaranthus.* Initial screening of 35 lines of amaranth from 12 species indicated wide variation in total iron, and small, but significant, differences in bioavailable iron, as determined by an in vitro assay. To verify if the differences in bioavailable iron detected by the in vitro assay were biologically significant, two lines of amaranth, *A. tricolor* Ames 5113 and *A. hypochondriacus* Ames 2171, were evaluated using a hemoglobin repletion assay in rats. Weanling Sprague-Dawley rats were made anemic by feeding an iron-free casein-based diet for 4 weeks. The anemic animals were fed treatment diets in which all Fe was provided by the amaranth lines. Hemoglobin levels were measured at the start and end of the treatment period to determine bioavailability. Although *A. tricolor* contained a higher concentration of total iron (670 ppm), the bioavailability of this iron to rats was lower than from the *A. hypochondnacus* line (total Fe = 210 ppm). Similar amounts of either amaranth line added to the diet produced similar changes in hemoglobin, although total iron concentrations were significantly different, confirming results observed with in vitro assays.

397

Electronic Sensing of Volatiles from Tomato Juice as a New Technology for Quality Control and Detection

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Recent developments in electronic odor-sensing technology has opened the opportunity for non-destructive, rapid, and objective assessment of food quality. We have developed an electronic sensor (electronic sniffer) that measures aromatic volatiles that are naturally emitted by fruits and fruit products. The ability of our sniffer to detect contamination in fruit juice was tested using tomato juice as a model system. Tomato juice was extracted from cultivar Rutgers and divided into eight glass jars of 300 g juice each. The jars were divided into two treatments: the control jars contained tomato juice mixed with 0.15% sorbic acid to suppress microbial growth, and the experimental jars contained only tomato juice. All the jars were placed open, on a counter top in the laboratory for 8 days. The juice was tested daily with the electronic sniffer and for pH. The total volatiles in the headspace of the juice was extracted on alternating days via dynamic headspace method using charcoal traps, analyzed by gas chromatography, and confirmed by GC/mass spectometry. The results indicate that the sniffer is able to detect differences between the two treatments 4 days after the tomato juice was exposed to ambient atmosphere. The electronic sniffer output for the control juice showed a monotonous decline, while the output for the experimental juice exhibited a sharp incline after day four. This sensor output correlated well with the total volatiles.

398

Studies on the Fruit and Vegetable Handling System at Farmers' Market in Hawaii

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Homestead and organic farming systems are the main sources of commodities sold at farmers' markets in Hawaii. Consumers are attracted because the products are generally accepted as safe and of premium nutritional quality. Markets were frequented by many groups, including senior citizens. Two models were studied in urban and rural Hawaii, respectively, to determine the support systems that make then function properly with special attention to the postharvest technology component of operations. Innovative preparation, presentation, and display methods were observed for bananas, ethnic vegetables, and herbs. Homestead and organic farmers work in the mornings and strict use of shade is significant in maintaining freshness from produce temperature standpoint. Hawaiian fresh produce distribution models that emphasize grower participation as found in this study could rapidly expand the horticultural industry and reduce postharvest losses significantly if adopted by developing countries.

399

Impact of Storage Temperature Fluctuation on Modified-atmosphere Packaging of Fresh Produce

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Use of modified atmosphere (MA) as an adjunct to low temperature can be effective method for prolonging the shelflife of fresh fruits and vegetables. However, if storage temperature fluctuates, anoxic conditions can result and, consequently, the fresh produce quality can deteriorate rapidly. The objective of this investigation was to evaluate the effects of temperature fluctuation on the atmosphere inside the package and on the quality of packaged produce. Mushrooms (*A. bisporus*, U3 Sylvan 381) were packaged in rigid containers (4 liters) fitted with diffusion windows to obtain an atmosphere of 5% O_2 and 10% CO_2 at 4C. Temperature fluctuation had a major impact to the atmosphere inside package. During the first fluctuation sequence, O_2 level depleted to 1.5% and CO_2 increased to 18%. When the temperature returned to 4C during the next sequence, CO_2 level fell back to 10%, but O_2 level remained at 1.5%. The quality of mushrooms stored under temperature-fluctuating conditions was severely affected, as indicted by the extent of browning, loss of texture, and level of ethanol in the tissue compared to mushrooms stored at constant temperature. It was clear from this experiment that under temperature fluctuation, even it occurs once, can seriously compromise the benefits of MA packaging and safety of the packaged product. It is thus necessary that MA packaging compensate for the additional permeability required that is caused by storage temperature fluctuations.

25 POSTER SESSION 1 Breeding/Floriculture & Woody Ornamentals (Cross-Commodity)

410

RAPD Analysis of Hosta Species and Cultivars

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The genus of *Hosta* (plantain lily) is a shade-loving herbaceous plant with attractive foliage. Confusion exists in the genus regarding nomenclature and taxonomy. In this study, the possibility of application of RAPD markers to characterize *Hosta* species and cultivars was investigated. DNA was extracted from 28 *Hosta* species and cultivars. Thirty-six of 37 primers generated RAPD markers. Phylogenic analysis and principal components analysis showed groupings among cultivars. Results indicated that *H. plantaginea* and *H. ventricosa* were the most distant from the other tested species and cultivars. These results suggest RAPDs may be useful in the identification and analysis of relationships among *Hosta.*

414

Consumer Evaluation as an Adjunct to F_1 Hybrid Seed Development of Hexaploid Chrysanthemums (*Dendranthema grandiflora* Tzvelv.)

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The change from asexual to sexual propagation for annual and perennial bedding plants has been successfully accomplished for floral crops, e.g., *Pelargonium.* Seed-propagated cultivars do not necessarily possess the clonal uniformity of vegetatively propagated cultivars. In the development of F_1 hybrid garden chrysanthemums, this lack of uniformity was assessed with the use of consumer sensory evaluations. Seedlings (n = 10–20 plants/cross) were transplanted for field trials in St. Paul and five Minnesota branch stations each year during 1988–94 to test for G x E. Early flowering F_1 hybrids, developed from inbred parents with general combining ability, were evaluated for flowering earliness, plant uniformity, and a general rating. Consumer rankings of top performers were not

significantly different (5% level) from mum breeders. The top performers for all three ratings were selected each year for repeat evaluation the next year. The two highest performing F_1 hybrids were submitted for All American Selection Trials in 1995.

418

Transfer of the Long-lived Postharvest Keeping Characteristic from a long-lived Inbred line of *Antirrhinum majus* (L.) to a Short-lived Line through the Inbred Backcross Method

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In an effort to reduce chemical usage to prolong postharvest keeping time of cut flowers, a cross was made between a long-lived (vase life, 10.9 days) inbred line of *Antirrhinum majus* and a short-lived (vase life, 5.0 days) inbred line. The F_1 hybrid was backcrossed to the short-lived parent. Sixty plants of the BC_1 generation were carried on through three generations of selfing by single-seed descent. Eight replications each of 60 BC_1S_3 families, the parents, and the F_1 hybrid were grown in the greenhouse, harvested with 40-cm stems when five florets opened, and placed in distilled water for vase life evaluation. Stems were discarded when 50% of the florets on a spike wilted, browned, or dried. Three families proved not significantly different from the long-lived inbred parent. Results indicate that inbred backcross breeding shows potential to increase the postharvest keeping time of short-lived *Antirrhinum majus* inbred lines.

0422

Genetic Analysis in *Nicotiana alata*: The Inheritance of Flower Doubleness

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Genetic analysis of a white double-flowering *Nicotiana alata* is being investigated. Self-pollination of the double-flowering plant produced all double progeny. Reciprocal hybridization of the double-flowered selection with *N. alata* cultivars produced nondouble F_1 progeny that segregated 3:1 (nondouble to double) in the F_2 generation. Reciprocal backcrosses of F_1 plants to the parents resulted in nondouble progeny when backcrossed to the nondouble parent and 1:1 segregation when backcrossed to the double parent. Intercross of F_1 plants resulted in progeny segregating 3:1. Double flowering habit has been transferred to white, red, salmon, green, and bicolor *N. alata*. Results suggest double flowering is under nuclear control regulated by a recessive allele.

426

Elm Growth and Japanese Beetle Damage on Selected Cultivars

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Ten single plant replications of 11 taxa were planted 6 May 1994, fertilized regularly, and maintained under drip irrigation. Japanese beetle damage became apparent in mid-June. Sevin SL at 1 qt/100 gal was applied with a tractor-mounted mist blower on 22 June, and 7 and 19 July. Data on Japanese beetle populations were recorded using an arbitrary scale of 0 (no beetles) to 10 (heavy infestation). Damage on each tree was recorded using an arbitrary scale of 0 (no damage) to 10 (completely skeletonized). The annual increment in height and caliper growth was recorded for each tree in Fall 1994. *Ulmus japonica* and *U. glabra* 'Pendula' had the most height growth (>60 cm increment) but were not significantly different from most other accessions, while NA 60070, *U. crassifolia*, and NA 60071 had significantly slower growth than the former group(<25 cm increment). Japanese beetles fed first on *U. carpinifolia* 'Variegata', NA 60071, and 60070, skeletonizing most of the new growth before the first Sevin application, resulting in the most damage. This may have resulted in poor growth of the USDA/NA selections in 1994.

430

Growth of Silver Maple and Boxelder Taxa in Tennessee

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Several commercially available *Acer saccharinum* and *A. negundo* taxa were established with 10 single-plant replications in a cultivar trial at the TSU–NCRS in 1993 and 1994. Each plant was fertilized in spring and early summer with 100 gm 15–15–15 beginning Summer 1993. Drip irrigation was applied as needed beginning Summer 1993. Vegetation within tree rows was controlled with preemergent and postemergent herbicides, while grassed middles were mowed. Growth data were recorded in Fall 1993 and 1994 and height and caliper increment calculated for the 1994 season. In the silver maple group with most height growth were: 'Silver Queen', 'Skinneri', and 'Silver Pyramid'. These differed significantly from a group of four slower growing cultivars. Cultivars with the most height growth also had the most caliper growth. Seedling boxelder grew faster than one accession of 'Flamingo', while three other cultivars were intermediate. Data will also be presented on insect and disease ratings.

434

Growth of Sugar Maple Taxa in Tennessee

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Commercially available *Acer saccharum* cultivars, and some closely related species accessions (*floridanum, leucoderme, macrophyllum,* and *nigrum* 'Greencolumn'), were established as 10 single-plant replications in a cultivar trial at the TSU–NCRS in 1993 and Spring 1994. Plants were regularly fertilized and drip irrigation was begun Summer 1993. Growth data were recorded each fall and height and caliper increment calculated for the 1994 season. In the group with most height growth were: 'Bonfire', 'Majesty', *nigrum* 'Greencolumn', *leucoderme*, 'Sweet Shadow', 'Fairview', and *macrophyllum*. These, except for 'Fairview' and *macrophyllum*, differed significantly from a group of seven slower growing cultivars. With some exceptions, cultivars with the most height growth tended to have the most caliper growth, while those with the least height growth tended to have the least caliper growth. Data will also be presented on insect and disease ratings.

438

Growth of Norway and Sycamore Maple Taxa in Tennessee

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Commercially available Norway and sycamore maple taxa were established as 10 single-plant replications in a cultivar trial at the TSU–NCRS in 1993 and Spring 1994. Each plant was fertilized regularly and drip irrigation was begun Summer 1993. Vegetation within tree rows was controlled with preemergent and postemergent herbicides, while grassed middles were mowed. Growth data was recorded in Fall 1993 and 1994 and height and caliper increment calculated for the 1994 season. In this group of 29 taxa, 9 cultivars were in the group with most height growth: 'Columnare', 'Pond', 'Deborah', 'Crystal', 'Parkway', 'Columnarbroad', 'Schwedleri', 'Summershade', and 'Fairview'. With some exceptions, cultivars with the most height growth tended to have the most caliper growth, while those with the least height growth tended to have the least caliper growth, with the notable exception of 'Columnar'. Data will also be presented on insect and disease ratings.

442

Growth of Red Maple Taxa in Tennessee

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Commercially available *Acer rubrum* and *A. freemanii* taxa were established as 10 single-plant replications in a cultivar trial at the TSU–NCRS in 1992 and Spring 1993. Plants were fertilized regularly and drip-irrigated as needed beginning Summer 1993. Growth data were recorded each fall and height and caliper increment calculated for the 1994 season. Ten cultivars were in the group with most height growth: 'Armstrong', 'Autumn Blaze', 'Schlesingeri', 'Olson', 'Morgan', 'Scarlet Red', 'Embers', 'Indian Summer', 'Scarsen', and 'October Glory'. These all differed significantly from a group of 11 slow-growing cultivars. With some exceptions, cultivars with the most height growth tended to have the most caliper growth, while those with the least height growth tended to have the least caliper growth. Data will also be presented on insect and disease ratings.

446

Powdery Mildew Observatios and Growth of Crapemyrtle in Teneessee

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Fifty-five cultivars of crapemyrtle were established in a cultivar trial with 10 single-plant replications during Fall 1993 and Spring 1994. Drip irrigation began on a regular basis on 18 May 1994 and plants were fertilized regularly. Powdery mildew appeared in July, and within 2 to 3 weeks maximum levels of infection occurred. Plants were rated using a scale of 0 (healthy) to 5 (totally mildewed). In the group of seven cultivars, most heavily infected (>2.8 rating), 'Byers Wonderful White' was worst (4.1), followed by 'Royalty', 'Pink Lace', 'Prairie Lace', 'Petite Plum', 'Firebird', and 'Christmastime'. There were 21 cultivars with no mildew (0.0). Many of these were USDA–NA hybrids but also included 'Hope', 'Bourbon Street', 'Glendora White', 'Petite Snow', 'Centennial Spirit', and 'Hardy Lavender'. A few USDA–NA hybrids had slight mildew: 'Potomac', 'Powhatan', 'Catawba', 'Seminole', 'Biloxi', and 'Hopi' (<10% of foliage mildewed).

450

Powdery Mildew Observations and Growth

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Eighty-one oak taxa were established at the Nursery Crops Research Station in McMinnville, Tenn., in Fall 1993 and Spring 1994. Drip irrigation was applied as needed beginning 18 May 1994 and plants were fertilized regularly. Powdery mildew began to appear in July on some taxa. Each plant was rated on a scale where 0 = healthy plant and 5 = totally mildewed. Height and caliper were recorded in Fall 1994 and the 1994 growth increment calculated. *Quercus robur fastigiata* was most severely affected by powdery mildew (4.1), followed by a group of six taxa, including *douglasii*, *oglethorpensis*, *macrocarpa*, *virginiana*, *prinus*, and *aliena* (2.3–1.4). There were slight amounts of mildew on 26 taxa and 48 taxa were mildew-free. Growth increment in height and caliper will also be presented.

454

Powdery Mildew Observations and Growth of Lilac in Tennessee

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Sixty cultivars of lilac obtained from two commercial nurseries were planted 18 May 1994 and immediately placed under drip irrigation and fertilized regularly. Powdery mildew appeared in July. Each plant was rated in July, August, and September for powdery mildew on a scale of 1 (healthy) to 5 (totally mildewed). There were 22 cultivars in the most resistant group (0–1.8) in July, 13 in August (0–1.0), and 11 in September (0–1.0). Mildew-free were: 'Miss Kim', 'Royalty', 'Palibin', 'Summer Snow', 'White Summers', 'Minuet', 'Ivory Silk', 'Anna Amhof', 'Donald Wyman', but these were not significantly different from 'James MacFarlane' and 'Superba' (<10%of plant mildewed). Data on growth will also be presented.

458

Adaptability of Selected Half-sib Families of Sycamore to Container and Nursery Production

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Ninety seedlings from each of seven half-sib families of sycamore (*Platanus occidentalis* L.) were grown to marketable size in 9.1-liter containers in College Station, Texas. Dry matter partitioning was assessed with 10 seedlings each of four half-sib families grown in 4.7-liter containers. Half-sib families included selections native to Brazos County, Texas, and Putnam County, Tenn., and four half-sib families from the Westvaco Corp. (WV) or Texas Forest Service (TFS) tree improvement programs. Families could be separated into three groups with TFS-09 attaining a significantly greater height than other families, while Brazos-D, Brazos-C, and TFS-24 were intermediate and WV-10 and WV-14 were shortest. Contrary to previous field production studies, a weak inverse correlation (R^2 = –0.19, P > 0.01) was observed between the number of cuts required to remove multiple leaders and plant height, perhaps due to episodic shoot elongation in south Texas conditions vs. a single flush in northern regions. Corrective pruning removed more dry matter from TFS-09 than from Brazos-D, Brazos-C, and Putnam seedlings. Total dry weights of TFS-09 and Brazos-C were greater than WV-14 or Putnam seedlings.

462

Screening of Deciduous Azalea for Resistance to Azalea Lace Bug

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Azalea lace bug is the most serious pest of cultivated azalea. Though deciduous azaleas are generally considered to be more resistant to lace bug than are evergreen azaleas, some variation in resistance has been reported. The identification of the genetic and physiological basis of resistance is important to eventual development of resistant cultivars of both the deciduous and evergreen azaleas. The first step in this program is to evaluate a wide range of deciduous azaleas for level of resistance. Laboratory evaluations were conducted on nine species and two hybrid cultivars of deciduous azalea and a known susceptible cultivar of evergreen azalea, 'Delaware Valley White'. Oviposition rate, rate of egg hatch, number of nymphs surviving, and percent damaged leaf area were evaluated for each of the tested genotypes. Results indicated a wide range of susceptibility, with *R. canescens* and *R. periclymenoides* plants highly resistant to infection, while *R. atlanticum* and *R. viscosum* were highly susceptible.

466

RAPD Analysis of *Acer*

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DNA from 27 *Acer* species was used for RAPD analysis. A relatively high number of phylogenically informative polymorphisms were detected, as would be expected in intraspecific comparisons. Principle coordinates analysis was used to discern groupings among the species and a RAPD-based phylogeny was constructed. As expected when making comparisons among species, very high levels of polymorphism were found. Cultivars that grouped together in the principle components analysis also grouped together in the phylogenic analysis. Parts of the phylogenic analysis do not agree with morphology-based phylogenies. This may be due to poor correlation between morphological and DNA markers, or perhaps RAPDs may be too discriminatory to be used for interspecies comparisons. The extremely high level of between-species variation coupled with the low level of within-species variation, indicates the potential of DNA-based identification and discrimination of *Acer* species is high.

470

Plant Introductions from the Mt. Cuba Center

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Over the past 7 years, eight plants have been introduced from the Mt. Cuba Center for the Study of Piedmont Flora—two woody and six herbaceous ornamentals—which will be illustrated and described. *Cornus sericea* 'Silver and Gold', 1988, is a sport of and similar to 'Flaviramea' with white variegated leaves. *Aster novae-angliae* 'Purple Dome', 1989, is a widely known and compact form (50 cm tall) of the species. *Heuchera americana* 'Garnet', 1989, has shiny green foliage of the species mottled garnet-red. *Solidago sphacelata* 'Golden Fleece', 1989, is a compact (50 cm) form of the species with semi-evergreen basal foliage, winning the ISU outstanding plant award in Switzerland in 1994. *Leucothoe axillaris* 'Greensprite', 1991, is easy to propagate and quick to grow, with solid green, narrow leaves with undulating edges and attenuated tips. *Pachysandra procumbens* 'Forest Green', 1992, has larger leaf whorls and a more smoothly undulating surface than the species. *Trillium grandiflorum* 'Quicksilver', 1992, is similar to the species only with 1-year doubling time. *Aster laevis* 'Bluebird', 1995, is similar to the species but has so far been free from foliage diseases.

474

Horticultural Crops Germplasm in the S-9 Plant Germplasm Collection

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The S-9 Plant Germplasm Collection maintains and distributes germplasm of various horticultural crops, including pepper (*Capsicum* spp.), watermelon

(*Citrullus lanatus*), okra (*Abelmoschus* spp.), eggplant (*Solanum melongena*), miscellaneous *Solanum* spp., sweetpotato (*Ipomoea batatas* spp.), luffa (*Luffa* spp.), gourds (*Lagenaria* and *Momordica* spp.), squash (*Curcurbita moschata*), pumpkin (*Curcurbita maxima*), marigold (*Tagetes* spp.), Stokes' aster (*Stokesia laevis*), hibiscus (*Hibiscus* spp.), Engelman daisy (*Engelmannia pinnatifolia*), pampasgrass (*Cortaderia selloana*), ornamental bamboo (*Bambusa* spp.), and other ornamental grasses. Seed or other propagules of these plant materials are available for research purposes. Detailed information on individual collections and general information on the USDA National Plant Germplasm System will be presented.

478

Evaluations and Plant Descriptors of New Collections of *Lesquerella fendleri*

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Lesquerella fendleri (Gray) Wats. (Brassicaceae) is a potential oilseed crop with many commercial applications, primarily as lubricant additives, but also in resins, waxes, plastics, and cosmetics. This species is native to the southwestern United States where new populations have been collected over the past 2 years to increase germplasm diversity for plant breeding. Some of these new accessions were evaluated and seeds increased at Phoenix, Ariz., over the 1994–95 season. Measurements of stand establishment; plant height and width; leaf, shoot, and flower characteristics; and growth habit were taken over the season. Plants were also examined for autofertility and male sterility. Seed-oil characteristics, seed size and yield, glucosinalate content, and seedcoat gum content will be measured at harvest. Plant descriptors for *Lesquerella* have been developed as a result of these measurements. Following seed increase, germplasm will be entered into the National Plant Germplasm System. This information will be useful in determining the most promising material for plant breeding.

481

Cytogenetic Evaluation and Foliage Color Inheritance within Interspecific Begonia Inbreds

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A dominant gene, R, is hypothesized to control the red underfoliage color inheritance in tetraploid fibrous-rooted *Begonia* x*semperflorens-cultorum*. This dominant gene R is considered to also affect the intensity of the foliage color, with RRRR and RRRr giving dark red color on the underside of the leaves. The combination of RRrr and Rrrr gives intermediate red coloration, and homozygous recessive rrrr gives all green foliage. A homozygous RRRR inbred line is being test-crossed for potential commercial value. Cytological investigations of hybrids and inbreds derived from species crosses are ongoing. The results will be presented.

26 POSTER SESSION 2
Postharvest Physiology/Fruits & Nuts (General)

602

Postharvest Changes of Carambola Fruit (*Averrhoa carambola* L.) Picked at Different Ripening Stages

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Carambola fruit collected at the dark-green, light-green, color-break, and ripe stages were evaluated during storage at 21C for up to 10 days. Fruit size, weight, postharvest changes in color, compositional characteristics, CO_2 production, ethylene evolution, and weight loss were monitored daily. Fruit size ranged between 78 to 82 mm. Peel color luminosity and chroma values increased with maturity stage, while hue values decreased. However, hue and chroma values of the four ripening stages tended to decrease with storage time. Weight loss and fruit flesh firmness were both affected by storage time and ripening stage, and ranged among the maturity stages from 5.1% to 6.7% and from 2.11 to 0.94 kg-f, respectively. On dark-green fruit, total soluble solids and titratable acidity were 4.89° Brix and 0.808%, respectively. Fruit collected at the ripe stage presented values of 6.7° Brix and 0.412% titratable acidity. None of the fruit among maturity stages changed significantly during storage on these parameters. Carbon dioxide production increased from 6.06 to 21.83 ml CO_2/kg-h during storage time among maturity stages and always was highest on ripe fruit. Fruit harvested at the color-break and ripe stages produced ethylene after 9 and 6 days, respectively, and ranged from 1.15 to 3.92 $\mu l \cdot kg^{-1} \cdot h^{-1}$.

606

Identification of Isolated Membrane Major Volatiles of Fresh Tomato

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This research is aimed at the identification of volatile compounds from the isolated membranes fractions, microsomes, and deteriosomes. Fractions were isolated from tomato pericarp by ultracentrifugation at 252,000x *g* during 1 hour, followed by 362,000x *g* during 12 hours. The supernatant was infiltrated through a membrane of 300,000 D cut off to concentrate the deteriosomes. The volatiles from the fractions were analyzed by dynamic headspace and GC-MS. Our results suggest that the isolated fractions contained most tomato volatiles. Analysis by GC-MS identified two groups: compounds originating from fatty acids [e.g., hexanal and (E)-2-hexenal] and compounds coming from amino acids (e.g., 2 and 3-methyl butanal). Both microsomes and deteriosomes were highly enriched in volatiles on a protein basis. The increase in volatile compounds in these fractions was influenced by fruit maturity and correlate closely with volatile development in the intact fruit. Volatiles may be generated in the microsomes and released from the membranes via deteriosomes.

610

Some Ripening Changes during Storage and Ripening in Wax-coated Mangoes

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'Palmer' and 'Keitt' mangoes (*Mangifera indica* L.) were treated with two commercial wax coatings. The fruit were placed in 20-liter plastic containers, stored at 5C, and 85% to 95% relative humidity. Fruit were dipped fully in 1% aqueous suspensions of Pro-long and Primafresh C (original concentration) and analyzed at 2-day intervals for 18 days, with day 0 being 24 h after harvest. The following parameters were monitored: peel and pulp color (L*, chroma, and hue), fresh weight loss, total soluble solids, and titratable acidity. Both waxes reduced the rate of loss fresh weight of mangoes as compared with uncoated fruit. No differences were found for titratable acidity and total soluble solids. Waxed fruit were lighter (higher L* values) and less intense (lower chroma values) in color than control fruits.

614

Seasonal and Geographical Effects on Subsequent Ripening Characteristics of Bananas

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Mature-green 'Grande Naine' bananas from Costa Rica, Mexico, Ecuador, and Guatemala were harvested in June, Sept., and Dec. 1993 and Mar. 1994. Fruit were treated with ethylene and held at 17C and 80% to 90% relative humidity until they reached color 6 of the standard color scale. Guatemalan bananas had the highest respiration rate, followed by Costa Rican, Mexican, and Ecuadoran fruit. Peel color, ethylene production, and soluble solids content did not differ among the countries. Measurements made at arrival in the United States had a low correlation with days to reach color 5. Prediction equations showed significant linear relationships for most variables; however, correlations were very low. The highest coefficient of determination was observed with respiration rate (r^2 = 0.289). Maximum R^2 (0.342) was determined using CO_2, C_2H_4, pH, and soluble solids in the model. pH and soluble solids were good variables to determine the physiological stage of the fruit, and they also detected ripening changes earlier than peel color or firmness.

0618

Characterization of Chitinases and β-1,3-glucanases in Grapefruit Flavedo during Fruit Development

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Chitinases (EC 3.2.1.14) and β-1,3-endoglucanase (EC 3.2.1.39) are enzymes that are believed to be components of a plant's natural defense against fungal pathogens. We are interested in the potential role of these enzymes in citrus decay resistance. In our preliminary work, we have determined the activities of chitinases and β-1,3-endoglucanases in the flavedo of grapefruit (*Citrus paradisi* cv. Marsh) at 17 times during the course of fruit development. Chitinase activity is initially high in flavedo, but drops rapidly and is low, although fairly constant, throughout the remainder of fruit development. In contrast to chitinase, β-1,3-endoglucanase activity is lowest in young fruit and increases during development. Western blots of crude flavedo extracts following SDS-PAGE were probed with antibodies raised against purified citrus chitinase and glucanase, and results revealed that changes in the activities of chitinase and β-1,3-endoglucanase were reflected in the amount of chitinase and glucanase protein present in the extracts. Partial purification of flavedo chitinases and glucanases revealed that acidic and basic forms of both enzymes were present in the extracts, although the basic forms were predominant.

622

Cell Wall Degradation in Irradiated Tomato Fruit

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The irradiation of harvested fruit is typically accompanied by excessive tissue softening, a process that is not well understood. In this study, we examined the role of specific cell wall polymers and the extent of general cell wall degradation and softening in irradiated tomato fruit. 'Sunny' tomato fruit at mature-green and pink stages were subjected to X-ray radiation at 0, 83, and 156 Krad. Immediate softening was noted for both maturation classes, although some postirradiation recovery was evident in green fruit. Pectic polymers of both mature-green and pink fruit exhibited depolymerization and altered neutral sugar profiles in response to irradiation. Pectins, either as components of total ethanol-insoluble solids (EIS), purified by selective extraction, or of commercial origin were similarly affected by irradiation. Cellulose preparations were unaffected by irradiation. The data demonstrate that the effect of irradiation on the cell wall exhibits specificity, can occur nonenzymatically, and does not require initiating adducts of cytosolic origin.

626

Botrytis cinerea Decay in Apples is Inhibited by Postharvest Heat and Calcium Treatments

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'Golden Delicious' apples (*Malus domestica* Borkh.) were treated postharvest with heat (38C/4 d or 42C/24 h) or 2% $CaCl_2$ (applied as a dip or pressure-infiltrated) or a combination thereof and then stored. Decay caused by *Botrytis cinerea* was virtually eliminated in fruit heated at 38C after inoculation prior to storage, regardless of Ca treatment. Apples inoculated upon removal from storage were almost completely protected from decay if they had been previously pressure-infiltrated with Ca, regardless of heat regime. Heating at 42C or Ca dips were only partially effective in preventing decay. Pressure infiltration of Ca (regardless of heat regime) or heating at 38C (regardless of Ca treatment) resulted in firmer fruit (68 N) than Ca dips or heating at 42C (56 N), which were firmer than nontreated fruit (52 N).

630

The Effect of Delayed Cold Storage and Controlled-atmosphere Storage on Chilling Injury in Nectarines

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'Fantasia' nectarines (*Prunus persica* L.Batsch) were either stored immediately at 0.5C or subjected to a 48-h delay at 20C in air or with 5% CO_2 in air before storage. Samples were evaluated at harvest and after 18, 25, 32, 39 and 46 days storage in air or in 5% O_2 with 0%, 4%, 8%, or 12% CO_2. All samples were evaluated at optimum ripeness. A combination of delayed storage and elevated CO_2 in storage effectively delayed chilling injury (CI) symptoms. Control of CI increased with increasing CO_2 level in delayed and nondelayed treatments. Delayed storage was not effective without elevated levels of CO_2 in the storage atmosphere. Fruit that was stored without delay did not soften normally during the ripening period and developed a dry, rubbery texture. The effect was enhanced as CI progressed, resulting in increased firmness of ripened fruit with increased storage time. The delayed storage treatments softened normally during ripening, but CI fruit had a dry, mealy texture. Internal conductivity measurements correlated well with CI development. Off-flavors were detected at the higher levels of CO_2 storage.

634

Storage and Modified-atmosphere Packaging of Chinese Chestnuts (*Castanea mollissima*)

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The shelf life of chestnuts is limited by water loss. Polymeric packages have been used to prevent dehydration, although little specific information is available on the use and design of MA packaging for extending shelf life. To investigate the product response to MA conditions, a range of O_2 levels were generated inside low-density polyethylene (LDPE) packages containing chestnuts. The respiration rate decreased with decreasing O_2 levels below 16 kPa at 0C. A rapid increase in RQ and ethanol were noticed when the chestnuts were exposed to O_2 levels below 1 kPa at 0C, indicating a shift to fermentative metabolism. In a flow-through system, the respiration rate at 0C and the Q10 were measured as 108 $nmol \cdot kg^{-1} \cdot s^{-1}$ and 2.5, respectively. Chestnuts were stored at –2, 0, 5, and 20C in LDPE packages for 6 months and quality was periodically evaluated. Off-flavors were noticed from chestnuts stored in O_2 levels below 1 kPa at 0C on day 38. Chestnuts stored at 0C but at higher O_2 levels were acceptable for 5 months. Chestnuts stored at –2C were still acceptable after 6 months of storage.

638

Reduction of Microbial Populations on Prunes by Vapor Phase Hydrogen Peroxide

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Moisture is raised in dehydrated prunes to improve palatability before packaging and potassium sorbate is added to inhibit microbial growth. Vapor phase hydrogen peroxide (VPHP) technology uses hydrogen peroxide pulses to disinfect dried prunes. Dried prunes were obtained from dehydrators. The number of colony-forming units per 10 prunes (cfu/p) was compared between untreated and VPHP treated. Three culture media—dichloran rose bengal chloramphenicol agar base (DRBC, Oxoid), aerobic plate count agar (PCA), and potato dextrose agar (PDA)—were used to evaluate cfu/p. Similar mean microbe populations were observed on DRBC (67) and PDA (70); PCA had higher cfu/p (99). Microbes washed from untreated prunes obtained from dehydrators were 58 to 112 cfu/p, depending on the culture medium used. The number of cfu/p assessed on all media on VPHP-treated prunes was near 0 after 100 min exposure. Unlike potassium sorbate, hydrogen peroxide is a microbiocide rather than a microbiostat.

642

Cell Membrane Stability and the Role of Calcium Infiltration in Postharvest Quality of Apples

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Postharvest $CaCl_2$ pressure infiltration improves firmness and storage quality of apples but is still in the experimental stages. Its effectiveness could be increased if we had a better understanding of how Ca affects the tissue at the cellular level. 'Golden Delicious' fruit were harvested from a commercial orchard and were pressure-infiltrated with $CaCl_2$ (0%, 2%, or 4% w/v), stored for 6 months at 0C, and then for 7 days at 20C. Between harvest and the end of storage at 20C, the net breakdown of galactolipids and phospholipids decreased with increasing $CaCl_2$ in infiltration solutions. During 0C storage, $CaCl_2$-infiltrated fruit maintained greater concentrations of conjugated sterol lipids, and these lipid classes are thought to be closely associated with the plasma membrane. As membrane lipid alterations are viewed as a central factor in the senescence of fruits, Ca (from postharvest infiltration) may serve a major role in regulating fruit quality losses through its interactions with cell membranes.

646

Changes in Pectins in Apple Fruit during Development and Ripening

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Pectins isolated from three cultivars with different maturity were compared to find a potential role of pectin modification on the fruit softening during fruit development and ripening. There was an increase of total pectins in developing fruit and no significant decrease of pectins was confirmed even after storage in 'Tusgaru' (30 days) and 'Fuji' (120 days), whereas soluble pectins, except NaOH-soluble ones, gradually increased in all cultivars. Gel-filtration profile and ion exchange chromatographic evidence of soluble pectins revealed that pectin degradation in apple fruit may not be associated with softening. However, a degree of esterification probably has an important role on softening of fruits. Further results will be discussed in the presentation.

650

Using Chloroplast Fluorescence for Prediction of Scald Development in 'Red Delicious' Apple Fruit

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Apple scald (peel browning) is hypothesized to involve a chilling disorder. Numerous studies have linked chloroplast fluorescence changes with chilling injury before symptom development. Therefore, chloroplast fluorescence was used for the prediction of scald in apples. 'Red Delicious' apple fruit were harvested at three maturities and stored at 1 to 2C. They were removed from storage weekly and placed at ambient temperature (22C). Chloroplast fluorescence was measured at 0, 3, and 7 days after removal. A significant decline in quantum yield response (Fv/Fm), which indicates a reduction of chloroplast function, was recorded after 30 days in first-harvest fruit and 40 to 50 days in the second- and third-harvest fruit. The decline in Fv/Fm preceded scald development by ≈30 days in first-harvest fruit and 20 to 30 days in second- and third-harvest fruit. The data suggest that fluorescence changes and scald development may be related physiologically. Fruit firmness and other fruit ripening phenomena were also measured and their relationship to the fluorescence and scald development were investigated. The results indicated that the chloroplast fluorescence may be used as a predictive tool for scald development in stored apple fruit.

654

Modified-atmosphere Packaging of 'Sweetheart' Cherries

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Kilogram quantities of 'Sweetheart' cherries were stored in HDPE perforated bags (1993, 50.8 μ thickness, OTR = 750 $ml \cdot m^{-2} \cdot day^{-1}$) or in nonperforated bags (1994, 11 μ thickness, OTR = 5196 $ml \cdot m^{-2} \cdot day^{-1}$) at 0C. Samples were removed at 1, 2, 4, and 6 weeks of storage and evaluated for fruit and sensory quality. Bag atmospheres after 6 weeks of storage were 10% CO_2 and 4.6% O_2 for the perforated bags and 3.5% CO_2 and 6.6% O_2 for the nonperforated bags. Fruit brightness, firmness, and titratable acidity declined during storage. Skin color tended to be redder with the longer storage periods. Sensory evaluation in 1993 showed a decline in overall appearance and flavor with time, but texture and juiciness did not change. Acceptability remained high for the first 4 weeks of storage but dropped at week 6. Surface pitting was noticeable at weeks 4 and 6, particularly from stem bruising.

656

Electronic Sensing of Apple Ripeness Based on Volatile Gas Emissions

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A prototype of a nondestructive electronic sensory system (electronic sniffer) that responds to volatile gases emitted by fruit during ripening was developed. The electronic sniffer is based upon four semiconductor gas sensors designed to react with a range of reductive gases, including aromatic volatiles. In 1994, we examined the potential of using the electronic sniffer as a tool to nondestructively determine ripeness in 'Golden Delicious' and 'Goldrush' apples. Fruit were harvested weekly from 19 Sept. to 17 Oct. ('Golden Delicious') and 27 Sept. to 18 Nov. ('Goldrush'). Each week, apples of each cultivar were evaluated individually for skin color, weight size, and headspace volatiles. Each fruit was then evaluated by the electronic sniffer, and headspace ethylene was sampled from air within the testing box. Individual fruits were then evaluated for total soluble solids, firmness, pH, total acidity, and starch index value. The electronic sniffer was able to distinguish and accurately classify the apples into three ripeness stages (immature, ripe, and over-ripe). Improved results were obtained when multiple gas sensors were used rather than a single gas sensor.

658

Apple Storability as Influenced by Tufted Apple Bud Moth Injury, Orchard Fungicide Programs, and Horticultural Factors

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As public pressure increases to reduce the use of agricultural chemicals, the effects of lower chemical dosages in the orchard on fruit storability must be determined. Based on both artificial and natural damage, minor tufted apple bud moth (TABM) injury (<10 mm aggregate diameter) did not cause significant loss during controlled-atmosphere (CA) storage. However, damage in excess of 10 mm often caused significant weight loss and decay. Damage occurring closer to harvest caused more loss of quality than earlier damage (i.e., during July and early August). Forty percent of apples damaged 1 week before harvest decayed during storage. Several orchard fungicide spray programs were studied, and in 1993–94, all of the tested programs adequately controlled both fruit blotches and rots, and few storage rots developed. These diseases were light in 1993 due to low rainfall during the summer months. Development of the summer diseases were somewhat higher in 1994, but similar fungicide programs provided adequate control of the complex at harvest. Apples inoculated with *P. expansum* (punctured with a nail) decayed less when stored in 3% CO_2 than in 0% CO_2 (at both 1% or 2.4% O_2). Decay of 'Golden Delicious' caused by *P. expansum* inoculation increased with later harvest (twice as much decay in fruit harvested 14 Oct. than in fruit harvested 23 Sept.–7 Oct.).

662

Effect of Heat Treatment on the Development of Superficial Scald in 'Red Delicious' Apples

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Heat treatment of apples (*Malus domestica* Borkh cvs. Red Delicious, Starkrimson) and its effect on scald development have been investigated. Several parameters indicative of scald, such as ethanol and acetaldehyde content, UV-absorbing components from skin, and fruit quality parameters, such as fruit firmness and soluble solids content, were monitored after exposing apples to heat therapy at 40C for 24 h, followed by storing them at room temperature in polyethylene bags. In general, heat-treated apples possessed higher ethanol and acetaldehyde levels. As well, heat-exposed apples appeared to possess a lower degree of scald. The content of soluble solids did not appear to be affected by heat treatment. The degree of firmness, however, was maintained in heat-treated apples. Effect of heat treatment on several other physiological and biochemical parameters will be presented.

666

Physiological Changes during Maturation, Ripening, and Storage of Asian Pears Grown in Southeastern United States

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Morphological and physiological changes during maturation and ripening of eight Asian pear cultivars grown in the southeastern United States were evaluated. Fruit size increased throughout maturation. Flesh firmness decreased as fruit matured and averaged ≈30 to 35 N at harvest maturity. The average TSS in mature fruit ranged from 10% to 13%, with 'Shinko' having the lowest and 'Shinsui' having the highest. TSS increased during 4 weeks of storage at 1C, but the increase was greater in immature fruit than in mature fruit. Respiration rate declined as fruit matured. Ethylene production was low in 'Hosui', 'Kosui', 'Nijisseiki', 'Shinseiki', 'Chojuro', and 'Shinko' fruit. Mature 'Ichiban' and 'Shinsui' fruit produced high amounts of ethylene. 'Kosui', 'Shinsui', 'Chojuro', and 'Ichiban' fruit showed a climacteric rise in respiration and ethylene production at 20C, while 'Hosui', 'Nijisseiki', 'Shinseiki', and 'Shinko' behaved as nonclimacteric fruit. Ethylene production by 1C-stored 'Kosui', 'Shinsui', 'Chojuro', and 'Ichiban' fruit was

increased on removal to 20C. Glucose and fructose were low during early maturation but sharply increased ≈80 to 85 days after full bloom (DAFB). Sucrose was low in immature fruit but accumulated rapidly late in maturation ≈100 to 107 DAFB. In mature 'Hosui', 'Kosui', 'Nijisseiki', 'Shinsui', 'Shinko', and 'Ichiban' fruit, fructose was the predominant sugar, while in 'Shinseiki' and 'Chojuro' fruit, sucrose was the predominant sugar.

670

β-Galactosidase II in Ripening Tomatoes

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Tomatoes contain several isozymes of β-galactosidase, but only one, β-galactosidase II, can hydrolyze the β-1,4-galactans in tomato cell walls. β-galactosidase II has now been highly purified by modification of the original procedure. The molecular weight of this isozyme is ≈62 kDa according to gel infiltration, but SDS-PAGE of the purified enzyme separated three components with molecular weights of 29, 42, and 82 kDa. The 82-kDa peptide may be the intact enzyme and the smallest peptides are subunits as proposed for other β-galactosidases. The N-terminal amino acid sequence of β-galactosidase II showed high homology with amino acid sequences reported for other plant β-galactosidases. A new assay for β-galactosidase II in tomato extracts has been developed using FPLC. This isozyme was not detected in mature-green tomatoes but appeared at about the breaker stage and increased during ripening. The increase in b-galactosidase II was accompanied by a decrease in galactose content of cell wall polysaccharides, suggesting that this enzyme may be involved in the loss of galactose during tomato ripening.

674

Cell Wall Changes Associated with Normal and Mealy Fruit Softening for a Novel Peach Genotype

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The 'Stony Hard' gene of peach conferred a unique ability to manipulate softening and textural properties of the fruit by controlling the concentration and duration of exposure to ethylene. Fruit ripened in ethylene-free air softened very slowly. Exposure of fruit to 1 ppm ethylene continuously for 48 h, or discontinuously at 100 ppm over the same time period, significantly accelerated softening—to a normal texture. Exposure of fruit to 100 ppm ethylene continuously for 48 h induced softening to the same level, but to a mealy texture. We have prepared cell walls and conducted sequential chemical extractions from fruit exposed to the ethylene treatments above. Galacturonic acid content of chelator soluble pectin fractions decreased for mealy fruit, compared to fruit with normal texture, indicating that selective pectin degradation was associated with mealiness. Other differences in polysaccharide sugar composition and apparent molecular size associated with slow, accelerated, and abnormal softening in peach fruit will be addressed.

678

Operator and Instrument Affect Apple Firmness Readings

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Apple flesh firmness, a common indicator of maturity and postharvest quality, can be measured destructively using several instruments. This study compared readings obtained with a Magness-Taylor tester, an Effegi device, and an electronic tester with Magness-Taylor testing in the on or off mode. Three trained operators measured firmness of 50-apple samples of three cultivars with a wide range in suspected maturity. In the instrument test, each operator measured firmness using a different instrument or mode on one half of each apple. In the operator test, the firmness of each apple was measured three times (once by each operator). Both soft and firm lots had consistent operator and instrument differences in readings. Ignoring the operator differences, five out of six comparisons of instrument and mode produced significantly different readings. Operator differences between instruments and modes were also significant in many instances. The results suggest that a single instrument and operator should be used in long-term experiments when multiple determinations of apple flesh firmness are planned.

682

Relationships between Textural and Structural Differences of Various Apple Cultivars during Cold Storage

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The relationships between cellular characteristics of cortical tissue and changes in texture during storage under controlled atmosphere (CA, 3% O_2 + 3% CO_2) or air at 0C were studied. The cultivars used were 'Delicious', 'Cortland', 'Honeycrisp' and its parents, 'Honeygold' and 'Macoun'. The force needed to break a 7-mm cylinder of apple flesh (breaking force) was greatest for 'Delicious' and 'Honeycrisp'. Scanning electron microscopy demonstrated that tissues of firm-fleshed cultivars ('Honeycrisp' and 'Delicious') fractured through cells, while that of soft-fleshed cultivars ('Cortland', 'Honeygold', and 'Macoun') fractured between cells. 'Honeycrisp' had fewer cells/100 cm^2 than the other cultivars. After 9 months of storage, breaking force, cell size, and K^+/Ca^{2+} decreased, while cell number/100 cm^2, Ca^{2+} content, and K^+ content increased for all cultivars. Cell number/100 cm^2 was significantly less and breaking force was significantly greater for tissue from CA than air-stored fruit.

686

Free Volume Changes in Modified-atmosphere Packages Containing Fresh Produce: Measurement and Control

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Flexible modified-atmosphere (MA) packages of fruits and vegetables can shrink or expand with time depending on the net flux of gas from the package to the surroundings. Excessive shrinkage can cause product damage if the tissue is fragile. However, reducing free volume should reduce the amount moisture loss and condensation. It would be useful to understand the factors that determine the rate and direction of free volume changes when applying MA packaging technology to fruits and vegetables. Free volume was measured in packages using a simple procedure based on dilution of injected ethane gas. The free volume in low-density polyethylene packages containing cut broccoli at 0C changed from 284 cc to 148 cc in 33 days. A computer model was developed to estimate changes in package free volume for different situations. The model predicted that the rate of shrinkage will be less if packages are flushed with a low permeable gas. Flushing with a highly permeable gas such as CO_2 will increase the rate of shrinkage. The rate of package shrinkage will be less if made with films that have low permeability to N_2.

690

Response of Respiration Rate, Ethylene Production, and Membrane Permeability to Vibration in Fig Fruit

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Changes in respiration rate, ethylene production, and membrane permeability of fig (*Ficus carica* L. 'Masui Dauphine', 'Celeste', and 'Brunswick') fruit subjected to vibration at acceleration of 4x *g* for 10 min were investigated. Vibration increased respiration rate significantly, which, however, declined quickly to low level soon after the treatment. Ethylene production and membrane permeability also increased significantly during vibration. However, vibration stress up to 4x *g* did not have significant effect on the physiological changes of the fig fruit after vibration. 'Masui Dauphine' is more susceptible to vibration stress than 'Celeste' and 'Brunswick'.

694

Storage Studies with Virus-infected Blueberries

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Concord blueberries treated with biocontrol fungi (*Trichoderma* and *Gliocaladium*) both at 1 and 2x rates and with fungicides benlate + captan + B 1956 and Tween for controlling botrytis flower blight were stored at 32F. *Trichoderma* (2x)-treated fruit was 71% without infection; *Gliocaladium* (2x)-treated fruit 69%, compared to 57% from untreated control. Momentum Transfer Generator (MTG) readings indicating fruit firmness ranged from 474 to 494 for the above treatments, indicating that fruit firmness was not affected by the treatments. Concord blueberries from bushes infected with blueberry scorch carla virus showed no difference in fruit firmness compared to healthy berries either before or after 7 weeks of storage at 32F.

698

Role of β-Galactosidase, Cellulase, Pectinesterase, and Polygalacturonase in Pectin Solubilization in Ripening Rabbiteye Blueberries

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Fruit of two rabbiteye blueberries (*Vaccinium ashei* Read cvs. Premier and Tifblue) were analyzed at five stages of growth and development for cell wall softening enzymes in relation to pectin solubilization. The enzymes examined were β-galactosidase, cellulase, pectinesterase, and polygalacturonase. The decrease in fruit firmness was associated with increased activities of cellulase, polygalacturonase, and pectinesterase, which preceded the former enzymes. The activity of β-galactosidase remained relatively unchanged throughout. The pattern of enzyme activities from both cultivars were similar. Results from this study indicate that these enzymes may play a crucial role in overall fruit shelf life and hence postharvest marketing duration.

702

Effect of Harvest Maturity, Storage, and Cultivar on Strawberry Fruit Aroma Volatiles

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'Annapolis', 'Cavendish', 'Honeoye', 'Kent', and 'Micmac' strawberry fruit (*Fragaria* x*ananassa* Duch.) were harvested underripe (75% to 90% red) or fully ripe. Fruit were stored at 0C for 5 days followed by 2 days at 15C. Volatiles were trapped onto Tenax-GR from the headspace over fruit before and after storage and analyzed using GC-MS. Volatile esters identified in headspace included methyl and ethyl butanoate, methyl and ethyl hexanoate, methyl and ethyl 3-methylbutanoate, 3-methylbutyl acetate, hexyl acetate, and methyl 2-methylbutanoate. Headspace concentrations of volatile esters over freshly harvested strawberries averaged 1.3 and 6.8 $\mu mol \cdot m^{-3}$ for underripe and ripe fruit, respectively. After 7 days of storage, volatile concentrations increased in both underripe and ripe fruit to 6.3 and 12.2 $\mu mol \cdot m^{-3}$, respectively. There were quantitative and qualitative differences between cultivars. Total volatile concentrations were 16.0, 8.1, 5.7, 2.4, and 0.9 $\mu mol \cdot m^{-3}$ in the headspace over 'Annapolis', 'Kent', 'Micmac', 'Cavendish', and 'Honeoye', respectively. 'Annapolis' had the highest concentrations of methyl and ethyl butanoate, while 'Micmac' had the highest concentrations of methyl and ethyl hexanoate. Volatile concentrations at harvest increased 5.7, 1.9, 1.7, 1.4, and 1.3 times during storage in 'Kent', 'Annapolis', 'Micmac', 'Cavendish', and 'Honeoye', respectively. Results indicate that strawberry fruit continue to produce aroma volatiles after harvest.

706

Postharvest Biological Control of Gray Mold (*Botrytis cinerea*) on Strawberry Fruit

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Biological control using antagonistic microorganisms has been the subject of increased interest for postharvest pathogen control. Gray mold is an important factor in the perishability of strawberry fruit, both pre- and postharvest. In view of the specific characteristics of this host–pathogen interaction, strawberry fruit represent a suitable commodity with which to investigate the efficacy of alternative control, including the use of biological measures. During 1994 and 1995, ripe strawberry fruit were harvested from local plantings and endemic microflora were analyzed for potential antagonist modes of action toward *B. cinerea*. Two bacteria were isolated and these, along with other bacteria and yeast obtained from other sources, were used to inoculate strawberry fruit stored at different temperatures. Effects of storage temperature and interactions of pathogen/antagonist and fruit quality were determined. The results illustrate the potential of using yeast at low temperatures and bacteria at higher, ambient conditions to achieve effective postharvest control of *B. cinerea*. Microorganisms derived from the fruit and of presumably local origin exhibited significant biocontrol effects and showed a higher capacity for adaptation to the handling practices of strawberry fruit, especially at lower storage temperatures.

710

PCR Amplification of Persimmon Fruit β-Galactosidase

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We are studying β-galactosidase (EC 3.2.1.23) in softening persimmon fruit (*Diospyros kaki* L.f. cv Fuyu) and hope to decrease the rate of softening by inserting an antisense construct of the β-galactosidase gene. The *N*-terminal amino acid sequence of persimmon fruit β-galactosidase was recently reported. Here we report the cloning of a putative β-galactosidase gene from persimmons. Degenerate oligonucleotide primers were synthesized based on the amino acid sequence. 5′-RACE (rapid amplification of cDNA ends) was done using persimmon Poly A^+ mRNA extracted using a phenol : chloroform/LiCl method. Purification was done on an oligo dT-cellulose column. A fragment of roughly 150 base pairs was purified by agarose gel electrophoresis and subcloned into the pCR-Script cloning vector from Stratagene. After sequencing and verifying the insert's identity, it will be isolated and used to screen a persimmon fruit cDNA library currently being constructed. Ultimately this cDNA clone will be used to make an antisense β-galactosidase construct that will be transformed into persimmon.

714

Involvement with Flavonoids on Chlorophyll Degradation by Peroxidase in Wase Satsuma Mandarin Fruits

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Effects of flavonoid pigments on chlorophyll (Chl) degradation by Chl peroxidase in the flavedo of Wase satsuma mandarin (*Citrus unshiu* Marc. var. *praecox* Tanaka) fruits were studied. Chl was degraded when hydrogen peroxide was added in a reaction mixture containing Chl and a phosphate buffer extract from the flavedo. Chlorophyllide, which was formed by the action of chlorophyllase in the extract, was also degraded. The flavonoid contents decreased with the Chl degradation in the reaction mixture. Analysis of the flavonoid with HPLC showed that hesperidin and narirutin were contained in the flavedo as a major flavonoid, and that the former decreased significantly and the latter showed almost no change with the Chl degradation in the reaction mixture. In the ethylene-treated fruits, the hesperidin content in the flavedo also decreased with the degreening of stored fruits, suggesting that the flavonoid oxidation by Chl peroxidase could be involved in the Chl degradation.

29 POSTER SESSION 3
Weed Control/Cross-Commodity

858

Leaching and Persistence of Oxidiazon in Several Organic-based Substrates

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The objective of this study was to determine the persistence and leaching of the herbicide oxadiazon in five substrates. The substrate mixtures consisted of the following: peatmoss, compost, and sand in the following proportions: 1:1:0, 3:3:2, 1:1:2, 1:1:6, and 0:0:1 in 5-liter containers. Rates of oxadiazon used were 4 and 8 kg a.i./ha on two separate split-split plots. Each experimental design had three factors: five substrates, four harvest times (24 h; 1, 2, and 3 months) and five soil depths (0–2, 2–4, 4–6, 6–8, 8– cm). Only herbicide persistence and leaching from the various substrates were investigated in this experiment; therefore, we did not remove plant material. Substrate oxadiazon residues were determined by gas chromatography analysis, and it was shown that leaching was more evident in media with a lower percentage of organic matter. In addition, oxadiazon did not leach below 4 cm in conventional substrate (1 peatmoss : 1 compost : 1 sand, respectively). The persistence of oxadiazon was affected by soil composition and herbicide persisted more in substrates with great percentage of organic matter.

862

Allelopathy in Cover Crop-based Production Systems

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Little research has been conducted to quantify allelopathic suppression of weeds in the field. The objectives of this study were to develop an adequate control for separating physical from allelochemical effects, use the control to quantify allelochemical suppression in the field, and determine whether a mixture of cover crops would provide a broader spectrum of weed control than single species. Hairy vetch, rye, crimson clover, and barley were cut into 5-cm pieces, shaken in distilled water (pH 6) to leach allelochemicals, and redried. A seed germination bioassay confirmed that leached cover crops were nontoxic to germinating seeds. Physical suppression of Eastern black nightshade by the four cover crop species occurred in the field study, as did allelochemical suppression by crimson clover. Only rye physically suppressed yellow foxtail, and none of the cover crops suppressed yellow foxtail allelochemically.

866

Importance of Introgressive Hybridization in the Development of Invasive *Lythrum salicaria*

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Since its evolution as an invasive species in Quebec (1930s), *L. salicaria* has spread across North American wetlands virtually unchecked. Initially, it was theorized that the rapid invasion was due to the absence of phytophagous insects (present in the native habitat). However, evolutionists theorized that invasive characteristics probably arose from introgressive hybridization with a native species (*L. alatum*), since their ecotypes overlap. Several horticultural cultivars are also fertile interspecific hybrids. These two species differ for diagnostic traits (number of flowers/axil, plant height, phyllotaxy, style morphology, seed dormancy). Minnesota *L. salicaria* populations were examined for evidence of introgression. *Lythrum salicaria* introgressive genotypes were found for all diagnostic traits. Seed dormancy was the most common, i.e., OP seed showed significant seed dormancy ($F = 5.2$, $P = 0.024$). Such hybrids would have adaptive advantages as weeds, having evolved for each ecotype by introgression with locally adapted *L. alatum* populations.

870

Sweet Corn Cultivar Response to Postemergence Application of ALS/AHAS Inhibitors

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This study was conducted in 1993 and 1994 to determine if nicosulfuron or primisulfuron had any adverse effects on ear or whole-plant development. Factors considered were cultivar, herbicide, rate, and timing of application. Four sweet corn cultivars: 'More' (*su*), 'Calico Belle' (*se*), and 'Frontier' and 'Challenger' (*sh2*) were evaluated for foliar injury, plant vigor, plant height (1994 only), ear injury, and yield. Nicosulfuron and primisulfuron were applied at two rates: the labeled rate (x) of 35 g a.i./ha and 40 g a.i./ha, respectively, and at the 2x rate. Herbicides were applied early postemergence at V2 (corn height 10–15 cm) or late postemergence at V7 (corn height 30–50 cm). Plant foliar injury ratings, ear injury ratings, number of ears, number of injured ears, and yields were collected. Ears with injury were described as pinched. There was a constriction of the cob, caused by a reduction in kernel row number, ranging from two to eight rows lost. Sweet corn cultivars varied in their response to nicosulfuron and primisulfuron. Timing of application had a greater impact on ear injury than did the rate. Applications at the V7 stage caused more severe ear injury than application at the V2 stage. Ear injury was more severe in nicosulfuron treatments than primisulfuron treatments. Height reductions were caused by both compounds at both applications, with primisulfuron causing greater stunting. Primisulfuron caused more severe foliar injury.

874

Protocol for Developing Weed-tolerant Crops

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While there are published reports of varietal differences in competitiveness with weeds, no crop varieties have been specifically developed for tolerance to weed interference. We explored several methods that mechanistically compare potential sources of tomato varietal tolerance to purslane, velvetleaf, and black nightshade: 1) The influence of canopy structure and development was studied with a wide range of crop and weed germplasm with different growth habits. Leaf expansion rate and other morphological characters were used to select crop genotypes for more-detailed study. 2) Replacement series experiments with selected cultivars found that purslane and other species can adapt to avoid competition. The greatest varietal differences in competitiveness were with nightshade species that had a canopy structure similar to tomatoes. 3) Field measurements of canopy development and light interception found that competitive advantage shifted over time as height and leaf area of weeds and crops changed. 4) A systems analysis method, sensitivity analysis, found that changes in plant architecture over time were more important than initial or final crop characteristics in determining competitive outcomes.

878

Propane Burner Characterization for Thermal Weeding

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To develop new alternatives to chemical pesticides in agriculture, a research program was elaborated on the use of propane flamers for weed control. One part of this project is the evaluation of different propane burners commercially available. We measured the temperature distribution within the burner flames and the fuel consumption of three different types of burner. Flame characterization allowed for the selection of appropriate burners and settings for specific applications. We also investigated the effect of preemergence thermal weeding on crop establishment for 10 different crops. The use of flaming in preemergence of crops is an effective method for controlling weeds, especially for younger and broadleaf weeds. Depending on the crop, thermal weeding can affect the emergence rate when applied just before seedling emergence.

881

Leptine-based Resistance to Colorado Potato Beetle among Interspecific Hybrids of Wild Potato

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Leptine (LP) glycoalkaloids have been demonstrated to confer natural resistance to the Colorado potato beetle (CPB) in *Solanum chacoense* (*chc*). Development of cultivated potatoes with natural resistance to CPB has the potential to reduce both costs and environmental impacts of production by reducing pesticide use. To introgress the genes conferring leptine production from *chc* into *S. tuberosum* (*tbr*), clones of *chc* have been crossed with clones of S. *phureja.* Leaf disks from eight hybrids were subjected to a CPB second instar feeding bioassay to determine if extent of feeding was related to LP levels. Most hybrids contained leptinidine (LD, the aglycone of LP) levels intermediate to *chc* and *tbr,* and insect feeding was suppressed 30% to 50% in hybrids containing >10 $mg \cdot g^{-1}$ DW LD. One hybrid displaying feeding suppression contained a very low level of LD, whereas another hybrid that contained higher levels of LD had higher feeding rates. The presence of LD at "threshold" levels in these hybrids will suppress feeding of CPB, but other factors affecting resistance are also present and need to be explored.

882

Preemergent Weed Control in Container-grown Herbaceous Perennials

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Herbicides were applied to container-grown herbaceous perennials and evaluated on the basis of weed control and phytotoxicity. During the 1994 season, seven preemergent herbicides, napropamide (Devrinol) at 4.5 and 9.1 $kg \cdot ha^{-1}$, metolachlor (Pennant) at 4.5 and 9.1 $kg \cdot ha^{-1}$, isoxaben (Gallery) at 1.1 and 2.3 $kg \cdot ha^{-1}$, oxadiazon (Ronstar) at 4.5 and 9.1 $kg \cdot ha^{-1}$, oxyfluorfen + oryzalin (Rout) at 3.4 and 13.6 $kg \cdot ha^{-1}$, oryzalin (Surflan) at 2.8 and 4.5 $kg \cdot ha^{-1}$, and trifluralin (Treflan) at 4.5 and 9.1 $kg \cdot ha^{-1}$, were tested on *Aquilegia caerulea* 'McKana's Giant', *Digitalis purpurea*, *Gaillardia aristata*, *Limonium latifolium*, and *Veronica spicata*. Isoxaben (both rates) resulted in visual phytotoxicity symptoms and death to *Digitalis*. Metolachlor (both rates) resulted in plant death to *Veronica*. Pennant (both rates), when applied to *Limonium*, resulted in stunted growth. *Aquilegia* and *Gaillardia* were not adversely affected. Most herbicides controlled both dicot and monocot weeds effectively.

886

Developing Cover Crops for Weed Control in Establishment Year for Strawberries

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The goal of our program is to learn how to effectively establish first-year strawberry plantings without using herbicides. Before strawberry transplanting, four treatments were established: winter wheat, a dwarf *Brassica* sp., napropamide (2.24 kg·h^{-1}) plus hand hoeing and rototilling, and no weed management. 'Honeyoye' transplants were set into plots measuring 6.1 x 7.32 m on 21 May 1993 and 10 May 1994. Weekly data was taken on the percentage of soil area covered with plant material, height, and stage of development of plants, and weeds present. Weed transects and plant dry weights were done periodically during the growing seasons. The most promising cover crop treatment was the dwarf *Brassica* sp. for early season weed suppression because of rapid germination and short stature. Winter wheat was very competitive with the strawberry plants. The herbicide treatment had the largest inputs; however, it did produce the largest strawberry plants at the end of the season.

890

Comparison of Two Methods to Evaluate Water Use by Row Middle Cover Crops in Fruit Plantings

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Cover crops are of increasing interest in fruit plantings. Previous studies indicated that, in unirrigated New York vineyards, effects of row middle cover crops is primarily competition for soil water. Row middle management trials in 'Concord' vineyards compared cover crops (orchardgrass, bluegrass, vetch, clover, and rye) to straw mulch, bloom glyphosate, and cultivation for water use patterns. Neutron probe tubes within each plot were read weekly at 15-cm intervals down to 120 cm. A second method to examine water use patterns used double florist pots with native soil sunken within the plots to provide a removable sample of the cover. These pots were lifted and weighed at intervals to examine in situ water use. The pot weight loss data generally correlated well with the neutron probe data. Precautions are needed related to differences in natural rooting depth, more rapid drying of pot vs. normal soil volume and representativeness of plant cover and health. The neutron probe method gives more complete data, but the pot method may be a useful simple, inexpensive method of examining relative water use patterns of cover crops with natural boundary layers that exist in discontinuous fruit plantings.

894

Selectivity of Propane Flamer as a Means of Weed Control

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With growing public concern about environmental quality, farmers must turn to new plant protection alternatives that minimize the use of agrochemicals. Flaming has been practiced for several years as a means of weed control in noncropped areas (railroad, ditches, etc.), but its selectivity toward crops has yet to be defined. Experiments were conducted in the ICG-Propane laboratory at Laval Univ. to determine the temperature needed to kill weeds and the temperature that corn could tolerate. Four weed species were studied: *Amaranthus retroflexus*, *Brassica kaber*, *Chenopodium album*, and *Setaria viridis* and each species was tested at three growth stages: 0–2, 4–6, and >8 leaves. Corn tolerance was tested at four growth stages: coleoptile, 0–2, 4–6, >8 leaves. All plants were grown in the greenhouse and were submitted to different combinations of operation speeds and of propane pressures, giving 10 temperature intensities ranging from 110 to 390C. The response of each species was evaluated by measuring its height and dry biomass 2 weeks after treatment. The threshold temperature for corn was below 200C; above this temperature, significant corn injury occurred at all growth stages tested. The corn growth stages most tolerant to heat were coleoptile and >8 leaves. While the most sensitive was 4–6 leaves. All weeds tested were sensitive to heat at 0–2 leaf stage. *Amaranthus retroflexus* and *Chenopodium album* were controlled until six leaves with temperatures that were not harmful to corn. Weeds with more than eight leaves needed higher temperature, and control rarely reached 60%. Flaming could be a selective method of weed control if operated at a temperature of 170C. Selectivity can be increased by creating a growth differential between corn and weeds.

898

Effects of Preemergence Herbicides on Weed Control and Yield and Vase Life of Leatherleaf Fern

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Six preemergence herbicides were applied twice a year at 1x and 2x rates for 2 years to leatherleaf fern [*Rumohra adiantiformis* (Forst.) Ching] starting from the time of rhizome planting. Predominant weeds present were *Cardimine hirsuta*, *Erechrites hieracifolia*, *Oxalis stricta*, and *Phyllanthus tenellus*. All herbicides, except pendimethalin and oxadiazon at the 1x rates, reduced weed biomass by 60% to 99% compared to the unweeded control during the fern bed establishment phase (year 1). During that period, hand-weeding times were reduced (51% to 95%) by prodiamine and dithiopyr at both rates, and oxadiazon and pendimethalin at 2x rates. During year 2, herbicides were of greatly reduced benefit due to reduced weed growth caused by the increasingly competitive fern. After 2 years, only 2x dithiopyr-treated plots had reduced yields compared to the hand-weeded controls. Herbicide treatments had no detrimental effects on frond postharvest longevity. In fact, fronds harvested from the 1x isoxaben-treated plots exhibited increased vase life compared to the controls.

55 POSTER SESSION 4
Breeding/Vegetable Crops

411

Construction of a Genetic Linkage Map and Locations of Common Blight, Rust, and Web Blight Resistance Loci in *Phaseolus vulgaris* L. Using Random Amplified Polymorphic DNA (RAPD) Markers

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Common blight, web blight, and rust, incited by the bacterial pathogen *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye (Xcp) and the fungal pathogens *Thanatephorus cucumeris* (Frank) Donk (Tc) and *Uromyces appendiculatus* (Pers.:Pers) Unger, respectively, are important diseases of common beans (*Phaseolus vulgaris* L.). The objectives of were to construct a linkage map, and to locate CBB, rust, and WB resistances and plant architecture traits using RAPDs. Ten linkage groups were identified. Eighty-nine RAPD markers and rust resistance were mapped in 128 RI lines of the cross BAC-6 and HT-7719. Regression analysis and interval mapping using MAPMAKER/QTL were used to identify genomic regions involved in the genetic control of the traits. One, two, two, and three putative QTLs were identified for leaf, seed, and pod reactions to Xcp, and foliar reaction to Tc. These regions accounted for 11%, 9%, 32%, and 30% of the phenotypic variation in the resistances. Two, two, and three regions were identified for plant uprightness, branch density, and pod distribution. These regions accounted for 27%, 13%, and 16% of the phenotypic variation. Unassigned marker G17d influenced some of the phenotypic variation in all three traits. A rust resistance gene controlling pustule size on primary leaves was located in linkage group 1.

415

Evaluation of Techniques for Screening Verticilium Wilt of *Capsicum annuum*

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Two studies were performed to evaluate techniques for screening verticillium wilt of *Capsicum annuum* L. The first study tested inoculation methods. The original method involved mixing the inoculum with planting medium in a cement mixer for 1 h. Seeds then were planted in the infested medium. In the new technique, inoculum is poured directly into the row, and seeds are placed directly on top of the inoculum. Inoculum levels of 2000 and 1000 mcrosclerotia/g of soil were tested in the new "in-row" method. The disease severity of the "in-row" plants was significantly less than the plants inoculated by the original method. A significant difference remained between resistant and susceptible lines. There was no difference between inoculum levels. The second study compared three commer-

cial planting media to the standard soil used in previous screenings. Disease severity did not differ among media, and all media showed significant differences between resistant and susceptible *C. annuum* lines.

419

Antiplatelet Activity, Solids, and Pungency of Four Onion (*Allium cepa* L.) Genotypes during Cold Storage

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Raw onion extract contains organosulfur compounds that prevent aggregation of platelets in human blood plasma and influence onion pungency. Organosulfur compounds are volatile and may change concentration during storage. A study was conducted to determine 1) whether antiplatelet activity of filtered onion extract decreases during time in cold (4C) storage; and 2) correlations among antiplatelet activity, pyruvic acid content, and percent solids during time in cold storage. Two low-pungency genotypes (8155 and Exhibition) and two high-pungency (W420 and W434) genotypes were grown in replicated plots in two Wisconsin and two Oregon locations in 1994. Bulbs were evaluated for antiplatelet activity, percent solids, and pyruvic acid content at 40-day intervals after onion harvest. Significant differences were found for pyruvic acid content, solids, and antiplatelet activity among dates of sampling, genotypes, and locations. Mean pyruvic acid concentrations ranged from 6.4 $\mu M \cdot ml^{-1}$ of extract for Exhibition, to 8.0 $\mu M \cdot ml^{-1}$ of extract for W420. Mean solids concentrations ranged from 5.8 g/100 g for Exhibition to 11.4 g/100 g for W434. Antiplatelet activity averaged over all genotypes increased over 120 days and was positively correlated with percent solids and pyruvic acid content.

423

The Effect of Genotype on Winter Production of Collard and Kale in the Southeastern United States

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Collard and kale (*Brassica oleracea* L. var. *acephala*) cultivars and several landraces obtained from southeastern growers were tested for potential winter production. Collard and kale entries were grown in four winter environments in South Carolina from 1993 to 1995. Transplants were set in the field during November or December, and leaf production and plant fresh weight were monitored through the winter. When plants reached a 22-leaf stage, a plot subsample was harvested and weighed. The date at which 50% of the plants per plot had bolted was also recorded. Essentially all entries survived the conditions of four winter environments. However, whether an entry reached harvest size depended on its date of bolting. Collard entries typically bolted earlier than kale entries, and most kale and several collard entries attained harvestable-size before bolting. The ranking of genotypes for days to 50% bolting was consistent among environments. 'Blue Max' and a landrace of collard, and 'Squire' and 'Blue Knight' kale usually never reached 50% bolt.

427

Resistance of 25 Melon Cultigens to Race 1 and Race 2 of Fusarium Wilt under Two Soil Fumigation Treatments

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Twenty-five melon (*Cucumis melo* L.) cultigens were screened for resistance to fusarium wilt in a field infested with race 1 and race 2 of *Fusarium oxysporum* f.sp. *melonis* in 1993 and 1994. Plants were grown on clear plastic mulch using commercial production recommendations. The soil was fumigated with methyl isothiocyanate at a broadcast rate of 340 liters$\cdot ha^{-1}$ in 1993, and with dichloropropene at a broadcast rate of 136 liters$\cdot ha^{-1}$ in 1994. Resistance was determined by the percentage of plants surviving 8 weeks after transplanting. In general, highly resistant cultigens (>90% survival) and highly susceptible cultigens (<20% survival) performed consistently in the two experiments. However, differences in performance between the two years were noted for cultigens with intermediate resistance, and their performance may have contributed to the significant cultigen x year interaction in this study.

431

Inheritance of Leptine Glycoalkaloids in *Solanum chacoense*

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Leptine glycoalkaloids found in certain genotypes of *Solanum chacoense*, a wild potato relative, are resistance factors against the Colorado potato beetle (CPB). To efficiently introgress CPB resistance through leptine production into the cultivated potato, an understanding of leptine inheritance is important. Analysis of sibs within PI lines revealed a wide segregation for level of leptines. Leptine levels ranged from not detectable to 120 mg/100 g fresh weight among six sibs in a PI line, suggesting leptine production may be controlled by a few major genes. TLC analysis of F_2 and backcross progeny, however, indicated that several genes probably control leptine level. This apparent multigene control of leptine level may make it difficult to incorporate leptine synthesis into the cultivated potato. Therefore, we are presently identifying microsatellite and RAPD markers associated with leptine synthesis to enable marker-assisted selection and facilitate the incorporation of leptine synthesis into the cultivated potato.

435

Genetic Variation and Selection for Carotene Content in Carrots

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A six-parent diallel which included carrot inbreds with a range of carotene content from 80 to 490 ppm was evaluated over 2 years. General combining ability accounted for most of the variation observed. Phenotypic mass selection was exercised for high carotene content in three carrot populations. Response to selection continued to be high in one population, HCM, after 11 cycles of selection. In contrast, after three generations of selection, little progress was able to be made in a population derived from primarily Nantes-type open-pollinated cultivars. Realized heritability estimates varied from 15% to 49%. Environment contributed significantly to variation in carotene content.

439

Arkansas Blackeye #1: A New Southernpea

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Southernpeas (*Vigna ungurculata*) are a popular crop in the southeastern United States. They are an important crop to Arkansas processors, market gardeners, and home gardeners. While the bulk of the acreage produced in the state is pinkeye purple hull types, there is a demand for other horticultural types. At present, there is not a well-adapted blackeye that is available to producers in the state. For that reason, Arkansas Blackeye #1 is being released. Arkansas Blackeye #1 has been widely tested under the designation Arkansas 91-245. It produces a medium-sized bush plant that is well suited to conventional or narrow row spacing and matures 2 to 3 days earlier than Coronet under Arkansas conditions. Arkansas Blackeye #1 produces yield similar to the best pinkeye purple hull types. Samples have been canned by the Food Science Dept. at the Univ. of Arkansas and the canned samples have compared favorably to the industry standards.

443

An Unstable Mutation Affecting Tomato Reproductive Development

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Somatic sectors possessing mutations affecting flower and fruit development were found at a high frequency in an F_4 tomato plot. Over the past 4 years, this population has manifested a range of variant phenotypes, including conversion of calyx to leaflets; flecking, striping of sectoring of fruit; and development of "prolific callus" (PC) fruit, characterized by the green fruit bursting open, with new flowering shoots developing from the internal tissue. The variant phenotypes were not stably inherited. The majority of plants having sectors with abnormal flowers, abnormal fruit, or PC fruit developed phenotypically distinct somatic sectors. The aberrant phenotype ratios, the very high frequency of somatic reversions toward normal development, and the range of traits affecting tomato reproductive development indicate this could involve a transposable element interacting with control genes involved in tomato reproduction, with the phenotype partly dependent on the timing of the transposition event.

447

Fruit Characteristics of Hybrid Triploid Melons

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Thirteen triploid lines of melon (*Cucumis melo* L.) were derived from crosses involving five tetraploid and seven diploid lines. Fruit characters were assessed. When allowed to open pollinate in field plots with adjacent diploid pollinators,

eight triploid genotypes were sterile or nearly sterile (<1% viable seed). Five triploid genotypes were partially fertile, indicating viable pollen grains were present. Cytological analysis performed on progeny of a partially fertile triploid plant fertilized by open pollination indicated euploid female gametes were common. Triploid hybrids between tetraploid 'Miniloup' and several other diploid parents had vegetative and fruit characteristics intermediate to the parents. Most triploid genotypes yielded round fruit in contrast to their diploid parent whose fruit were oval to oblong and the tetraploid parent that had oblate fruit. Sugar levels of some triploid hybrids were as high as diploid parents.

451

Combining Ability and Correlations for Fruit Firmness Components in Parthenocarpic x Nonparthenocarpic Pickling Cucumber Hybrids

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One concern that has restricted the use of parthenocarpic pickling cucumber cultivars in the United States has been firmness of fruit processed by brining. Selection for mesocarp and endocarp firmness, in addition to morphological traits associated with firmness, such as fruit length, length : diameter ratio, seed cavity size, and seed cavity : fruit diameter ratio, may produce parthenocarpic cultivars with improved quality. Combining ability of a set of parthenocarpic and nonparthenocarpic parents for fruit firmness and these related morphological characteristics were investigated using a factorial mating design grown in 1992 and 1994 at Brooks, Ore. General combining ability was greater than specific combining ability for all traits before and after processing. Fruit firmness, mesocarp firmness, endocarp firmness, length, and length : diameter ratio were positively correlated phenotypically and genetically to one another. Seed cavity diameter and seed cavity : fruit diameter ratio were positively correlated phenotypically and genetically, but were negatively correlated to all other traits.

455

Barriers to Introgression into Tomato of Intergeneric Fusion Hybrids of *Solanum ochranthum* and Tomato

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Somatic fusion hybrids created between tomato and *Solanum ochranthum*, a wild nontuber-bearing diploid species that is genetically isolated from tomato, were evaluated in an effort to introgress traits from *S. ochranthum* into tomato. Pollen stainability and pollen tube growth examination demonstrated that little or no viable pollen was present in tetraploid and hexaploid fusion hybrids. Aneuploidy was noted in a small percentage of these hybrids. Use of tetraploid and hexaploid fusion hybrids as female parents in backcrosses to diploid and tetraploid tomato was studied. Chemical treatments that induce either chromosomal recombination or reduction may be advantageous for overcoming difficulties in introgression of these wide hybrids into tomato.

459

Michigan Asparagus Clone Trial

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Outstanding asparagus crowns were identified in established Michigan asparagus fields, MSU germplasm, variety trials, or were provided by commercial sources. The single-crown selections were micropropagated to provide cloned plants for the trials. Field trials consisting of four replications of 12 plants each were established at two locations. Crowns were planted 8 inches deep and spaced 18 inches apart in rows 4.5 or 5 feet apart. Five, 37, and 25 selections were planted in 1998, 1989, and 1991, respectively. Plots were not harvested until 2 years after planting, when they had partial harvests of six pickings. In the third and following years, plots received full harvests of 20 to 25 pickings. In the third full harvest at the Hart location, clones Hart-2 and Hart-3 yielded 6989 and 6875 lb/A, respectively, and were significantly more productive than Syn4-56, which had 3720 lb/A. At Benton Harbor, Hart-4 produced 4184 lb/A, significantly higher than the Syn4-56 yield of 3088 lb/A at that location. These significant differences were not observed until the second full harvest.

463

Fertility Losses in Congruity Backcross (CBC), Intraspecific *Phaseolus vulgaris* Hybrids

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Decreases in fertility are most common among interspecific, wide crosses of *Phaseolus*; intraspecific hybrids are less likely to exhibit sterility. Intraspecific CBC hybrid pedigrees were created to test for comparative fertility losses. Eight *P. vulgaris* cultivars from different centers of origin, polymorphic for seed proteins (15, 20, 50 kDa), were used to create 16 CBC populations: dry ('Cuarenteño', 'Great Northern Harris', 'Sulfur', 'Swedish Brown') and snap beans ('Purple Pod Pole', 'Romano Bush', 'Royal Burgundy Bush', 'White Half Runner'). Despite repeated attempts, two crosses failed to produce primary hybrids. Primary hybrids had decreased percent stainable pollen from the parents. Female sterility was more severe, necessitating the screening of the F_1–F_3 before producing the next CBC. Yield was significantly lower than midparent values for all F_3 CBC pedigrees. In several cases, phaseolin was no longer the major seed protein. Other hybrid breakdown symptoms were similar to those found with wide crosses, indicative of incongruity between centers of origin.

467

Heritability Estimates of the Pungency and Single-center Traits in Onion

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Heritabilities of the pungency and single-center traits were estimated in onion breeding lines using selection response and half-sib family analyses. Pungency was determined by measuring enzymatically produced pyruvic acid in individual bulbs. After one generation of selection, pungency was lowered by 0.37 and 0.42 μmol pyruvic acid/gram fresh weight in the breeding lines 90-61-1 and 89-69-8, respectively, and realized heritabilities of 0.21 and 0.51 were estimated. Heritability estimates calculated through half-sib progeny analysis were 0.53, 0.48, and 0.25 for pungency in the breeding lines 90-61-1, 90-62, and 89-69-8, respectively. The number of single-centered onions was increased by 19% and 22% in the lines 90-62 and 89-69-8, respectively, after one generation of selection, and the realized heritability estimates were 0.37 and 0.34, respectively.

471

Inheritance of Resistance to *Xanthomonas campestris* pv. *vesicatoria* Race T3 in Tomato

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Resistant Hawaii 7981 (P_1) was crossed with susceptible Fla. 7060 (P_2), and F_1, BCP_1, BCP2, and F2 generations were obtained. Hypersensitive reactions (Hr) were measured 24 and 48 hours after inoculation in growth chambers at 24 and 30C. At 30C, there was no Hr. At 24C and 24 hours, 100% of Hawaii 7981 plants, 54.2% of BCP_1 plants, and 21.7% of F_2 plants had Hr. At 24C and 48 hours, 100% of Hawaii 7981, the F_1, and BCP_1 plants; 50% of BCP_2 plants; and 73.3% of F_2 plants had Hr. Other plants were inoculated and rated for race T3 in the field. Disease for each generation was significantly different ($P < 0.05$) and their order from most to least resistant was P_1, BCP_1, F_1, F_2, BCP_2, and P_2. The F_1s were distributed between the parents with slight overlaps. BC plants had bimodal peaks similar to the F_1 and their respective parents. The F_2 had three peaks corresponding to P_1, F_1, and P_2. The data suggest Hr and field resistance are controlled by the same incompletely dominant gene.

475

Varietal Improvement of Pepper in Cote d'Ivoire

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Pepper (*Capsicum* spp.) is an important component of various cropping systems and dishes in Cote d'Ivoire. The need to meet local market demand has prompted the development of high-yielding hot pepper varieties. Three local selections and 20 AVRDC-introduced breeding lines were evaluated in a three-replicate randomized complete block design. Data were collected on fruit and plant characteristics as well as on fruit yield and yield components. Large variations were found in all studied variables. Date of 75% flowering occurred between 52 and 77 days after sowing. First harvest date varied from 99 to 134 days after

sowing, while plant height at first harvest ranged from 42 to 92 cm. Fruit size and fruit form were quite diverse. Maximum total fresh fruit weight (5490 g/plot) was about 10 times higher than that of the lowest-yielding (557 g/plot) entry. Selection within those lines has potential to contribute to the improvement of pepper productivity in Cote d'Ivoire.

479

The Inheritance and Association of Rust (*Uromyces appendiculatus*) Resistance and Foliar Abnormalities in *Phaseolus vulgaris* L.

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The inheritance of specific resistance (SR) and foliar abnormalities (FA) were studied in the F_2 and F_3 progeny of the following crosses; 'PC-50' x Chichara 83-10, 'PC-50' x 'EZ Pick', A-10-2 x GN 'Beryl', and A-10-2 x P114. A single dominant gene controlled SR to rust strain US85NP10-1 in 'PC-50' x Chichara 83-10. Duplicate recessive genes determined foliar crippling (FC) in 'PC-50' x Chichara 83-10 and A-10-2 x P114. The inheritance of hybrid plant abnormality in 'PC-50' x 'EZ Pick' and A-10-2 x GN 'Beryl' differed from previously reported complementary dominant genes or duplicate recessive genes. Foliar variegation (FV) was controlled by duplicate recessive genes in 'PC-50' x Chichara 83-10 and by triplicate recessive genes in 'PC-50' x 'EZ Pick', A-10-2 x GN 'Beryl', and A-10-2 x P114. No associations were detected between SR and FC, SR and FV, or FC and FV.

59 POSTER SESSION 5
Postharvest Physiology/Vegetable Crops

603

Effects of Moisture Loss on Water Potential Components and Tissue Deterioration in Carrots during Short-term Storage

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Studies were carried out to understand the effects of moisture loss on water potential and root deterioration in carrot (*Daucus carota* L. 'Eagle') roots during short-term storage. The roots were stored at various temperatures and relative humidities (RH) to provide 0.7 (low), 3 (medium), and 9 mbars (high) of water vapor pressure deficit (WVPD). Carrots at high WVPD lost the most weight, followed by those at medium and lowest WVPD. Water potential and osmotic potential of the carrot tissue at high WVPD did not change significantly up to 6 days, but decreased thereafter. There was no change in water potential and osmotic potential for carrots at medium and low WVPD. A significant quadratic relationship ($P = 0.05$, $r = -0.764$) between water potential and carrot root weight loss was observed. Relative electrolyte leakage increased over time in carrots at the high WVPD. At medium WVPD, relative electrolyte leakage did not change up to 6 days, but increased significantly thereafter. Carrots at the low WVPD did not change in relative electrolyte leakage. Relative electrolyte leakage and weight loss correlated positively ($P = 0.05$, $r = 0.789$). The results suggest that water stress during short-term storage causes tissue deterioration that may further increase rate of moisture loss and hence reduce the shelf life of carrots.

607

Methanethiol Production by *Brassica* Vegetables Held in Anaerobic Atmospheres

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Methanethiol (MT) is a volatile compound responsible for the strong off-odor that is evolved when fresh broccoli is held under anaerobic atmospheres. Inductive atmospheres can develop in modified-atmosphere packages, resulting in reduced quality. To determine if related vegetables are capable of producing MT, 12 different vegetables from the genus *Brassica* were cut into ready-to-eat forms. Fifty-gram samples of these cut vegetables were sealed in 500-ml glass jars and flushed with N_2. After flushing, jars were held for 24 h at 20C in the dark. Headspace samples from the jars then were analyzed for MT and other volatiles using a GC-MS> The concentration of MT was greatest in jars containing broccoli florets. Broccoli flower buds removed from florets produced 40 times more MT than peduncle and stem tissues (38.3 vs. 0.87 $mmol \cdot m^{-3}$). Headspace concentration of MT ($mmol \cdot m^{-3}$) in jars containing these different vegetables was: broccoli florets, 22.7; pak choi leaf blades, 17.8; savoy cabbage, 12.4; broccoflower, 7.5; green storage cabbage, 5.2; red cabbage, 2.7; kale, 0.81; Brussels sprouts, 0.36; pak choi petioles, 0.28; rutabaga root, 0.26; cauliflower florets, 0.18; Chinese cabbage, 0.03; and kohlrabi tubers, 0.02. In addition to MT, ethanol, dimethyl disulfide, and dimethyl trisulfide were detected in the headspace over each of the 12 vegetables. The contribution of these induced compounds to off-odor development in packaged, precut vegetables will be discussed.

611

Influence of Potassium (K) and Cultivar on Watermelon Quality

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The influence of potassium (K) on respiratory behavior, flesh firmness, and internal color of watermelon (*Citrullus lanatus*) was studied. Two cultivars (Crimson Sweet and Sangria) were planted at the Univ. of Florida research station, Gainesville. The fruits from both cultivars were harvested at two different stages of maturity (25 days and 35 days after anthesis). Respiration and ethylene production were measured using gas chromatography under a static system. The internal color was measured by a colorimeter, while the flesh and rind firmness were measured by a instron Universal pressure tester. Carbon dioxide and ethylene production were non-climacteric in behavior and were not greatly affected by K treatment or cultivar.

615

Gamma-ray-induced Changes in Plasma Membrane from Hypodermal Mesocarp Tissue of Muskmelon Fruit

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Postharvest gamma-irradiation of melons at low dosage has been reported to extend shelf life. This study assessed how irradiation alters the structure and function of plasma membrane (PM) from hypodermal-mesocarp tissue. Administration of gamma rays (1 kGy at 0.017 kGy/min) to mature melon (*Cucumis melo* L.) fruit caused a 14% drop in H^+-ATPase activity within 4 h. Total protein content did not differ in PM from non-irradiated (NIR) vs. irradiated (IR) fruits. Following storage (7 days at 7C then 3 days at 21C), H^+-ATPase activity was ≈10% to 20% lower in PM from both groups of fruit, with no difference between the two. Total PM protein had declined by 34% and 49% in IR and NIR fruits, respectively. After irradiation, the phospholipid to protein ratio (PL:protein) was substantially higher in PM from IR fruit (0.67 vs. 0.58 in NIR). With storage, PL:protein dropped to 0.52 in NIR fruit PM, but changed little (0.65) in IR fruit PM. These results may indicate that irradiation stimulates PL synthesis or inhibits PL catabolism. Further analyses of PM lipid content and composition are underway.

619

Sugars and Respiration Profiles in Asparagus Spears and Changes during Storage

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Base-to-tip profiles of sucrose, glucose, fructose, and respiration rate were measured for asparagus (*Asparagus officinalis* L.) spears stored at 0C. Fructose content was ≈3-fold and 4-fold higher than glucose and sucrose, respectively. The highest level of fructose was found in the base and was ≈15-fold higher than the tip. The changes in asparagus metabolism were characterized by loss of sucrose and a high rate of respiration within the first hours after harvest. Sucrose was more rapidly lost than the other sugars during this period. The respiration rate was measured along the length of intact spears at 0.5, 1, 2, and 3 h after harvest. Subsequent measurements were taken after larger time intervals for 23 days. The respiration rate declined rapidly to ≈60% of the initial rate within 12 h, decreasing more slowly thereafter. Initially, the respiration rate of the tip was about four times that of the base, but, after 23 days, the respiration rate of the tip was only twice that of the base. Sucrose content and respiration rates were closely correlated.

623

Heat-induced Volatiles in Fresh Broccoli

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Heat can induce physiological changes in plant tissues, including the inhibition of broccoli senescence. Hot water treatments at 52C for 3 or more minutes may induce off-odors in fresh broccoli. The objective of this study was to identify heat-induced volatiles that may indicate physiological injury and/or be responsible for off-odors. Heads of fresh broccoli (*Brassica oleracea* L. Italica group cv. 'Paragon') were immersed in water at 25C for 10 min (control); 45C for 10, 15, or 20 min; or 52C for 1, 2, or 3 min. Following treatment broccoli was held at 20C in the dark. Volatiles in the headspace above treated broccoli were trapped on Tenax-GR 2, 24, and 72 h after treatment and analyzed on a GC-MS. Heat treatments increased the production of ethanol, dimethyl disulfide (DMDS), dimethyl sulfide (DMS), dimethyl trisulfide (DMTS), hexenol, methyl thiocyanate, and several other unidentified compounds. Two hours after treatment, ethanol and hexenol concentrations in the headspace of all heat-treated broccoli were greater than those of the 25C/10 min controls. In the 52C/3 min-treated broccoli, headspace concentrations of ethanol, hexenol, DMDS, and methyl thiocyanate were 600-, 42-, 4-, and 4-fold greater than those of controls. After 72 h at 20C, concentrations of DMDS, DMS, and DMTS in broccoli from all six heat treatments were 10- to 200-fold, 8- to 35-fold, and 1.5- to 23- fold greater than those of controls, respectively. Concentrations of ethanol and methyl thiocyanate did not change relative to the controls during the additional 70 h at 20C. Concentrations of hexenol decreased in heat-treated broccoli during this time. The relationship of these volatiles to physiological changes and off-odor development in treated broccoli will be discussed.

627

Inhibition of Galactolipid Biosynthesis in Tomato Pericarp at Chilling Temperature

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We examined the relationship between reduced galactolipid content in tomato fruit at 4C and chilling injury. Galactolipid biosynthesis from ^{14}C-acetate was compared in pericarp discs of cold-tolerant 'New York 280' ('NY') and -sensitive 'Early Cherry' ('EC') at 4C and 20C. Labeled lipids were separated by 2D-TLC. Labeled monogalactosyldiglyceride (MGDG) molecular species were hydrolyzed using a position-specific lipase; the fatty acids released were hydrogenated and separated according to chain length by reverse-phase TLC. At 4C, the relative amount of radioactivity was reduced in MGDG and enhanced in phosphatidylcholine (PC) in both cultivars, in comparison with labeling at 20C. In discs from fruit chilled for 6 h, labeling was similar in 'NY' and 'EC'. In fruit held at 4C for 8 days, labeling of MGDG was reduced and that in PC was enhanced to a greater extent in chilling-sensitive 'EC' than in 'NY'. The proportion of the MGDG label in eukaryotic species (i.e., the ratio in C18/C16 fatty acids in position *sn-2*), was less in 'EC' at 4C than at 20C, even for fruit held at 4C for only 6 h. The ratio was little affected in 'NY'. The data indicate that biosynthesis of eukaryotic MGDG was inhibited in tomato fruit at chilling injury-inducing temperatures.

631

Ultrastructural Changes in Chloroplasts in Harvested Broccoli Flower Buds During Senescence

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Green broccoli (*Brassica oleracea* L. Italica Group) flower heads were stored in perforated polyethylene bags at 20C. Green color of sepals in broccoli flower buds changed to yellow and individual flower buds wilted gradually during storage. Chlorophyllase activity in flower buds tended to increase and chlorophyll content decreased during senescence. Optical and scanning electron microscopic observations were conducted to elucidate the structural changes of chloroplasts in sepals of broccoli flower buds through the senescence. The chloroplasts observed with optical microscope were fine and green when the stage of broccoli flower buds was all green. However, at half-yellow stage, the shapes of chloroplasts obscured and the green color faded. After this stage, colored small particles appeared in the cells and the number of particles tended to increase as yellowing of the flower buds progressed through the senescence. Scanning electron micrographs indicated that the small particles were formed in the chloroplasts and come out from them with senescence followed by aggregation with each other.

635

Effect of Methyl Jasmonate on the Quality of Chilled Zucchini Squash

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Methyl jasmonate (MJ) was applied to zucchini squash (*Cucurbita pepo* L.) fruit be pressure-infiltration (82.7 kPa for 3 min). Control fruit were similarly treated with distilled water. All fruit were then stored at a chilling temperature of 5C. Chilling injury occurred in the control fruit within 4 days of storage. However, the onset of chilling injury was significantly delayed by the MJ treatment. MJ-treated fruit also maintained higher levels of carbohydrates, while malic acid was the major organic acid. These constituents deteriorated slower in the MJ-treated fruit than in the control fruit.

639

Calcium Application Increases Potato Tuber Medularry Tissue Calcium Concentration and May Reduce the Incidence and Severity of Soft Rot Due to *Erwinia carotovora* pv. *atroseptica*

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Plots set up on a commercial seed farm were supplemented with 0 or 168 Ca/ha supplied from liquid calcium nitrate at 3 and 6 weeks after hilling (84 kg Ca/ha per application). Paired measurements of tuber medullary tissue Ca concentration and decay severity after inoculation with *Erwinia carotovora* pv. *atroseptica* (*Eca.*) were taken on identical tubers from these separate plots of 'Atlantic', 'Superior', 'Red Norland', and 'Russet Burbank'. Fresh-cut seed pieces sprayed with a suspension of *Eca.* (10^8 cfu/ml) were planted in separate 1-liter containers filled with field soil maintained under two soil moisture regimes: 1) air-dry days 1–5, saturation days 6–10, field moisture capacity (FMC) days 11–18, or 2) FMC days 1–18. Containers were placed at 22C constant air temperature at the Univ. of Wisconsin–Madison Biotron. Decay severity (percent volume seed piece decay) and decay incidence (percent tubers with any decay) were rated after 18 days. Eight seed pieces per treatment were evaluated. The mean tuber Ca concentration was higher in plots receiving calcium compared to nonsupplemented plots. Mean medullary Ca concentration varied among cultivars as 'Russet Burbank' > 'Atlantic' > 'Superior' > 'Red Norland'. The influence of cultivar on decay showed an incidence and severity pattern 'Atlantic' = 'Russet Burbank' > 'Superior' = 'Red Norland'. Decay incidence and severity were greatest in seed pieces kept in temporarily saturated soil compared with those in soil maintained at FMC. Decay incidence and severity were ≈6% lower in tubers produced on Ca-supplemented soil. A scatter plot of decay severity x Ca concentration for seed pieces held at FMC suggests that a threshold of Ca concentration exists above which little or no decay occurs.

643

Effects of Carbohydrate Loading on Sugar Profile and Respiration of Asparagus Spears during Storage

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Asparagus spears (*Asparagus officinalis* L.) were placed in solutions of six different concentrations of sucrose (0%, 1%, 2%, 4%, 8%, and 16%) plus citric acid at 0C for 24 h following harvest. The profiles of sucrose, fructose, glucose, and respiration rate along the length of the spear were evaluated throughout storage. The effect of carbohydrate loading on the rate of respiration, sucrose loss, and the shelf life of asparagus was determined. For all treatments, sugars decreased and respiration rate increased from the butt to the tip. The 4% sucrose treatment enhanced the sugar level in the tip ≈5-fold relative to the control. For the 8% and 16% treatments, sucrose tended to accumulate in the base. Spears loaded with higher sucrose concentrations had higher respiration rates than controls up to 3 h after loading. After this time, no significant differences were observed between treatments. For all treatments, respiration rates declined rapidly following harvest, stabilizing in ≈24 h. Weight gain and growth increased as the treatment sucrose concentration decreased. Solution uptake was enhanced by loading at lower humidity levels.

647

Cuticle Differences during Ripening of Normal and *rin* Tomato Fruits

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Ripening mutant gene *rin* (ripening inhibitor) in tomato inhibits, or greatly slows down, a wide range of processes related to ripening of the fruit, leading to a markedly extended shelf life. Although the use of films or coatings has been shown to retard ripening, the natural film that covers the fruit and delimits interchange with the environment, the cuticle, has not been well-characterized and related to ripening. The objective of this work was to characterize cuticle changes and establish their relationship with respiratory behavior. Turning tomato fruits with the gene *rin*, selection S-164 and normal tomato fruits were stored under marketing conditions (20C; 65% to 70% RH) to determine cuticular and physiological changes. Parameters evaluated were: cuticular weight changes (CW), permeability, soluble cuticular lipids (SCL), and epicuticular waxes (EW). In addition CO_2 production was monitored every other day. Normal fruit increased in CW from 1.17 to 1.30 mg·/cm^{-2} and its EW from 11.49 to 24.49 µg·cm^{-2}. On the other hand, *rin* tomatoes declined in CW and EW during storage. Both kind of fruits decreased their SCL content. Normal tomatoes exhibited the characteristic climacteric peak and showed an increase of cuticle permeability, while in *rin* tomatoes, these changes were not expressed.

651

Quality Changes and Respiration Rate of Eggplant Fruits Infected with *Phytophthora capsici* L.

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Classic-type eggplant fruits collected at the packing line were stored at 21C to evaluate respiration, weight loss, and quality characteristics. Fruits were divided on two groups. One group was inoculated with *Phytophthora capsici*. Fruit size, postharvest changes in color, compositional characteristics, CO_2 production, weight loss, and spread area of the disease were monitored daily. Fruit size at harvest ranged between 15 to 17 cm of longitude and 7 to 9 cm of diameter. Seventy two hours after inoculation (HAI) of the fruits with *P. capsici* , a significant increase on respiration was detected even before the fungus was visually present. After 144 HAI, respiration on infected fruits reached 49 ml CO_2/kg per h, while healthy fruits achieved only 15.7 ml CO_2/kg per h, reducing quality and shelf-life on rotten fruits. Firmness, titratable acidity, and pH showed a significant difference between healthy and infected fruits. pH on infected fruits change from 4.96 after 96 HAI to 6.91 after 144 HAI, while healthy fruits did not change in the same period. Results were closely related with time after inoculation. Forty-eight HAI, the surface affected was of 2.7 cm by 1.8 cm; while 168 HAI, the affected surface area increased to 12.2 cm by 13.4 cm, representing damage above 60% of the total surface of the fruit.

655

Effect of Heated Water in Prevention of Chilling Injury in Tomatoes

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Mature green tomatoes (*Lycopersicon esculentum* Mill. cv. Vibelco) were immersed in 38, 42 , 46, 50, and 54C for 90 min prior to storage at 2C for 2, 4, or 6 weeks in paper bags. After storage, they were kept at 20C. Fruits immersed in heated water showed lower ethylene production, rate of respiration, electrolyte leakage, and visible chilling injury than nontreated fruits. During storage and after removal at 20C, hot-water-treated fruits ripened faster than nontreated fruits The increase in water temperature from 38 to 46C resulted in declined ethylene production, rate of respiration, electrolyte leakage, and visible chilling injury, but, with further increase in water temperature (46 to 54C), they increased. Of all the pretreatments, the treatment at 42 or 46C were most effective in enhancing fruit color changes. Inhibition in ethylene production, rate of respiration, electrolyte leakage, and visible chilling injury was highest on fruits immersed at 42 and 46C.

659

Relationship between Sugar Content in Raw, Baked, and Microwaved Sweetpotato Roots during Storage

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Seven compositionally diverse sweetpotato lines were examined for changes in individual sugar concentrations at harvest (green), after curing (7 days at 90% RH and 29.5C), and after 4 and 8 weeks of cold storage (16C) to determine the relationship between raw and cooked root sugar composition. Raw root sucrose concentrations at harvest in two dessert types, 'L91-80' and 'Heart-O-Gold', were at least 22% higher than other dessert types, such as 'Beauregard' and 'Jewel', and 26% higher than white starchy types ('Rojo Blanca' and 'White Star'). The sucrose concentration remained correspondingly higher for these two lines when baked or microwaved. Total sugar concentration was not significantly correlated between raw vs. baked or microwaved roots. The major sugar in most baked and microwaved roots was maltose, accounting for 18% to 93% of the total sugars. 'L91-80' behaved differently from other lines during microwaving, where sucrose was the major sugar. The total sugar concentration of 'L91-80' and 'Heart-O-Gold' were not statistically greater after baking and microwaving for all dates, including the white, starchy types. These results suggest the need to further evaluate the relative importance of individual sugar concentrations on consumer preference.

663

Effect of Preharvest Conditions on Chilling Susceptibility of Tomato Fruit

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In a 2-year study, tomato plants (*Lycopersicon esculentum* Mill. cv. New Yorker), grown in field lysimeters, were subjected to water table levels (WTD) of 0.3, 0.6, 0.8, and 1.0 m from the soil surface, factorially combined with five K–Ca combinations, and replicated four times. Four mature green fruit per plant were stored at 5C for 21 days, and fruit color (L*,a*,b*) was measured daily. Fruit were then ripened at 21C for 10 days, and the surface area with chilling damage and the ripening stage noted for each fruit. In 1993, a dry year, the 1.0 m WTD showed the greatest color change, the 0.3 m WTD the least. The 1.0 m WTD showed the least damaged area and least delay in ripening, the 0.3 m WTD the most. In the wet year, 1994, differences by WTD were not significant. K and Ca fertilizer effects were not significant in either year. The number of hours below 15C, precipitation, and crop evapotranspiration in the week prior to harvest appeared to be of lesser importance than WTD in subsequent chilling response. Preharvest plant water relations appear to have some bearing on postharvest chilling sensitivity.

667

Effect of Permeable Coatings on Some Quality Parameters of Two 'Galia' melons during Storage

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Melon hybrids (*Cucumis melo* L.) C-8 and H-5 from Hazera C.O. (Israel), were treated with two commercial wax coating, Primafresh at the original concentration, and Prolong at 1.5% (w/v). Fruits were sprayed with wax and stored for 5, 10, and 15 days at 10, 15, and 25C in storage rooms. Total soluble solids, titratable acidity, pH, reducing and total sugars, dry matter, electric conductivity, and pulp fruit color were analyzed. No difference was found to TSS; titratable acidity was high at 10 and 15C in fruits stored for 5 days. The C-8 hybrid showed the highest reducing and total sugar content at 10C. For both hybrids, dry matter content was reduced at higher stored temperature and longer storage time. The hybrid H-5 showed higher color a* value and a clear pulp color was increased in fruit at 15C.

671

Ethylene Production in Watermelon Fruit Varies with Cultivar and Fruit Tissue

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To determine whether ethylene production was related to locular tissue breakdown in watermelon, plugs from ripe 'Jubilee', 'Black Diamond', 'Tiger Baby', 'Mirage', and 'King of Hearts' were taken from the skin (epidermis and hypoderm), rind (hypoderm and mesocarp), and placenta (locular and heart) tissues. ACC

oxidase activity was <0.05 nmol·g^{-1}·h^{-1} in locule and heart locations for all cultivars. Skin tissue had the highest activity, ranging from 0. 1 8 for 'Jubilee' to 0.5 to 0.62 nmol·g^{-1}·h^{-1} for the other four cultivars. ACC (1-aminocyclopropane-1-carboxylic acid) and ACC oxidase activity were measured in unripe, ripe, and overripe 'Jubilee' melons. ACC oxidase activity from skin tissue was lowest in unripe (0.05 nmol·g^{-1}·h^{-1}) and highest in overripe (0.13 nmol·g^{-1}·h^{-1}) melons, and was 0.05 nmol·g^{-1}·h^{-1} or less in all other tissues. Free ACC was highest in the skin tissue (1.3 nmol·g^{-1}·h^{-1}), but there was no difference in ACC content with stage of ripeness for any tissue. Results indicate that ethylene may be transported from the outer skin and rind tissues to locular areas and that wounding of the skin tissue could lead to deleterious ethylene production.

675

Coating Waxes on Pepper Fruits cv. Caribbean and Quality on Different Storage Conditions

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Pepper fruits (*Capsicum annum* L. c.v. Caribbean) were treated with two commercial was coatings , Primafresh and Prolong. Fruits were sprayed with Primafresh (original concentration) and Prolong at 0.5% and 1.5% (w/v) concentration. Fruit samples were taken for analysis each of 5 days during 20 days from storage rooms at 1, 5, 10, and 15C. Parameters TSS , titratable acidity, pH, fresh fruit weight loss, texture, and dry matter content were analyzed. TSS and dry matter decreased with the storage time. Titratable acidity increased until 10 days after storage and decreased when fruit were stored for a longer time. The lowest texture deformation was observed at 1 and 5C. Coating treatments reduced the rate of fresh fruit weight loss of peppers compared to uncoated ones .

679

Transpiration in Eggplant Fruits as Affected by Fruit Stage of Development and Storage Conditions

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Fruit transpiration or weight loss was measured gravimetrically on eggplant fruits (cv. Classic) at various stages of development. The calyx of some fruits was covered with Vaseline to measure its relative contribution to total fruit transpiration. To evaluate the effect of storage conditions on fruit transpiration and quality, fruit of commercial size (24/37.4 liter box) were stored at either low evaporative demand (10C, 100% RH) or high evaporative demand (20C, 70% RH) for 7 days. After storage period, fruit transpiration and other fruit quality characteristics were determined. The results indicated that ≈70% of total fruit transpiration occurred through the calyx and stem in fruits size-24, where the calyx accounted for ≈10% of total fruit surface area. The surface area of the calyx relative to the total fruit area decreased as fruits developed. There was a positive correlation between evaporative demand in the storage room and fruit transpiration. At a higher evaporative demand, there was a reduction in fruit shelf life, fruits being more withered and less firm as compared to those stored at a lower evaporative demand. Thus, eggplant fruit quality would probably be extended by a reduction in fruit transpiration.

683

The Use of Immunoassays for the Detection and Quantification of Pesticides in Fresh and Processed Fruits and Vegetables

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There is a continuous need for the monitoring of agrochemicals in foods. For this purpose, there is a need for sensitive and inexpensive techniques. The recent use of immunoassays for the detection and quantification of environmental residues is advantageous as being specific, sensitive, fast, and potentially inexpensive compared to traditional methods. In this work, we have used an immunoassay method to quantify 13 pesticides in eight fresh and processed fruits and vegetables consumed in northwestern Mexico. The concentrations detected were much lower than the maximum permitted levels in all products analyzed. Minimum concentration detected was 0.1 ppb of chlorothalonil in tomato fruit. The maximum concentration detected was 386 ppb of benomyl in Mexican-produced apples .

687

Ethanol Accumulation as an Indicator of Sensitivity of Different Horticultural Produce to 30% CO_2 in Air Storage at 7C

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Controlled atmospheres (CA) have been used as auxiliary to refrigeration for the storage and transportation of food crops. Commodities sensitive to high levels of CO_2 experience fermentation. This study was focused upon the effects of CO_2-enriched atmospheres on ethanol (ETOH) accumulation as an indicator of the sensitivity of 22 different produce to short-term exposure to 30% CO_2 in air for 2 days at 7C. Commodities were obtained from a wholesale or grocer supermarket. ETOH was determined by gas chromatography (GC). Differences in response to 30% CO_2 in air were observed among commodities. Kiwi fruit and broccoli had initial low levels of ETOH, which greatly increased after the first day of storage. Cherries and spinach maintained approximately a constant increase in ETOH accumulation during the whole period of storage. Pickling cucumber and zucchini squash had high ETOH accumulation at the early period of storage, which was even higher by the second day of exposure to 30% CO_2 in air. In most of the commodities under study ETOH accumulation increased as a response to 30% CO_2 levels in air. There was no apparent influence of plant organ on ETOH accumulation.

691

Comparison of Assays for the Quantitation of Superoxide Dismustase in Apple and Potato Tissues

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The enzyme superoxide dismutase (SOD; EC 1.15.1.1) catalyzes the conversion of the superoxide radical (O_2^-) to O_2 and H_2O_2. SOD is thought to be critical in delaying aging and senescence in plant tissues such as apple fruit and potato tubers. A variety of assays have been reported for the quantitation of SOD based on the inhibition of O_2-driven reactions. Four assays were examined, including 1) the reduction of nitro blue tetrazolium (NBT) by O_2^- generated by the reaction of cysteine and $FeCl_3$; 2) the reduction of NBT by O_2^- generated by photochemical activation of riboflavin; 3) the inhibition of nitrite formation from hydroxylammonium chloride (nitrite subsequently converts sulfanilic acid to a diazonium compound, which reacts with α-naphthylamine to form a red azo compound); and 4) the autoxidation of hematoxylin to hematein by O_2^-. In all cases, the production of colored compounds was inversely proportional to SOD activity. Although all of the assays were successful in quantitating SOD activity, assays 1 and 4 appeared simplest to use and had the fewest drawbacks.

695

The Influence of Storage Duration on the Performance of Hydrocooled and Packaged Broccoli under Simulated Shelf Conditions

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Broccoli (*Brassica oleracea* L., cv. Mariner) was harvested and the crop divided into four treatments; 1) "hydrocooled + no wrap", 2) "hydrocooled + wrap", 3) "not hydrocooled + no wrap", and 4) "not hydrocooled + wrap." Microperforated film (SM60, CryoVac) was used for the wrapped treatments. The broccoli was then placed in 1C storage. On day 3, samples of each of the four treatments were removed from storage and placed into a 13C room to simulate shelf conditions. Visual quality, weight loss, and respiration were monitored over 5 days at 13C. This shelf evaluation was repeated with broccoli samples that had been stored for 10 and 17 days at 1C. Hydrocooling had the greatest effect on shelf performance when broccoli was held in storage for only a few days. However, after a week or more of storage, wrap had the greatest effect on shelf performance. The shelf performance of the "hydrocooled + wrap" treatment was similar for all three shelf evaluations (i.e., after 3, 10, and 17 days of storage). The shelf performance of the other three treatments had significantly deteriorated by the 1st or 2nd week of storage. Broccoli in the "hydrocooled + wrap" treatment maintained the greatest firmness and the lowest respiration and water loss rates. Yellowing was not found to be a problem until a high degree of wilting had occurred. These results show that, with hydrocooling and wrapping, poststorage shelf performance of broccoli is stable for at least 2 weeks of storage at 1C.

699

Ethylene Production Rate and Postharvest Shelf-life Diversity in Melon (*Cucumis melo* L.) Germplasm

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Cucumis melo varieties show a great diversity of ripening and abscission phenotype, ethylene production, and postharvest keeping quality. As a preliminary step in the development of melons with improved shelf-life and modified ripening, we surveyed 100 genotypes of melons with diverse ripening characteristics for ethylene production rate and shelf-life. Genotypes representing seven melon types (Western shipper cantaloupes, Eastern cantaloupes, Long shelf life cantaloupes [LSL], Charenteis, Galias, Honeydews, Casabas) were planted in the field in a randomized complete block with three replications. *C. melo* var. *reticulatus* and *C. melo* var. *inodorus* were harvested 40 and 50 days post-anthesis, respectively, and brought in the lab for ethylene production measurement. Fruit at horticultural maturity were also harvested and stored at room temperature. After 7 days, a postharvest decay rating (1 = complete rot and collapse–5 = no softening or decay) was taken to determine relative shelf-life of the genotypes. Average ethylene production rate ranged from 44.44 to 0.64 $nl \cdot h^{-1} \cdot g^{-1}$ for Eastern cantaloupes and Casaba melons, respectively. A negative linear relationship was observed between ethylene production rate and postharvest decay rating. LSL cantaloupes had the lowest ethylene production rate of the netted, orange flesh types. The relationship between ethylene production rate and polymorphism for ACC oxidase (pMEL1) and ACC synthase (pMEACS1) cDNA probes is being investigated.

60 POSTER SESSION 6
Crop Protection & Pest Management Cross-Commodity

849

Resistance in Tomatoes to *Meloidognyne incognita* and *M. arenaria* as Affected by Gene *Mi* Heterozygosity and Temperature

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The *Mi* gene, which is the only source of resistance to the root-knot nematodes *M. incognita* and *M. javanica* in tomatoes, is effective only at soil temperatures below 28C. This single dominant gene exists in a homozygous form in certain tomato cultivars, in a heterozygous form in others, and is lacking in others. It has also been introduced into heat-tolerant and heat-sensitive cultivars. The availability of such genotypes allows determining whether a) the homozygous form provides more resistance than the heterozygous form and b) heat tolerance protects the *Mi* gene at high-temperature stress. The results of in vitro tests using excised roots show that the resistance offered by the *Mi* gene in the homozygous or the heterozygous form to *M. incognita* and *M. arenaria* was the same. The presence of heat tolerance gene did not protect the *Mi* gene from losing its effectiveness above 28C.

859

Remote Sensing Techniques Coupled with Leaf Spectroscopy to Evaluate the Severity of Dogwood Anthracnose

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Flowering dogwoods. (*Cornus florida* L.) have been attacked by dogwood anthracnose. In vivo leaf reflectance values of infected leaves from Summer 1993, Fall 1993, and Fall 1994 were obtained using a spectroreflectometer at wavelengths from 300 to 2500 nm to determine what wavelengths could best detect differences between dead and healthy leaves. At -those wavelengths, a mathematical expression was devised and used to calculate the predicted reflectance value for that percent disease severity ($R_{exp50\%}$). The predicted reflectance values were compared with actual mean reflectance values (R_{mean}) obtained from leaves with up to 50% disease severity achieving correlations of 0.95, 0.66, and 0.84, for the Summer and Fall 1993, and Fall 1994, respectively. For Fall 1994, actual disease severity values were obtained by scanning and image analysis to compute an expected reflectance for these actual percentages ($R_{real\%}$) for a correlation value of 0.98.

863

Acylsugars of the Wild Tomato [*Lycopersicon pennellii* (Corr.) D'Arcy] Alters Settling and Reduces Oviposition of *Bemisia argentifolii* (Silverleaf Whitefly)

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Acylsugars, the primary components of the exudate secreted by type IV trichomes of *Lycopersicon pennellii* (Corr.) D'Arcy LA716, mediate the resistance of this accession to silverleaf whitefly, *Bemisia argentifolii* Bellows & Perring, n. sp. Reduction in the settling of the adult silverleaf whiteflies correlates with the concomitant increase in applied acylsugars. Oviposition of *B. argentifolii* is also affected by acylsugars, resulting in a reduction in the number of eggs and nymphs found; however, acylsugars do not affect hatching of nymphs. The threshold amount of acylsugars required for deterring settling and oviposition is under the amount of acylsugars (50 to 70 $\mu g \cdot cm^{-1}$) required for control of other insects.

867

Implementation of *Brassica* spp. as Trap Crops and as Beneficial Insectaries for Caterpillar Management in Cabbage Ecosystems

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Experiments conducted over 3 years have determined the potential of utilizing Indian mustard and 'Tastie' head cabbage multi-species borders as trap crops for management of caterpillar pests of head cabbage in Hawaii. 'Scorpio', a cultivar that showed less feeding damage than 'Tastie', was used as the main crop. The studies point toward the use of isolated patches of multi-species attractant crops separated from the main crop by a buffer of non-host crops such as sweet corn. A sweet corn buffer was effective in preventing insect movement between plots. Initial studies showed the high susceptibility of Indian mustard to white rust (*Albugo candida*), to be a constraint to its use as a trap crop. Follow-up studies found that 'Excel' and 'Parkland' mustards may be adequate substitutes for mustard crop due to their attraction of caterpillars and their tolerance to white rust. Gradient experiments conducted on 60 x 30-m plots indicate that the trap crop may be effective for a distance of 25 to 30 m in terms of attraction of caterpillars and dispersal of beneficials into the main crop. A record was also made of growth, flowering patterns, and of beneficials hosted by 12 different *Brassica* cultivars during the winter and spring growing seasons.

871

Differential Reaction of Melon (*Cucumis melo* L.) Germplasm to *Monosproascus* Vine Decline

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We conducted a field screen of 130 melon cultigens to identify potential sources of host-plant resistance to *Monosporascus cannonballus*. Seed were sown in Speedling trays with inoculated or non-inoculated media. Plants were transplanted into a field known to be highly infested with *Monosporascus cannonballus*. Non-inoculated plots were planted in rows that were fumigated with Telone II. Cultigens were arranged in a randomized complete block with three replications in each treatment (fumigated, nonfumigated). A disease symptom rating (1 = complete death to 5 = no symptoms) was taken at 78 and 90 days post-transplanting. Disease symptoms were most severe and occurred earliest in the inoculated, nonfumigated plots. Natural infection by *Monosporascus* occurred in the fumigated plots as over 95% of root samples collected contained perithecia. At the second rating date, 108 of the 130 cultigens tested were classified as moderately to highly susceptible (rating < 2.5). The four most resistant genotypes had a second rating equal or close to 4.0 ('Galia', 'Deltex', 'Rocky Sweet', and 'Charlynne'). A group of 14 genotypes showed moderate resistance with a second rating of 3.0. Included in this group were 'Morning Ice', 'Doublon', 'Israeli', 'MR-1', 'Santa Clause', and 'Primo'. The physiological stress of a concentrated fruit set increases severity of vine decline symptoms.

875

Commercial Outlook and Adoption of Landscape IPM Tactics in Central New Jersey

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The largest agricultural industry in New Jersey is the commercial landscape/nursery/turfgrass industry; it is also one of the highest users of pesticides. In the lawn care industry alone, >906,000 lb of pesticides (active ingredients) were used in 1990. A proven way to commercially reduce pesticide usage while maintaining landscape quality is through Landscape Integrated Pest Management (LIPM) tactics; however, adoption of LIPM nationally has been slow. In 1994–95, a survey of 525 landscape contractors, arborists, groundskeepers, and turfgrass professionals was conducted to determine attitudes towards adoption of LIPM tactics. Customer perceptions, products utilized, educational needs, and attitudes toward alternative control tactics were assessed. Results show the majority of landscapers do not wish to spray pesticides, and do utilize good horticultural methods. However, purchasing traditional pesticide products that are cost-effective and proven are favored relative to environmentally "safe" and new. Concerns constraining LIPM adoption include potential for customer dissatisfaction, recovering monitoring costs, increased knowledge requirement for LIPM tactics, and fear of inadequate control.

879

Improved Control of the Main Pests in Pome-fruit Orchards of the Forest Steppe Zone in Ukraine

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The purpose of this research was to develop an improved system of controlling the main pests in pome-fruit plantations without damaging beneficial insects and with a minimal negative effect of pesticides. Current methods of controlling a broad spectrum of pests and diseases were studied. Several variants of spraying regimens were tested. It was established that most of the damage to the fruit is caused by coddling moth and, to a lesser degree, by pear fruit moth on the one hand and mildew and scab on the other. The most-effective and least-harmful spraying regiments were identified.

883

Effect of Floating Rowcover and Transparent Mulch on Insect Populations, Virus Diseases, and Yield of Muskmelon

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The effect of floating rowcover and transparent polyethylene mulch was evaluated on insect populations, virus disease control, yield, and growth of muskmelon (*Cucumis melo* L.) cv. Durango in a tropical region of Colima state, Mexico. Aphids (*Aphis gossypii* Glover and other species), sweetpotato whitefly (*Bemisia tabaci* Gennadius), beetles (*Diabrotica* spp.), and leafminer (*Lyriormyza sativae* Blanchard) were completely excluded by the floating rowcover while the plots were covered (until perfect flowering). Transparent mulch reduced aphids and whitefly populations, but did not show effect on leafminer infestation. The appearance of virus diseases of plants was delayed for 2 weeks by floating rowcover with respect to control (bare soil). Also, the transparent mulch reduced the virus incidence. The yield and number of fruit were positively influenced by floating rowcover and transparent mulch. Plot with transparent mulch combined with floating rowcover yielded nearly 4-fold higher (50.9 $t \cdot ha^{-1}$) than that plots with bare soil (13.1 $t \cdot ha^{-1}$). The yield from plots with floating row cover on bare soil was of 38.3 $t \cdot ha^{-1}$, while in the transparent mulch plots it was of 23.1 $t \cdot ha^{-1}$. The results of this work shows the beneficial effects of floating rowcover and transparent mulch in dry tropical conditions.

887

Potential of Plant Cystatins for the Production of Transgenic Strawberry Plants Resistant to the Black Vine Weevil

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Transformation of plant genomes with cysteine proteinase inhibitor (cystatin) genes represents an attractive option for the biological control of insect pests. However, this strategy must be carefully considered, because the transgenic plant endogenous proteinases may represent potential target enzymes for the exogenous inhibitors produced. For example, we are considering the transformation of strawberry (*Fragaria xananassa*) with cystatin cDNA clones, to control the Coleoptera pest black vine weevil (BVW; *Otiorynchus sulcatus*). Electrophoretic analyses of adult BVW proteinases have revealed the involvement of at least five proteinase forms for protein digestion, and the major form was strongly inhibited by oryzacystatins (OCI and OCII), two cystatins isolated from rice seeds. A similar analysis of proteinases showed the existence of OC-sensitive proteinase activity in the leaves of strawberry, suggesting a possible risk of interference of the inhibitors in the transformed plants. In addition, the two rice inhibitors were rapidly hydrolyzed at 25C when incubated with proteinase extracts from either young, mature or senescent leaves. An efficient control of BVW by plant cystatin-expressing transgenic strawberry plants is therefore potentially possible, but the correct targeting of the inhibitors in the plant cells using appropriate signal peptides could be necessary.

891

Chemical Control of the European Asparagus Aphid (*Brachycorynella asparagi* Mordvilko) in Northwestern Mexico

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Asparagus growers in the Caborca, Sonora, area consider disulfoton the only efficient insecticide for the control of the European asparagus aphid (EAA); therefore, this is the only insecticide used to control this pest. However, it is prohibited in Mexico. Therefore, during Fall 1991 in a commercial plantation of asparagus, six conventional and one microbial insecticides were evaluated. All the insecticides: chlorpirifos (480 g a.i./ha), dimethoate (400 g), malathion (2000 g), pirimicarb (375 g), oxamil (480 g), disulfoton (1000 g), and two doses of the fungus *Verticillium lecanii* (300 and 600 g) had a significant control ($P \leq 0.05$) in relation to the untreated check. However, chlorpirifos, malathion, disulfoton, and *Verticillium* (600 g) were more consistent, fast-acting, and registered from 90% to 100% control of the EAA for at least 51 days after application; 73 days after the application, control ranged from 16% to 57%, except oxamil, which registered 71% control.

895

Technical Feasibility of Pneumatic Control on Colorado Potato Beetle

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A front-mounted prototype designed to pneumatically remove Colorado potato beetles (CPB) from potato plants was tested in the field. Effects of different combinations of airflow velocities, nozzle widths, and travel speeds were investigated. Results showed that capture and dislodging of CPBs were better for adults and big larvae (L3 & L4). On the other hand, neither the airflow width and velocity nor the travel speed affected significantly the dislodging and the collection of small larvae. Field trials on the removal of larvae under the effect of different travel speeds showed that, the slower the prototype moved, the better was the collection of L3-L4 larvae. This study demonstrates the potential of pneumatic control of adult and L3-L4 CPBs.

899

Use of Propane Flamers in Potato Production

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We investigated the use of propane flamers in potato production. The thermal sensitivity of young potato plants and Colorado potato beetles (CPB) (eggs, larvae, adults) were determined in the laboratory and then validated in the field. The thermal treatment intensities for top killing prior to harvest were also determined both in the laboratory and in the field for three potato varieties and compared to chemical defoliant. The results obtained showed that young potato plants (0 to 10 cm) can recover from flaming treatments targeted against weeds and CPB early into the growing season. Effective thermal top killing is dependent upon potato variety (foliage density) and maturity level and inducement of sufficient temperature rise within the potato plant canopy to effectively control fall populations of CPB. A thermal strategy for weed and CPB control and top killing was elaborated and compared to chemical pesticides in term of operating costs.

903

Irrigation Affects Yield and Sweetpotato Weevil [*Cylas formicarius elegantus* (Summers)] Infestation of Sweetpotato

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A study was conducted to evaluate the effect of irrigation on yield and sweetpotato weevil (SPW) infestation of sweetpotato storage roots. Sweetpotato was grown in plots under controlled soil moisture regimes. The treatments were rain-fed (no applied irrigation) and irrigation applied to maintain soil moisture levels at 20, 40, and 60 kPa, based on tensiometer readings. The 40- and 60-kPa treatments produced the highest yield of root biomass. Irrigation applied at 40 kPa produced significantly more medium-sized storage roots (8.1 $t \cdot ha^{-1}$) than the rain-fed treatment, which produced 4.4 $t \cdot ha^{-1}$. All of the irrigation treatments produced significantly more marketable storage roots with a lower mean damage index (MDI) than the rain-fed treatment. There was an inverse relationship between MDI and soil moisture levels among the irrigation treatments. A significantly higher percentage of storage roots (51.5%) from the 20-kPa treatment were rated in the Damage Index (DI)-1 (uninfested roots) category than from the rain-fed treatment (27.7%). Additionally, the percentage (29.4%) of storage roots from the rain-fed treatment rated in the DI-6 (most severe) category was significantly higher than the applied irrigation treatments, with 13.9%, 13.9%, and 6.0% respectively, for the 60-, 40-, and 20-kPa treatments. Irrigation therefore has potential to increase sweetpotato yields while reducing SPW infestation levels.

907

Conditioning Treatments Affect Growth and Spider Mite Infestation of Greenhouse-grown Bedding Plants

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Two weeks after planting, plugs of New Guinea impatiens (*Impatiens* x *hybrida*), marigold (*Tagetes erecta*), or ageratum (*Ageratum Houstonianum*) were subjected to eight conditioning treatments: untreated, low N (50 ppm), high N (500 ppm), ebb/flow watering, drought, brushing (40 strokes twice daily), daminozide (5000 ppm), or paclobutrazol (45 ppm). Fertilizers were applied three times per week at 250 ppm N for all plants not treated with high or low N. Five adult twospotted spider mites were placed on each plant 1 week after treatment. New Guinea impatiens height was reduced by low N, brushing, or paclobutrazol at 4 weeks after treatment. Spider mite populations were reduced only by brushing. Marigold height was reduced by low N, drought, or brushing, but spider mite counts were reduced by brushing or paclobutrazol. Height of ageratum was reduced by low N, daminozide, or paclobutrazol, but spider mite counts were reduced by ebb/flow or brushing at 4 weeks after treatment.

911

Dispersal of *Perillus bioculatus*, a Stinkbug Predator of the Colorado Potato Beetle

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Predators and parasitoids used for biological control must possess good dispersal potential in order to ensure spatially uniform and cost-effective control. The rate of dispersal of *Perillus bioculatus* (F.) (Hemiptera: Pentatomidae), a predator of the Colorado potato beetle (*Leptinotarsa decemlineata),* was measured following central release in 0.025-ha potato plots. Factors influencing predator dispersal were also studied under controlled conditions in plant growth chambers. Temperature, predator size as affected by instar, and physiological age with respect to the completion of feeding during the intermolt stage were found to be significant factors. Predator density was also evaluated because of the strong tendency for this species to aggregate, thereby influencing dispersal. Results can be used to develop predictive models for inundative releases of *P. bioculatus.*

915

Effect of Blue Light on Flowering in *Dendranthema grandiflora* and Diapause Induction in *Orius insidiosus*

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Orius is an effective predatory bug of western flower thrips on chrysanthemum. However, long days are required to prevent reproductive diapause in *Orius*, which is counter to the short-day flowering response in *Dendranthema*. Two cut flower cultivars ('Manatee Iceberg' and 'Naples') and a pot cultivar ('Boaldi') were given short days, long days with broad spectrum light, and long days with supplemental blue light (430–480 nm) at critical threshold levels. Blue light at intensities of 2 to 5 $\mu mol \cdot m^{-2} \cdot s^{-1}$ had no effect on flower induction, size, or dry weight or leaf dry weight compared to the short-day control. Increasing intensity and blue light exposure reduced flowering in the cut mum cultivars. At 25C, 77% of *Orius* females were reproductive in blue light compared to 75% in broad spectrum and 46% in short days. Spectral quality had no effect on fecundity, survival, or insect development rate. At least 90% of *Orius* reproduced with blue light at 19, 22, 25, and 28C. These results indicate possibilities for providing favorable conditions for biocontrol of arthropod pests on short-day crops.

919

Effect of Soybean Oil on Photosynthesis and Aphids of Apple

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Four-year-old 'Gala' and 'Widjit' apple trees with significant apple aphid populations were sprayed to runoff on 13 May 1994 with 0%, 0.5%, 1.0%, or 2.0% (v/v) emulsified degummed soybean oil (SO) or with 1.0% petroleum (dormant) oil (PO). Treatments were arranged in a randomized complete-block design with five single-tree replications. Apple aphid populations were determined on 10 tagged shoots per tree. The top fully expanded leaf of two randomly selected shoots per tree were tagged and net photosynthesis (Pn) and transpiration (Tr) measured. Trees treated with SO or PO had <20% as many aphids after treatment as nontreated trees. Trees treated with 2% SO had lower Pn and Tr than the control for 18 days after treatment. Spraying 0.1% or 0.5% SO caused less initial reduction of Pn than 2.0% SO, and the effect was shorter lasting. Four-year-old 'Oregon Spur' and 'Empire' were sprayed with 0%, 0.1%, 0.5%, 1.0% SO or PO on 26 June. Treatments were arranged in a randomized complete-block design with four single-tree replications. Pn rates of trees treated with 0.1% to 1.0% soybean oil were <40% of nontreated trees the day after treatment, but recovered to >80% of control in 5 days.

923

An Outbreak of a New Whitefly in Guam

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The outbreak of a new whitefly was first reported in Summer 1993 at two sites in the southern part of Guam. Vegetable crops heavily damaged by this pest included cucumber, yardlong beans, and tomato. At present, the whitefly is found infesting tomato, eggplants, cucumbers, watermelon, and other vegetable crops throughout the island. The whitefly was identified as *Bemisia argentifolii* with the characteristics of a wide host range and the presence of silvering leaves on cucurbits. A larval parasitoid was recovered from eggplant and tomato leaves. The efficacy of pesticides against the pest is being investigated.

927

Zucchini Yellow Mosaic Virus in Colima, Mexico: Effect on Flowering and Yield of Muskmelon and Transmission by Aphids

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Zucchini yellow mosaic virus (ZYMV) infection causes heavy losses in cucurbit crops grown in the Mediterranean, Central Europe, the United States, and Mexico. Recently, ZYMV was found affecting muskmelon (*Cucumis melo* L.) in Colima, Mexico. An experiment was carried out under dry tropical conditions with the objectives: 1) to determine the effect of ZYMV on flowering and yield of muskmelon cv. Primo, and 2) to evaluate its transmission by some aphid species. Perfect and staminate flowers were significantly reduced when ZYMV was inoculated during vegetative growth, flowering, and fruit set. ZYMV affected yield when it was inoculated from vegetative growth to flowering and fruit set. In plants inoculated during vegetative growth the yield was null, while those inoculated at early flowering and fruit set the yield was reduced by 80% and 49%, respectively. The yield was not affected when ZYMV was inoculated on fruit growth. The aphid *Myzus persicae*, *Aphis gossypii*, *A. spiraecola*, and *Uroleucon ambrosia*-transmited ZYMV from *Cucurbita pepo* to *Cucumis melo*; but *Aphis nert*, did not.

931

Development of a Decision Support System for the Management of the Carrot Cercospora Blight

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In Quebec, the carrot Cercospora blight represents a major foliar disease. In carrot fields, it causes reductions in yields of up to 30%. The evolution of this disease can be predicted by considering the meteorological and biological parameters and by using expert knowledge. Disease management can be enhanced through the use of a computerized decision support system (DDS). The objectives of the project were: 1) to define a conceptual framework for the operation of a carrot protection module, 2) to integrate a model of Cercospora blight evolution within the framework, 3) to integrate and structure the information needed for the consultation of the DSS, and 5) to validate the recommendations of the module. The various components (knowledge base, database, simulation model) constitute an extension to an existing framework used for agricultural production management (SAGE). The latter is built using an object-oriented programming language (Smalltalk) and an object-oriented database management system. A fully operational version of the system was developed and will be tested during the summer of 1995. The developed system combines a Cercospora blight model and a set of rules that convey the expert's knowledge. These rules were formulated based on interviews with the expert. The nature and organization of the rules will be presented as well as a critical evaluation of the methodology and tools used to build the system.

935

The Effect of the Fungicides Metalaxyl and Fosetyl-Al on Root Rot (*Phytophthora cactorum*) of American Ginseng (*Panax quinquefolium*) in the Greenhouse

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Ginseng seedlings were inoculated with *Phytopthora cactorum* by dipping their roots for 5 min in a suspension of 10^5 zoospores/ml. Inoculated plants were repotted and grown under shade in the greenhouse. In various experiments, fungicides were applied 1 week before inoculation, at the time of inoculation, 2 days after inoculation, or a combination of the first two of these. Treatments included fosetyl-Al applied as a foliar spray until run-off at a concentration of 2.5, 5.0, or 10 g a.i./liter of water or as a soil drench containing 0.25, 0.5, or 1.0 g a.i./100 ml water per plant and metalaxyl applied as a soil drench containing 5 or 10 mg a.i./100 ml of water per plant. The treatments with fosetyl-Al as a spray did not reduce root rot ratings, but fosetyl-Al applied as a drench significantly reduced root rot ratings at all three concentrations when applied at inoculation. The best control was achieved using metalaxyl at either 5 or 10 mg a.i./plant applied either at inoculation or both 1 week before inoculation and at inoculation.

939

Toxicological Assays in *Bemisia tabaci* (Genn.) from Cabbage Plots in La Paz, Baja California Sur, Mexico

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The sweetpotato whitefly [*Bemisia tabaci* (Gennadius)] has become a high-risk insect pest in Mexico as well as in other countries, causing serious damage to several crops. Control of whitefly in Baja California Sur, ,Mexico, is usually done by intense insecticides applications, either alone or in mixtures of several kinds. The aim in this work was to determine its susceptibility to cypermethrin, endosulfan, methamidophos, and methyl-parathion. LC_{50} was obtained to identify the resistant and susceptible populations. A group of 20 whiteflies were introduced in a 20-ml scintillation vial coated in the inner surface with a known concentration of the insecticide. Mortality readings were obtained 3 h after exposing the insects to the residual activity at five concentrations. Five replications and control were run in different consecutive days for each bioassay. Results indicated that cypermethrin was the most toxic to *B. tabaci* and metamidophos the least. Data will be considered for further evaluations.

0943

Reducing Deer Damage to Woody and Herbaceous Plants

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Woody and herbaceous plants in urban and rural landscapes, nurseries, orchards, and Christmas tree plantations are becoming increasingly susceptible to deer damage. Most existing repellents are either ineffective, or are effective for short periods of time. This project presented four plant species treated with chicken eggs, Deer-Away, Hinder, Tree Guard, Milorganite, chicken eggs with Tree Guard, and chicken eggs with Transfilm, to 20 captive white-tailed deer (*Odocoileus virginianus*). Only chicken eggs alone and Deer-Away deterred deer from feeding on the containerized nursery stock. Chicken eggs alone performed significantly better than Deer-Away. In a second experiment, pelletized deer food treated with Deer-Away, Hinder (1:1 and 1:5), Tree Guard, Miller Hot Sauce (0.62% and 6.2%), and two experimental predator urines were presented to ten captive deer. Both rates of Miller Hot Sauce and predator urine #1 significantly reduced deer feeding on pelletized deer food. Deer-Away, Hinder 1:1, and predator urine #2 also reduced feeding. Hinder 1:5 slightly reduced feeding. Tree Guard was completely ineffective.

947

Leaf Phenolic Variation in *Malus* sp.

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The leaf phenolic content of 25 *Malus* species obtained from the National Germplasm Repository was evaluated. Two methods were utilized for determination of phenolic quantity and form. Total dihydroxy phenolic content was determined by spectrophotometric method using diphenlboric acid 2 aminoethyl ester as the reagent. These phenolics were quantified by using HPLC. Differences in phenolic quantity and type among the species were observed. This variation will be discussed in relation to apple–insect interactions.

951

Native Sand-prairie Plants That are Poor Hosts for *Pratylenchus penetrans*

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Root lesion nematodes (*Pratylenchus penetrans* Cobb) are well-adapted to sandy soils and have a host range including most agronomic, horticultural, and wild species grown in Ontario. As native climax sand-prairie species have coexisted with the nematode for millennia, resistance or tolerance may have developed. We have screened using the Baermann pan technique, soil samples taken from a private collection of sand-prairie species collected from local prairie remnants. Several species [*Liatris cylindracea* Michx., *Monarda punctata* L., *Pycnanthemum virginianum* L., *Echinacea purpurea* (L.) Moench] proved to be excellent hosts (>500/kg of soil) of root lesion nematode, confirming the presence of this nematode in the soil. Over two seasons, we determined that 10 plant species belonging to the families Asclepiadaceae, Compositae, Graminae, and Leguminosae to support very low numbers of *P. penetrans*. Brown-eyed susan (*Rudbeckia hirta* L.) had no root lesion nematodes throughout both seasons, Butterfly weed (*Asclepias tuberosa* L.) very low counts, while Switch grass (*Panicum virgatum* L.) and Indian grass [*Sorghastrum nutans* (L.) Nash] had detectable root lesion nematodes on only one sampling date each year. Big Bluestem (*Andropogon gerardii* Vitman), Little Bluestem [*Schizachyrium scoparium* (Michx) Nash], Sand Dropseed [*Sporobolus cryptandrus* (Torr.) Gray], Side-oats Grama [*Bouteloua curtipendula* (Michx.)) Torr], Broomsedge (*Andropogon virginicus* L.), Bush clover [*Lespedeza capitata* (Michx] also are poor hosts. These species have potential as cover or rotation crops useful for nematode management.

955

Evaluation of Onion Lines for Resistance to Onion White Rot and Onion Maggot

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Onion lines were evaluated for resistance to Allium white rot (*Sclerotium cepivorum* Berk.) and onion maggot [Delia antigua (Meig.)] in field plots established on organic soil in the Bradford Marsh, Ontario. White rote valuations were conducted on 20 lines in 1992–1994, with follow-up laboratory trials in 1995.

Onion maggot screening was conducted on these same lines in 1993 and 1994. Plots were arranged in a randomized complete-block design with four replications per line. Significant differences in susceptibility to white rot were found in 1992 and 1993, while differences in onion maggot resistance were identified in 1993 and 1994. Commercial cultivars Norstar and Fortress had relatively low levels of onion maggot damage and Fortress demonstrated some tolerance to white rot. Other lines with low levels of white rot infection were 1292-91, 1564-91, 124-93, 116-93, and 117-93, from the breeding program at the Univ. of Wisconsin. Line 1292-91 also had low levels of onion maggot damage. The horticultural characteristics of the onion lines will be discussed.

65 POSTER SESSION 7 Breeding/Fruits & Nuts

412

Quality Characterization of *Fragaria* Cultivars and Selections

Shiow Y. Wang, Gene J. Galletta,* and *John L. Maas*, Fruit Laboratory, BARC, ARS, USDA, Beltsville, MD 20705.

Fruit quality of 24 selected strawberry cultivars and selections were evaluated. There were great variations in the contents of soluble solids, titratable acidity, carbohydrates, organic acids, and ascorbic acid among different cultivars, reflecting primary genetic differences. Fructose, glucose, and sucrose were found to be the three major sugars, comprising >65% of the total soluble solids in strawberry. Fruit contained lower sucrose compared to fructose and glucose, whereas leaves contained comparable amounts of fructose, glucose, and sucrose. Citric acid was the major organic acid in strawberries. Strawberries were also rich in ascorbic acid. Leaves were much higher in ascorbic acid than fruit. There appeared to be no correlation between fruit and leaves on carbohydrate, organic acid, and ascorbic acid contents.

416

Bacterial Angular Leafspot Disease of Strawberry: Search for Resistance

*John L. Maas** and *Gene J. Galletta*, USDA/ARS, Fruit Laboratory, Beltsville, MD 20705.

Bacterial angular leafspot disease (BALD) of strawberry, caused by *Xanthomonas fragariae,* a slow-growing and often difficult pathogen to isolate from infected plants, is most commonly manifested as small discrete, angular, translucent lesions on leaves and sepals. As the bacteria infect systemically, plants may wilt and die. BALD has become increasingly important in North America and other strawberry-growing areas of the world. The systemic nature of the pathogen also is cause for concern with international shipment of strawberry plants, especially because there is no practical method for determining the presence of the bacteria in symptomless, infected plants, nor is there a practical method of chemical control. All cultivars of *Fragaria* x *ananassa* (8x) are susceptible to BALD, although a range of susceptibility is often apparent in plantings. Resistant genotypes have been reported among clones of *F. virginiana* (8x), *F. moschata* (6x), and *F. vesca* (2x). A program has been initiated to evaluate native octoploid and diploid strawberry germplasm for resistance to BALD.

420

Leaf Essential Oil Composition of Selected Strawberry Cultivars with Different Degrees of Susceptibility to Two-spotted Spider Mites

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Considerable variability in susceptibility to two-spotted spider mite (TSSM) were observed for the strawberry cultivars used as parents and some of our promising selections. Large variation was observed for 9-octadecenal oil composition followed by linalool, $C_9H_{10}0_2$, decanal, β-cyclocitral, α-terpineol and (Z)-3-hexenol. The purpose of this research was to identify the relative susceptibility of selected strawberry lines to TSSM in relation to leaf essential oil composition. One objective of our breeding program is the early identification of susceptible lines and/or seedlings so that they can be eliminated prior to field trials.

424

Benzyladenine and Gibberellic Acid (GA_3) Increase Runner Production in Day-neutral Strawberries

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Day-neutral strawberries produce runners less freely than June-bearing strawberries, which leads to reduced production in nursery fields. To alleviate this, a series of experiments were done to test how effectively benzyladenine (BA) and gibberellic acid (GA_3) increased runner production. In greenhouse tests with the varieties 'Tribute' and 'Selva' and in field trials with 'Selva', the combination of BA and GA_3 consistently increased runner production in day-neutral strawberries, but not alone. Runner production increased linearly with BA dosage to 1800 ppm. GA_3 produced very elongated internodes at high dosages, which led to fewer daughter plants in the field. Twelve-hundred ppm BA and 300 ppm GA_3 are recommended as suitable concentrations to induce runnering both in the field and greenhouse.

428

Characterization of *Rubus* Germplasm at the Canadian Clonal Genebank

*P.J. Macdonald** and *Margie Luffman*, Canadian Clonal Genebank, Agriculture and Agri-Food Canada, Box 340, Trenton, Ont., Canada K8V 5R5.

A collection of indigenous North American red raspberry (*Rubus strigosus* Michx.) was evaluated in an unreplicated field planting at the Canadian Clonal Genebank, Trenton, Ont. The accessions originated in British Columbia (B.C.) and the United States. Useful characteristics in the collection have been identified under B.C. conditions; however, field performance in Ontario has not been reported. Cultivars originating from B.C., Manitoba, and Ontario were included in the planting as standards. Overwintering injury ranged from slight to severe. Indigenous accessions were vigorous, with cane height comparable to standards; however, in some cases, primocane production was excessive. Most B.C. accessions flowered and fruited equivalent to, or earlier than, the earliest cultivar ('Boyne'), while *R. strigosus* from other locations were mid-season to late. Primocane fruiting was typical in B.C., but was not consistent in Ontario. Fruit were small, but had good color and structure. Accessions showed resistance to powdery mildew [*Sphaerotheca macularis* (Wallr.:Fr.)], but were very susceptible to late yellow rust [*Pucciniastrum americanum* (Farl.) Arth.].

432

Chemical Profiles of Lowbush Blueberry Clones

*W. Kalt** and *J. McDonald*, Agriculture Canada Research Centre, Kentville, NS Canada B4N 1J5.

Sugars, pigments, and organic and phenolic acids were examined in three name clones of lowbush blueberries (*V. angustifolium* Aiton) during two seasons. Between the two seasons, glucose and fructose content was not different, but anthocyanin content differed by 40%. Also, titratable acidity differed by 40%, and total acid content (as measured by HPLC) by 60%. Differences in total acid content between the two seasons could be attributed to changes in some, but not all, acids. Acid content of berries of different maturities suggested that some, but not all, acids decreased as fruit ripened. Although the acid profile was different in the 2 years of the study, overall the lowbush blueberry profile was distinct from that recently reported for highbush and rabbiteye blueberries [Ehlenfeldt et al., HortScience 29(4):321–323]. Succinic acid was absent in lowbush fruit, and there was a higher level of quinic acid than found in highbush or rabbiteye blueberries. Citric acid was present in lowbush fruit at a level intermediate between the other *Vaccinium* species.

436

'Black Ruby', a Japanese-type Plum Adapted to the Humid Southeastern United States

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'Black Ruby' is the newest plum released by the USDA stone fruit breeding program at Byron. This variety has large, firm fruit that ripens in early July, about 1 week after 'Santa Rosa'. Fruit has reddish-black skin and yellow flesh. Eating quality is very good. 'Black Ruby' has an upright tree similar to 'Santa Rosa', except that tree health and vigor are much better than 'Santa Rosa'. USDA has been breeding plums for the humid Southeast for 30 years. Goals are to combine

large, firm, high-quality fruit with a disease-resistant tree that will live 8 to 10 years. Most plum varieties are short-lived in our area due to disease caused by *Xanthomonas*, *Pseudomonas*, and *Xylella*. Most existing varieties adapted to our climate have fruit unsuitable for commercial production. Previous USDA releases include "green plum" types 'Robusto' (1980) and 'Segundo' (1984); a yellow plum, 'Byrongold' (1985); a black shipping plum, 'Explorer' (1980); and the blood-fleshed, high-quality 'Rubysweet' (1989).

440

Sensory Evaluation of Fruit Quality in an Apple Breeding Program

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Overcoming bias in fruit quality evaluation is a challenge to fruit breeders, who must predict consumer preferences; databases of accurate fruit descriptions would be invaluable in helping them make selections to suit market needs. In order to obtain as informative a description as possible, plant breeding staff worked with sensory science personnel to define and quantify the appearance, flavor, and texture sensations they were experiencing when evaluating apples. Ten visual properties, nine flavor attributes, and nine texture characteristics were identified by evaluators; these were then clearly defined and reference materials representing the range of values found in apples were chosen as benchmarks. After screening and a brief training, nine people are now carrying out evaluations for the breeding project. In order to streamline the procedure, after two seasons of use the attributes are being examined for the usefulness in discriminating between genotypes.

444

Preconditioning Effects of Proliferation Medium on Adventitious Regeneration of Pear

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Preconditioning effects of cytokinin in the shoot proliferation medium on explant quality and subsequent adventitious regeneration of 'Bartlett' and 'Beurre Bosc' pear were investigated. The basal medium for regeneration consisted of half-strength MS macro- and micronutrients, MS organics, 30 g·liter^{-1} sucrose, 6 g·liter^{-1} agar, and 10 μM thidiazuron (TDZ), and 1 μM NAA. Leaves from BAP medium were more effective than those from media with 2-iP or kinetin in spite of the increased leaf size of shoots cultured with 2-iP (28% vs. 10%). Use of leaves from in vitro-rooted shoots did not increase regeneration frequency (19.5% vs. 31%) of 'Bartlett'. Actively expanding leaves are more suitable explants than larger, fully expanded leaves. Liquid medium overlays and incubation in liquid medium decreased regeneration frequency when compared with agar-solidified medium. Among auxins in regeneration induction phase media, IBA (0.5 or 1.0 μM) resulted in greater regeneration than NAA.

448

Examination of Apple (*Malus* x *domestica*) Fruit Quality and Tree and Fruit Morphology using Molecular Markers

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Two half-sib populations (cross 1 = 'Wijcik McIntosh' (WM) x NY 75441-67, and cross 2 = WM x NY 75441-58) were used to create maps for the parents and to find RAPD or isozyme markers for qualitative and quantitative traits. WM is a sport of 'McIntosh' and is heterozygous for the dominant columnar (*Co*) gene for reduced branching. WM is of great interest in breeding because of the tremendous effect of the *Co* gene on many aspects of plant form. NY 75441-67 and NY 75441-58 are advanced selections with commercial fruit quality and resistance to scab (V_f resistance from *M. floribunda*). Traits examined included both tree (plant height, stem diameter, suckering, branching habit, leaf break, burr knot production) and fruit (size, shape, color, stem length, seed number) characters and fruit quality traits (pH, acid content, Brix). The conservation of RAPD markers in these closely related crosses will be examined and the usefulness of molecular markers to preselect for components of plant form and fruit quality will be discussed. Molecular markers will increase the efficiency of the apple breeding program by aiding the understanding and manipulation of complex genetic traits.

452

'Platonivs'ka': A New Scab-resistant and Cold-hardy Pear Cultivar

Anatoliy Kucher[1]* and *Raymond L. Granger[2]*, [1]The L.P. Simirenko Horticultural Research Inst. of Mliyv, Mliyv-1, Horodysche r-h, Cherkassy obl., 258532 Ukraine; [2]Agriculture and Agri-Food Canada, Horticultural R&D Centre, 430 Gouin Blvd. St-Jean-sur-Richelieu, Quebec, Que., Canada J3B 3E6.

'Platonivs'ka' has been released as a new autumn pear cultivar that combines scab (*Venturia pirina* Aderh.) resistance and cold hardiness under Ukrainian climate and soil conditions, selected from a cross of 'Hybrid 1931' ('Oleksandrivka' x 'Dekanka du Comice') x Beurré Bosk. The trees grow vigorously, are adequately winter-hardy, and resistant to both leaf and fruit scab. Very good tree productivity has been observed when 'Platonivs'ka was grafted on Limonska Oleksandrivka, Wild Forest Pear, Quince A, or BA-29 rootstocks. The fruit attains its picking ripeness between 10 and 20 Sept. (2 weeks after 'Bartlett') and eating ripeness between the beginning and end of October in Ukraine. Its storage life at 0 to 2C lasts until the end of January. The average weight per fruit ranges between 180 and 200 g (70–75 mm in diameter). The fruit eating quality is excellent; its juicy and pleasant sugar/acid ratio makes it a very good dessert pear. Fruits are ovate-pyriform in shape. Their skin color is light grayish-green and their finish is glossy at harvest. Flesh texture is moderately find and buttery. At harvest, grit cells are small and evenly distributed in the flesh and they become inconspicuous when the fruit is held at 20C for a week. 'Platonivs'ka' is recommended for both home and commercial orchards.

456

Seedling Reaction of *Prunus* Accessions to Crown Gall

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Crown gall incited by *Agrobacterium tumifaciens* is an important problem for nursery and field production of stone fruit and nut crops. Genotypes reportedly differ for crown gall reaction, but there is little information about resistance of *Prunus* accessions used as rootstocks. From among four wild-type strains of *A. tumifaciens*-virulent on apricot and almond, K12 was selected for inoculation of 6-month-old seedlings of cherry, plum, peach, almond, apricot, and miscellaneous species. The large majority of seedlings were very susceptible to crown gall, but some had few or no galls. Cherry, especially some lines of *P. mahaleb*, showed the most resistant or moderately resistant seedlings, while some accessions of plum, especially *P. cerasifera*, *P. angustifolia*, and *P. insititia* had the most resistant seedlings. Plants with different reactions were propagated to determine adult plant resistance and to study the heritability of crown gall reaction.

460

Incompatibility Alleles of Hazelnut Cultivars

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Incompatibility in hazelnut (*Corylus avellana* L.) is of the sporophytic type and is under the control of a single S-locus with multiple alleles. Tests in recent years have identified four new alleles, bringing the total to 26. Improved pollen testers have been identified for several alleles. The S-alleles of more than 90 cultivars have been identified by fluorescence microscopy and will be presented. These cultivars (and their alleles) include Tonda di Giffoni (2 23), San Giovanni (2 8), Gasaway (3 26), Gunslebert (5 23), Kadetten (20 25), Lang Tidlig Zeller (4 20), Nocciolino Sangrato (7 17), Rode Zeller (6 11), Segorbe (9 23), and Simon (6 22).

464

Promising Cultivars of *Prunus divaricata* for the Central Forest-Steppe Zone of Ukraine

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Prunus divaricata has attracted attention as a commercial culture only recently, but it is in the process of becoming a valuable fruit culture in Ukraine, where it has been planted in an area of >3000 ha. *P. divaricata* bears fruit earlier during the 2nd or 3rd year after planting. Its fruits ripen earlier than that of plums and are consistently abundant, fairly large, of high-quality, rich in vitamins, and easy to transport. These fruits can be eaten fresh or processed The trees have a short dormancy period, which may account for their relatively poor winter-hardiness. The root system of *P. divaricata* is shallow and mainly located at a depth of

50 cm from the soil surface. Its vertical roots, however, reach a depth of 2 m or more. The young roots may freeze at ≈12C. However, winter hardiness of the different cultivars varies and is determined by their origin. *P. divaricata* blooms early, roughly at the time when the flowering of early apricots ends. Its flowers are less susceptible to late frosts than those of apricots. For pollination, three or four different cultivars are needed. Yields ranging from >70 to 80 kg have been reached at the seventh leaf stage with the following cultivars in central Ukraine: 'Olen'ka', 'Obil'na'', 'Raketa', 'Zhemchuzhyna', and 'Vasylius'ka' (control standard).

468

Relationships of Fruit Development Period, Seed Germination, Seedling Survival, and Percent Dry Weight of Ovule in Peach

*T.A. Bacon** and *D.H. Byrne*, Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133.

A study was conducted on various peach [*Prunus persica* (L.) Batsch.] cultivars to determine the relationships among seed germination, seedling survival, seedling rosetting, fruit development period (FDP), and percent dry weight of the ovule (PDO). Germination and survival increased rapidly between 80 and 100 days of FDP, corresponding to an increase in mean PDO from 16% to 50%. Germination and survival leveled off after 105 days of FDP at >85%, corresponding to a mean PDO of 64%. Rosetting was high among seedlings for cultivars with FDP <110 days, but dropped rapidly as FDP increased. PDO was found to be a better indicator of seed germinability and seedling survival than FDP.

472

Moderate-chilling Peach Breeding Project for the Coastal Plain of the Southeastern United States

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The purpose of this three-way cooperative project is to develop new fresh-market peach and nectarine varieties in the 400 to 650 chill hour range for the early season shipping market. Since 1990, >3000 seedlings have been evaluated, resulting in 48 selections. Additionally, several hundred selections from other programs have been evaluated. 'Sunsplash', an attractive, early season, 400 chill hour nectarine, was released in 1993 as a result of this cooperative effort. A novel aspect of the program has been the use of non-melting flesh parents for the purpose of improving handling characteristics. Selections include both yellow- and white-flesh types, peaches and nectarines. Some may be adapted for use in other production areas and are available for testing under non-propagation agreement. Evaluation summaries of selections and standards will be presented.

476

Identification of a RAPD Marker Linked to Eastern Filbert Blight Resistance in Hazelnut

*Joel W. Davis** and *Shawn A. Mehlenbacher*, Dept. of Horticulture, Oregon State Univ., Corvallis, OR 97331.

Eastern filbert blight (EFB) is a serious disease of hazelnut and threatens crop production in the Willamette Valley of Oregon. We have employed the use of the bulk segregant analysis method to screen RAPD primers for identification of a marker linked to a disease-resistance gene for this pathogen. Using 100 progeny from a modified backcross population segregating for resistance to the disease, two pooled DNA samples from 10 individuals of each phenotype were constructed. One-hundred 10-mer PCR primers were screened for bands present in the resistant pool, but absent in the susceptible pool. We identified one primer that produces a marker cosegregating with resistance and appears to be linked to the resistance gene (frequency of recombination = 0.17). This marker proved to be easily scoreable and reliably reproduced, even under varying amplification profiles. From these results, we have determined that this method may be suitable for identification of markers more closely linked to the resistance gene. Such a marker would be useful for early selection of seedlings having resistance to EFB.

480

Inheritance of Dwarfness in Hybrids of Chinotto Sour Orange

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Chinotto is a selection of sour orange (*Citrus aurantium* L.) with short internodes and small leaves and fruit. Mature fruiting trees of Chinotto grafted on standard rootstocks produce healthy, but dwarf, trees. Most seedlings recovered from Chinotto fruit are of nucellar (maternal) origin and will faithfully grow to reproduce the Chinotto genotype and phenotype. Vigorous greenhouse-grown nucellar seedlings of Chinotto have internodes 5 to 10 mm in length and leaves 30 to 40 mm in length, about 30% the dimensions of the corresponding organs on standard sour orange nucellar seedlings. Sexual hybrids with Chinotto have been produced by controlled crosses with several other parents. Some hybrids with shortened internodes and small leaves were recovered among all hybrid progenies, regardless of whether Chinotto was used as seed or pollen parent. In some cases, segregation among Chinotto hybrids was about 1 normal : 1 dwarf. In other progenies, some intermediate forms were recovered along with normal and dwarf plants.

484

Rubus Genetic Resources in Bolivia

James R. Ballington[*1], Wes Messinger[2], David F. Williams[3],* and *Emilia Garcia*[4], [1]Dept. of Horticultural Science, North Carolina State Univ., Raleigh, NC 27695-7609; [2]Dept. of Botany and Plant Pathology, Oregon State Univ., Corvallis, OR 97331 [3]USDA/ARS, National Germplasm Resources Laboratory, Beltsville, MD 20705; [4]National Herbarium of Bolivia, La Paz, Bolivia.

Intermountain valleys in the Andean region of Bolivia are rich in diversity of *Rubus* species. Species in both subgenus *Orobatus* and subgenus *Rubus* occur in this region. These species include *Rubus betonicifolius*, *R. bogotensis*, *R. Boliviensis*, *R. briaceus*, *R. holtenii*, *R. imperialis*, *R. macrocarpus*, *R. megalococcus*, *R. nubigenus*, and *R. roseus*. *Rubus macrocarpus* and *R. roseus* have previously been determined to be worthy of domestication and commercialization as new crops in tropical highlands. The potential of the other species as new bramble crops and for use in breeding will be discussed.

488

Variation in Reproductive Traits of Western Trailing Blackberry (*Rubus ursinus*) in the Pacific Northwest

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The superb flavor of trailing blackberry cultivars, such as 'Marion', is derived from *Rubus ursinus* Cham. & Schlecht. Wild *R. ursinus* offer a range of horticulturally desirable traits to breeders, from high fruit quality to improved cold hardiness. Current cultivars are derived from relatively few sources of *R. ursinus*, selected primarily for fruiting characteristics. A replicated field trial of 460 clones, representing 20 populations from southern British Columbia, Washington, and Oregon, was established in 1994. Observations during the planting year have indicated that monitoring variability in the following reproductive traits will be useful in assessing diversity; budbreak, flowering, and fruiting date; lateral length; proportion of reproductive laterals; gender; flower and fruit number; and fruit size. In particular, there are clones that exhibit large fruit size (4 to 5 g), high flower number per lateral, and uniform fruit set. Analysis of these data will contribute to determination of relative genetic distances among the populations and enhance the understanding of the diversity available in *R. ursinus.*

492

Distinguishing Pacific Northwest Red Raspberry Cultivars using RAPD Markers

*Patrick P. Moore**, Washington State Univ. Puyallup Research and Extension Center, Puyallup, WA, 98371.

Randomly amplified polymorphic DNA markers (RAPDs) were used to distinguish among seven Pacific Northwest red raspberry (*Rubus idaeus* L.) cultivars. Random 10-base sequences were used to distinguish among 'Chilcotin', 'Chilliwack', 'Comox', 'Meeker', 'Qualicum', 'Tulameen', and 'Willamette'. The seven cultivars could be distinguished even though there is considerable relatedness among the cultivars. 'Chilliwack' and 'Comox' share 'Skeena' as a parent, and 'Chilliwack' is a parent of 'Qualicum'. 'Willamette' is a parent of 'Meeker'. This technology shows promise as a means of distinguishing cultivars and developing a genetic map to aid in breeding.

496

Chromosome Numbers of *Rubus* Accessions in the USDA/ARS National Clonal Germplasm Repository, Corvallis, Ore.

*Maxine M. Thompson** and *Kim E. Hummer*, USDA/ARS National Clonal Germplasm Repository, 33447 Peoria Rd., Corvallis, OR 97333.

Chromosome numbers were determined for the *Rubus* species and cultivars

held at the USDA/ARS National Clonal Germplasm Repository, Corvallis, Ore. Counts were made on a total of 205 taxa; 81 of which were new, 124 were corrections, and a few were corrections of previous reports. The numbers ranged from 2n = 2x = 14 to 2x = 98, and included odd-ploids and aneuploids. Knowledge of the chromosome number of a plant is important for its use in breeding because of potential sterility problems that may arise due to unbalanced gametes. The value of these particular counts are that they are vouchered by a permanent, living plant collection that is available to the scientific user community.

500

Use of Epifluorescent Microscopy to Observe Development of *Plasmopara viticola* on Grape Leaf Disks

Maurus V. Brown, James N. Moore, William M. Harris, and Patrick Fenn*, Dept. of Horticulture, Univ. of Arkansas, Fayetteville, AR 72701.

Calcofluor and berberine were used to determine the potential of epifluorescence microscopy to observe the interaction between grape leaves and *P. viticola*. Leaf disks (10 mm in diameter) were inoculated and incubated for 2, 4, and 7 days. Disks were stained with berberine at 0.1% for 1 h, rinsed, placed in 0.1 M Tris (pH 5.8) for 15 min, stained in calcofluor at 0.1% for 25 min, and rinsed. Disks were mounted abaxial side up in 30% glycerin and viewed with an epifluorescence microscope. Various leaf features (e.g., trichomes, stomates) were distinguishable from the fungal structures (e.g., hyphae, sporangiophores). Leaf surface colors were red, orange, brown, green, and yellow, and fungal structures were light to dark blue. Epifluorescence microscopy was a useful means of differentiating leaf and fungal structures.

504

Performance of Advanced Breeding Selections of Primocane-fruiting Raspberries in New Jersey

Joseph A. Fiola, Robert Lengyen,* and *Harry J. Swartz*, Rutgers Fruit R&E Center, Cream Ridge, NJ, 08514.

A major objective of the MD/NJ/VA/WI Cooperative Raspberry Breeding Program is to develop new primocane-fruiting raspberry cultivars that are early, with large fruit size, and good fresh flavor, relative to the 'Heritage' standard. Step I seedling selections were made and tissue culture-propagated. The Step III advanced selection trial, planted in 1993, consisted of two advanced selections, JCR-F1 [Geo-1 (Autumn Bliss x Glen Moy) x Heritage–red], and JEF-B1 (Amity x Glen Eagles–golden), with a 'Heritage' check. The planting was a RCB (four replications), with 3-m plots, 60-cm plant spacing, on raised beds with black plastic mulch (establishment year), and trickle irrigation. The 1994 season started dry, and mid-summer was warm and wet, inducing an early harvest overall. JCR-F1 was >2 weeks earlier, 40% higher yielding, with 18% larger fruit size than 'Heritage'. JCR-F1 fruit was tall conic, cohesive, and had good flavor; plant vigor was very good. JEF-B1 was 10 days earlier than 'Heritage', had 40% larger fruit size, but was 25% lower yielding; plant vigor was also good. The flavor was described as banana and apricot. The planting will be fruited for multiple seasons for continued comparison.

508

Blackberry Cultivars Differ in Susceptibility to Rosette Disease

Blair Buckley, III[1], James N. Moore[2],* and *John R. Clark[2]*, [1]Calhoun Research Station, Louisiana Agricultural Experiment Station, LSU Agricultural Center, Calhoun, LA 71225; [2]Dept. of Horticulture, Univ. of Arkansas, Fayetteville, AR 72701.

Rosette, incited by *Cercosporella rubi* (G. Wint.) Plakidas, is the most severe disease of blackberries in the southern United States. Sixteen blackberry cultivars and breeding selections were evaluated in a field test over a 3-year period for incidence and severity of rosette. Test plots were planted in a randomized complete block design with four replications. A plot consisted of a 3-m hedgerow of blackberry canes. Each test plot row was bordered on each side by a row of the rosette-susceptible cultivar Shawnee. Disease ratings were conducted on five random floricanes in each plot. Disease severity was rated with a 1 to 8 scale (1 = 0% floricane nodes with rosettes, 2 = 0% to 10%, 3 = 10% to 25%, 4 = 25% to 50%, 5 =50% to 75%, 6 = 75% to 90%, 7 = 90% to 100%, 8 = 100%). 'Shawnee' and 'Rosborough' had high incidence and severity. Cultivars and selections with moderate-high incidence and low-moderate severity were 'Brazos', 'Cheyenne', 'Choctaw', A-1260, A-1442, A-1560, and A-1585. Cultivars and selections with zero-low incidence and severity were 'Arapaho', 'Humble', 'Navaho', A-1374, A-1594, A-1616, and A-1617.

512

Twospotted Spider Mite Presence on 40 *Rubus* Species.

*Chad Finn** and *Kirsten Wennstrom*, USDA/ARS, Horticultural Crops Research Lab, Northwest Center for Small Fruit Research, 3420 NW Orchard Ave. Corvallis, OR 97330.

Twospotted spider mites (*Tetranychus urticae* Koch) can be a serious pest on *Rubus*, primarily red raspberry, in the Pacific Northwest. As we expand the *Rubus* germplasm in our breeding program, we must evaluate new material for its susceptibility or resistance to pests. Populations of 40 *Rubus* sp., representing the *Malachobatus*, *Idaeobatus*, *Eubatus*, and *Anoplobatus*, as well as 'Meeker' and 'Marion', were evaluated for mite presence in either a replicated or observation trial. Fully mature leaves, 10 in the replicated trial and 15 in the nonreplicated trial, were harvested at random from 15 to 60 cm above the soil surface. Mature, motile mites were counted on the lower surface of the leaves using a dissecting microscope. Because leaf size was extremely variable from species to species, leaf area was measured and a mite density calculated. There were significant differences in mite density among the species in the replicated trial. The average mite density was 0.03 mites/cm^2, and mite densities were high on one population of *R. lambertianus* and *R. hunanensis*, 2.7 and 1.6 mites/cm^2, respectively. In the nonreplicated trial, *R. glabratus* had the highest mite density (2.3 mites/cm^2). A population of *R. corchorifolius* (1.0 mites/cm^2) and *R. parviflorus (0.9* mites/cm^2) had fairly high mite densities. In both plantings, many of the populations had few or no mites.

74 POSTER SESSION 8
Postharvest Physiology & Propagation
Floriculture & Ornamentals

604

Influence of Simulated Transport on Keeping Quality in Miniature Potted Roses

*Kristian Borch** and *Lars Hoyer*, Danish Inst. of Plant and Soil Science, Dept. of Ornamentals, Aarslev, Denmark.

Stressing miniature roses during transport can reduce their appearance and keeping quality. Factors that stress plants during transport are: storage in darkness, fluctuating temperatures, exposure to ethylene, high humidity, and mechanical damage. The post-production keeping quality of three cultivars of Parade® miniature potted roses (*Rosa* x *hybrida*) from three growers in Denmark were evaluated during winter and summer 1994, using three levels of simulated transport (ST) for 0, 2, or 4 days. The main causes of decreased keeping quality were wilting of flowers, infection by botrytis, and an increased number of yellow buds. After 18 days, there was no difference in the percentage of wilted flowers between 0 and 2 days of ST for all cultivars. However, for two of the three cultivars exposed to 4 days of ST the percentage of wilted flowers increased, while there was no significant effect from the ST on the percentage of wilted flowers. The degree of wilting was also dependent on origin of the plants and was less severe in summer than in winter. The number of yellow buds and infection by botrytis increased in plants exposed to 4 days of ST, and was more pronounced in winter. We conclude that, if the initial quality of the miniature potted rose is good, and the stress conditions during transport are controlled, damage can be kept at a minimum level.

608

The Influence of Removal of Specific Wavelengths of Light on the Height of Chrysanthemum Plants

*Venkat K. Reddy** and *Nihal C. Rajapakse*, Dept. of Horticulture, Clemson Univ., Clemson, SC 29634.

The influence of removal of specific wavelengths [red (R), blue (B), and far-red (FR)] from sunlight on the height of chrysanthemum plants was investigated by overlaying Roscolux™ colored acetate films on 4% $CuSO_4$ or water (control) spectral filters. $CuSO_4$ filters removed FR wavelengths and significantly reduced plant height and internode length compared to control plants that received B, R, and FR wavelengths of light. Plants grown under Roscolux blue filters did not receive R light and were significantly taller compared to plants from any other treatments. Plants grown under Roscolux red filters did not receive B light and

were significantly shorter compared to plants from other treatments. Leaf area, leaf dry weight, and stem dry weight were highest in plants grown under Roscolux red and control filter combination. The amount of leaf chlorophyll and the ratio of Chl A : Chl B was highest in plants grown under Roscolux blue filters. In general, plants that received FR light (control + film) were taller than the plants that did not receive FR light in the corresponding ($CuSO_4$ + film) filter combination. The influence of removal of specific wavelengths on plant height control and developmental physiology will be discussed.

612

Longevity of *Buddleia* Not Affected by Silver Thiosulfate Pulse

*B.K. Behe** and *T.S. Krentz*, Dept. of Horticulture, 101 Funchess Hall, Auburn University, AL 36849-5408.

Research shows differences among flowering species in ethylene sensitivity in response to ethylene inhibitors, including silver thiosulfate. *Buddleia* sp. is an arching shrub with spike-shaped inlforescences in a wide range of colors, including pink, purple, yellow, and white. The objective of this study was to determine optimal pulsing time of silver thiosulfate to maximize the postharvest life of five cultivars of *Buddleia* sp.: 'Empire Blue', 'Lochinch', 'Nanho Blue', 'Pink Delight', 'Royal Red', and 'Sungold'. Flower stems harvested at 1/3 to 2/3 development were transported to a simulated consumer environment. Stems were recut under water and pulsed for 0, 30, 60, and 120 min prior to placing them in a solution of deionized water and Floralife at 10 3 $g \cdot liter^{-1}$. No silver thiosulfate treatment was more effective than the control at extending vaselife, increasing floret development, or increasing stem fresh weight.

616

Inhibition of Flower Senescence by 2,2'Dipryridyl

*Michael Knee**, Dept. of Horticulture and Crop Science, The Ohio State Univ., Columbus, OH 43210-1096.

Chelating agents were applied to petunia flowers to test for the involvement of apoplastic metal ions in ethylene-induced senescence. Compounds varying in polarity and charge were applied directly to the corolla prior to a 24-h treatment with 1 ppm ethylene. Charged and polar chelators were inactive. The only compound that inhibited senescence was 2,2'-dipyridyl, and there was evidence of cellular uptake of this compound. Fe^{2+} and Zn^{2+} did not reverse the inhibition of senescence by dipyridyl. Cu^{2+} as low as 0.1 mM reversed the effect of dipyridyl, but the time of senescence was independent of ethylene treatment. Dipyridyl caused a rapid shift in flower color from red to blue, but untreated flowers became more blue than dipyridyl-treated during 9 days. CO_2 and ethylene production were stimulated by ethylene, but inhibited by dipyridyl applied before or after a 24-h ethylene treatment. Continuous ethylene treatments did not reverse the delay of senescence by dipyridyl.

620

Postharvest Ethylene Production and Sensitivity of Eight Specialty Cut Flower Species

Paul B. Hedman, John M. Dole, Niels O. Maness,* and *Jeffrey A. Anderson*, Dept. of Horticulture and Landscape Architecture, Oklahoma State Univ., Stillwater, OK 74078-0511.

The postharvest biosynthesis of ethylene and CO_2 was measured at 0, 12, 24, and 48 h after harvest and the effects of exogenous applications of 0.0, 0.2, or 1.0 $\mu l \cdot liter^{-1}$ ethylene for 20 h was observed on eight speciality cut flower species. *Helianthus maximilliani* (Maximillian's sunflower), *Penstemon digitalis* (penstemon), *Achillea fillipendulina* ['Coronation Gold' (yarrow)], *Celosia plumosa* ['Forest Fire' (celosia)], *Cosmos bipinnatus* ['Sensation' (cosmos)], *Buddleia davidii* (butterfly bush), and *Weigela* sp. (weigela) exhibited a climacteric-like pattern of ethylene production followed by a steady rise in CO_2 production. *Echinacea purpurea* (coneflower) ethylene biosynthesis was not significant during the 48-h period after harvest. Vase life of coneflower, yarrow, celosia, cosmos, and butterfly bush was not affected by exogenous ethylene. Exogenous ethylene applications to Maximillian's sunflower, penstemon, and weigela resulted in flower abscission and decreased vase life, indicating that they are probably ethylene-sensitive cut flower species.

624

A Question for the Class: Why Do Roses Die?

Michael Knee, Peg McMahon,* and *Glenn Carey*, Dept. of Horticulture and Crop Science, The Ohio State Univ., Columbus, OH 43210-1096.

An undergraduate class in postharvest physiology observed a number of factors in the senescence of cut roses, which had been studied separately in the literature. They assessed the relative importance of the factors in determining vase life. 'Samantha' roses were held at 20C in distilled water or a floral preservative. Ethylene treatment caused petal distortion and premature senescence. Floral preservatives stimulated ethylene production, although vase life was extended relative to flowers in water. Higher sugar contents and respiration were maintained in preservative than in water. Water uptake by roses was almost constant, but stem resistance to water flow increased faster in water than in preservative. In the 2nd week of vase life, transpiration exceeded water uptake, particularly for roses in water. As much of this water was lost through leaves as through the flower. The results suggest that a complex interaction of several factors determines vase life.

628

Botryis-induced Postharvest Losses of Cut Roses May be Reduced by Electron-bean Irradiation

Ai-Yu Chang, Mark L. Gleason, Nancy H. Agnew, Dennis G. Olson, and *Richard T. Gladon**, Depts. of Horticulture and Plant Pathology and Utilization Center for Agricultural Products, Iowa State Univ., Ames, IA 50011-1100.

Irradiated cut *Rosa* x*hybrida* 'Royalty' flowers were used to determine the efficacy of electron-beam irradiation for extending flower postharvest life by reducing native and inoculated populations of *Botrytis cinerea.* In preliminary experiments, roses received irradiation dosages of 0.00, 0.50,1.00, 2.00, and 4.00 kilogray (kGy), along with an untreated control, to establish killing dosages. Irradiation dosages of 1.00 kGy or greater irreversibly damaged rose petal tissue. In subsequent experiments, roses irradiated at dosages of 0.00, 0.25, 0.50, 0.75, and 1.00 kGy, and an untreated control, were used for evaluating postharvest events. We have found that irradiation dosages of 0.25 and 0.50 kGy slowed the rate of flower bud opening slightly and did not decrease postharvest quality or longevity. Inoculated and uninoculated roses irradiated at 0.00, 0.25, 0.50, and 0.75 kGy were used to determine if electron-beam irradiation could reduce *Botrytis* infection and proliferation during postharvest storage, and these results also will be presented.

632

Effects of Harvesting Stages, Preservatives, and Storage Methods on Vase Life and Flower Quality of Cut Snapdragons

Jong Suk Lee , Young A Kim, and *Young Mi Sin*, Dept. of Horticulture, Chungnam National Univ., Taejon 305-764, Korea.

Cut snapdragons (*Antirrhinum majus* L. cvs. Fujinoyuki, Oakland, and Bismarck) were harvested at three different stages and pulsed with silver thiosulfate (STS). Then, the flowers were treated with several preservative solutions to test the effects on vase life and flower quality. Proper storage methods were also investigated. The best harvesting time of snapdragon was when seven to nine florets were opened in a spike. The flowers harvested at this stage had more fresh weight, increased number of opened flowers per spike, and longer vase life than those harvested at earlier stages. Pulsing with 0.2 mM STS for 16 h improved flower quality and prolonged vase life. The preservative solution containing 2% sucrose + 150 ppm 8-hydroxyquinone citrate (HQC) + 25 ppm $AgNO_3$ prolonged vase life. However, this solution caused longer internode between florets and excessive elongation of spike. The preservative solution containing 2% sucrose + 150 ppm HQC + 25 ppm $AgNO_3$ + 50 ppm daminozide improved flower quality by prolonging vase life, reducing the length of internode between florets, and preventing excessive elongation of spike. The flowers held in 50% 7-Up had 2 times prolonged vase life compared to water control. The flowers held in 4% ethyl alcohol also had prolonged vase life and increased fresh weight. Ethylene caused floret abscission and STS pretreatment prevented this floret abscission. Ethylene production in cut snapdragons maintained 2 to 6 nl/g fresh weight per h during vase life. The prolonging storage at low temperature (1C) shortened vase life. The flowers pretreated with STS, and then held in preservative solution during cold storage, had better flower quality and longer vase life than those in plain water.

636

The Response of Three *Ficus benjamina* Clones to Stress Imposed by Complete Darkness or Reduced Frequency of Watering at Two Temperatures

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Three clones of *Ficus benjamina* showed different responses to stress imposed by placing them in complete darkness for 2 weeks. 'Natasha' was the most affected, showing 75% leaf abscission and a reduction of 25% of the chlorophyll content of the leaves. 'Cleo' was the least affected. A general response of the three clones was the reduction in the quality of plants and in their shoot length. Withholding water for periods of 5, 9, and 14 days resulted in no stress response of

the three clones at 22 ±1C, and they only dropped their leaves at 30 ±1C with the percentage of leaves abscising in~creasing with longer periods between watering. 'Natasha' was an exception, and showed an increase in shoot quality and leaf expansion under the high temperature and dropped only 4% of its leaves while the other two clones dropped 20% to 30% with watering at intervals of 9 days. 'Cleo' dropped 90% of its leaves when watered at intervals of 14 days at 30C .

640

Effects of Benzyladenine, Temperature, and Bulb Diameter on Twin-scale Propagated Amaryllis

*Patrick Gushing** and *Gerald Klingaman*, Dept. of Horticulture, Univ. of Arkansas, Fayetteville, AR 72701.

Four bulb sizes of *Hippeastrum hybridum* 'Appleblossom' were twin-scale propagated, soaked in 0, 0.01, 0.1, and 0.5 $g \cdot liter^{-1}$ of benzyladenine (BA), and incubated at 15, 20, 25C and a fluctuating temperature of 31C day, 21C night. Bulbil numbers were recorded following incubation and leaf emergence after bulbils were planted. Eight weeks after bulbils were planted, bulb diameter and leaf numbers were observed. BA application had no effect on bulbil initiation. However, bulbil formation per twin-scale cutting increased as temperature (up to 25C) and mother bulb diameter increased. Bulbil diameter and survival of bulbils increased as incubation temperature increased up to 20C. After planting bulbils, leaf emergence was hastened as bulb size decreased.

644

Inhibition of Root Formation in Cuttings from Flowering Stock Plants of Chrysanthemum

Carrie DeVier and *Robert L. Geneve**, Dept. of Horticulture, Univ. of Kentucky, Lexington, KY 40546.

The influence of flowers on root formation in mum cuttings was evaluated for stock plants grown under long (LD) or short (SD) days. SD plants showed visible flower buds after 20 days and color after 30 days. Cuttings were taken from LD or SD plants at 10-day intervals until flowers were fully open. Cuttings from LD plants rooted at 100% throughout the study, with 24 or more roots per cutting. Cuttings from SD plants showed a gradual reduction in rooting percentage and number as flower development increased. After 30 days, roots per cutting for SD plants was reduced by 85% compared to LD cuttings and only 30% of SD cuttings rooted. In a separate experiment, cuttings were taken from stock plants after 40 long or short days. Partial or all flower buds were removed from SD plants prior to sticking. SD cuttings (regardless of flower bud removal) rooted at <47%. LD cuttings rooted between 23.6 to 43.8, while SD cuttings rooted between 3.1 and 8.5 roots per rooted cutting. The data indicates that cuttings taken from flowering plants show reduced potential for rooting and that this effect was not influenced by removal of flowers prior to sticking cuttings.

652

The Effect of GA_3 Concentration on Germination of *Trillium grandiflorum* (Michx) Salisb.

*Stephanie Solt** and *Leonard Perry*, Dept. of Plant and Soil Science, Univ. of Vermont, Burlington, Vt. 05405-0082.

In the wild, Trillium seeds are reported to take 2 years to germinate, producing the radicle the first year and the cotyledon the second year. The accepted treatment has been to stratify the seeds using a temperature sequence of 3 months cold–3 months warm–3 months cold–3 months warm. It also has been reported that Trillium seeds treated with GA^3 will germinate with no temperature treatment. The objective of this experiment was to determine the effects and optimum concentration of GA_3 on the seed of *Trillium grandiflorum.* Seeds were soaked for 12 h in concentrations of GA_3 K-salts at 500, 1000, 2000, or 4000 ppm dissolved in distilled water with five replicate petri dishes of 20 seeds each (100 seeds per treatment) in a randomized complete-block design in a growth chamber (zero light). Results were analyzed using ANOVA.

648

Hormonal Effects on the Germination Response of *Chasmanthium latifolium*

Derald A. Harp[1], Michael Wade[2], D. Frank Gilman[2], and John Calahan[3]*, [1]Dept of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133; [2]Dept. of Agronomy, Horticulture and Ag Economics, Tarleton State Univ., Stephenville, TX 76401; [3]Dept. of Biology, Tarleton State Univ., Stephenville, TX 76401.

Caryopses of *Chasmanthium latifolium* removed for the florets, treated with solutions containing 0.02 M KNO_3, 0.5 mM GA_3, and/or 0.1 mM kinetin, placed in germination chambers at alternating temperatures of 15/30C, and percentage germination was checked at 7, 14, and 21 days. Treatments with kinetin and/or KNO_3 significantly increased germination percentage over other treatment combinations. The maximum germination percentage for *Chasmanthium latifolium* was achieved by removing the caryopsis from the floret, treating the caryopsis with 0.02 M KNO_3, and germinating for 14 days at alternating temperatures of 15/30C.

76 POSTER SESSION 9
Water Stress, Water Utilization, & Water Management/Cross-Commodity

860

Water Relations of a Semidomesticated Chile Ecotype (*Capsicum frutescens* L.) in a Semiarid Zone in Northwestern Mexico

Alejandra Nieto-Garibay and *Enrique Troyo-Dieguez**, Centro de Investigaciones Biologicas del Noroeste, La Paz BCS, Mexico 23000.

Diurnal and seasonal water relations, soil humidity, transpiration, water demand, stomatal resistance, and fruit production, as well as some microclimatic parameters, were studied in a semidomesticated chile ecotype (*Capsicum frutescens*) under two treatments of plastic mulches, black and opaque, and compared with plants without a mulch in Baja California Sur, a Mexican semiarid state. Plants with opaque plastic mulch showed the highest chile production and total growth. The biggest transpiration rates from January to April was evidenced also by this treatment. The soil water content seemed to be determinant. Opaque plastic mulch plants had more soil moisture during the whole experiment. Plants without plastic mulch had the least chile production, with a lesser soil water content. These plants evidenced an osmotic adjustment under drought stress with low water potential, maintaining a partial turgor pressure, and stomatal regulation, in order to control the lost of water by transpiration.

864

A Model for Estimating the Yield of Coffee (*Coffea arabica*)

Domingo R. Loero and *Kent D. Kobayashi**, Dept. of Horticulture, Univ. of Hawaii at Manoa, Honolulu, HI 96822-2779.

Nine years of historical yield, meteorological, and soil data were input into a soil water balance simulation model to generate a daily soil water status value. The values for the number of days and millimeters of deficit (duration and magnitude) were grouped into trimesters and used to estimate yield. The greatest frequency of days with plant moisture stress occurred during the January–March and the October–December periods. The greatest magnitude of stress occurred during the January–March period. Annual coffee yields were best estimated by the model that incorporated variables for the previous year including, April–June deficit magnitude duration, July–September deficit magnitude duration, and the previous year's yield. Model testing with data from nine cultivars over an 8-year period showed that the model estimated yields with a mean error of 17%. The use of this model permitted yield estimation 2 months before anthesis and 8 months before the start of harvest.

868

Partitioning of a Drought-induced Root Signal within the *Fragaria chiloensis* Plant

*Douglas D. Archbold** and *Lailiang Cheng*, Dept. of Horticulture and Landscape Architecture, Univ. of Kentucky, Lexington, KY 40546-0091.

Plants of *Fragaria chiloensis* cv. RCP-37 were grown with their root system split between two separate containers. Water was withheld from one container of each pair (drought side), while the other was subirrigated. Control plants were subirrigated in both containers. Over several days, a drought-side leaf exhibited reductions in stomatal conductance (g_s) and transpiration rate (T), while a subirrigated side leaf showed no change in either parameter. However, foliar water relations components (water, osmotic, and pressure potential) did not differ between the two leaves. The leaf on the subirrigated side exhibited g_s, T, and water relations components similar to leaves on control plants. The abscisic acid (ABA) content of xylem exudate, collected from a stolon emerging from the axils of the measured leaves, was highest from the drought side and was negatively

correlated to g_s and T at some sampling dates. A root-derived drought stress signal, perhaps ABA, although other factors cannot be discounted, was limited within the plant to the drought side, even though water relations components indicated that water from the subirrigated side was allocated to all parts of the plant.

876

The Role of Osmotic Adjustment in *Thuja occidentals*' Response to Drought Stress

*D.R. Edwards** and *M.A. Dixon*, Dept. of Horticultural Sciences, Univ. of Guelph, Guelph, Ont. N1G 2W1, Canada.

Six-year-old trees were repeatedly conditioned by withholding irrigation until Ψ_{pd} (predawn) thresholds of either –0.9 ("mild") or –1.4 MPa ("moderate") were attained. After conditioning, trees were exposed to severe drought (Ψ_{pd} –2.0 MPa) and then to 10 days of well-watered conditions. Throughout the investigation, osmotic potential (Ψ_π), leaf RWC, transpiration, and total water potential (Ψ_x) were measured. Water stress was quantified by integrating Ψ_x. Conditioning caused a significant, but modest, degree of osmotic adjustment (0.08 to 0.28 MPa), which persisted after a brief relief from stress and transpiration rates were reduced 35% to 50%. Osmotic adjustment was not significantly enhanced by more than one stress exposure or conditioning beyond the mild threshold of stress. During severe drought, the moderate group maintained less negative Ψ_x and lower transpiration rates (38%). After prolonged stress relief, Ψ_x was similar among all treatments and daily transpiration rates and Ψ_x gradually recovered. *Thuja occidentalis* appears to rely on increased stomatal resistance more than osmotic adjustment to tolerate drought stress.

880

Rooting and Drought Resistance of Three Tall Fescue Cultivars

*J.D. Fry** and *W.S. Upham*, Division of Horticulture, Kansas State Univ., Manhattan, KS 66506.

The relative drought resistance of turf-type tall fescue (*Festuca arundinacea* Schreb.) cultivars compared to forage-type cultivars has not been well-documented. Greenhouse and field studies were conducted between 1991 and 1994 to determine rooting potential and drought response of a slow-growing, turf-type tall fescue ('MIC18'), a turf-type cultivar with a moderate growth rate ('Mustang'), and a forage-type cultivar ('Kentucky-31'). In the greenhouse, rooting was determined in sand or calcined clay using clear, polyethylene root tubes 4 cm in diameter by 122 cm deep. Root length density (RLD) was measured for 0- to 30-, 30- to 60-, 60- to 90-, and 90- to 120-cm depths. No differences were observed in RLD at the 0- to 30-cm depth. At other depths, RLD of 'Mustang'' was generally superior to that of 'K-31' and 'MIC18'. During a 3-week dry-down in the field in 1994, 'MIC18' exhibited greater drought stress and a higher canopy minus air temperature than other cultivars. Advantages afforded by reduced mowing of slow-growing tall fescue cultivars may be negated by reduced drought resistance.

884

Potato Production and Deficit Irrigation

Clinton C. Shock, Erik B.G. Feibert,* and *Lamont D. Saunders*, Malheur Experiment Station, 595 Onion Ave., Ontario, OR 9791 4.

Potato response to water stress and changes in soil available-N levels in relation to irrigation management were evaluated in 1992, 1993, and 1994. Potatoes were grown on silt loam with sprinkler irrigation in an adequately irrigated check (100% of crop evapotranspiration replaced at –60 kPa) and three deficit irrigation regimes. Water stress treatments were achieved by partial or complete replacement of crop evapotranspiration when soil water potential reached –80 kPa. In 1992 and 1994, relatively warm years, tuber yield and grade were significantly reduced by water stress. In 1993, a relatively cool year, yield was reduced by water stress, but grade was not. Each year, soil available-N accounting for the season showed large surpluses for all treatments. Potato cultivars grown as subplots varied in their response to deficit irrigation.

888

Onion Response to Water Stress

*Clinton C. Shock**, Erik B.G. Feibert, and Lamont D. Saunders, Malheur Experiment Station, 595 Onion Ave., Ontario, OR 97914.

Six soil water potential irrigation criteria (–12.5 to –100 kPa) were examined to determine levels for maximum onion yield and quality. Soil water potential at 0.2-m depth was measured by tensiometers and granular matrix sensors (Watermark Model 20055, Irrometer Co., Riverside, Calif.). Onions are highly sensitive to small soil water deficits. The crop needs frequent irrigations to maintain small negative soil water potentials for maximum yields. In each of 3 years, yield and bulb size increased with wetter treatments. In 1994, a relatively warm year, onion yield and bulb size were maximized at –12.5 kPa. In 1993, a relatively cool year, onion marketable yield peaked at –37.5 kPa due to a significant increase in rot during storage following the wetter treatments.

892

Growth, Yield, and Water Consumption of Greenhouse Tomato Plants as Affected by High Electrical Conductivity of Nutrient Solution and Low Water Content in Substrate

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Tomato plants were grown in peatmoss-based substrate and supplied with nutrient solution of high (4.5 $mS \cdot cm^{-1}$) or low (2.3 $mS \cdot cm^{-1}$) electrical conductivity (EC) under high (95%) or low (55% of capillary capacity) substrate water content (SWC) to examine the effects of high EC and low SWC on growth and physiology. Salts were allowed to accumulate in the substrate for 7 weeks. Both high EC and low SWC significantly decreased dry matter production (DMP) and fruit yield (FY). Fruit harvest index was lower in high EC- or low SWC-treated plants. Decrease in marketable FY was attributed to both the decrease in total FY and the increase in small and abnormal (cracked and rot) fruits. Both high EC and low SWC decreased photosynthesis (P_N) and leaf water potential (Ψ_L). However, chlorophyll content and respiration were increased by high EC under both high and low SWC. Water consumption based on both whole plant and unit of leaf area was decreased by high EC and low SWC. Ψ_L and transpiration were depressed by high EC and low SWC, especially at midday. There was a significant positive correlation between fruit yield and water consumption. The effects of high EC and low SWC were additive on most of the variables. Decreases in Ψ_L might ultimately account for water consumption reduction, P_N depression, and FY decrease.

896

Effect of Two Levels of Deficit Irrigation on Photosynthesis, Canopy Light Interception, and Yields in Prune

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Two levels of deficit irrigation were applied to mature French prune trees based on gradually declining midday stem water potentials decreasing to –1.5 MPa (moderate stress) and –2.5 MPa (severe stress) by harvest. The moderate and severe stress treatments resulted in 32% and 51% water savings, respectively, compared to the fully irrigated control. The average photosynthetic rate and dry fruit yield for the moderate stress treatment were not significantly lower than those for the fully irrigated control. The severe stress treatment had significantly lower photosynthetic rates from late morning until sunset on most days. However, this lower photosynthetic rate did not result in significantly lower dry fruit yields. There were no significant differences in light interception as measured diurnally or over the course of the season in the first year of the study. However, light interception and photosynthetic differences might be expected to be more pronounced in subsequent years, due to carryover effects.

900

Water Relations, Stomatal Conductance, and Abscisic Acid Content of Young Apple Trees in Response to Antitranspirant Treatment

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Potted apple trees (*Malus domestica* L. 'Gala') were drenched with either water or an antitranspirant (N-2001). After treatment, no additional water was applied to the plants. Abscisic acid (ABA) content of immature and mature leaves was determined by radioimmunoassay after 0, 1, 3, and 5 h and 1, 2, 4, 7, 8, and 9 days after treatment. ABA content of mature and immature leaves of antitranspirant-treated plants peaked 1 and 4 days after treatment, respectively, and remained constant thereafter. In contrast, with increasing water stress, the ABA content of mature and immature leaves of control plants without antitranspirant peaked at 7 and 8 days, respectively. The overall level of ABA in mature leaves of both treatment groups was significantly greater than in immature leaves. The water saturation deficit increased, water and turgor potentials of leaves decreased, and stomatal conductance decreased in response to antitranspirant application. The changes in water relations parameters and stomatal conductance were highly correlated with changes in leaf ABA content.

904

Xylem Sap Abscisic Acid Concentrations and Stomatal Conductance in Mycorrhizal Cowpea

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Mycorrhizal colonization can alter stomatal behavior of host leaves before or during soil drying, but the mechanism of influence is not always clear. We examined the possibility that mycorrhizal symbiosis might result in either altered stomatal sensitivity to abscisic acid (ABA) moving from roots to shoots in xylem sap, or altered movement of ABA in xylem as a function of soil water content (θ). Mycorrhizal colonization of *Vigna unguiculata* did not change the relationship between stomatal conductance (g_s) and xylem [ABA] during drying of whole root systems. Stomatal conductance was higher in mycorrhizal than in similarly sized and similarly nourished nonmycorrhizal plants when soil moisture was relatively high, perhaps related to lower xylem [ABA] in mycorrhizal plants at high soil θ. Neither g_s nor xylem [ABA] was affected by mycorrhizae at low soil θ. Higher g_s in mycorrhizal plants was evidently not related to a mycorrhizal effect on leaf water status, as neither g_s/shoot Ψ nor shoot Ψ/soil θ relationships were altered by the symbiosis. Stomatal conductance was much more closely correlated with xylem [ABA] than with soil θ or shoot Ψ. Decreased xylem [ABA] may explain why mycorrhizal colonization sometimes increases g_s of unstressed mycorrhizal plants in the absence of mycorrhizae-induced changes in host nutrition. This work was supported by USDA NRICGP grant 91-37100-6723 (R.M.A).

908

Feasibility of Using Saline Drainage Water for Processing-tomato Irrigation

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Field studies were conducted in 1992 and 1993 to assess the effects of irrigation with saline drainage water on processing-tomato fruit yields and quality constituents. Saline water (EC_{iw} = 7 dS/m) was used for 66% of the seasonal irrigation requirements in 1992 and 82% in 1993. Yields of tomatoes irrigated with saline water were maintained relative to nonsaline irrigation in 1992, but were decreased by 33% in 1993. Juice Brix and Bostwick consistency were generally improved by irrigation with saline water. pH was unaffected by irrigation treatment, and titratable acidity, an estimate of citric acid content, was increased only in 1993. Calculated quantities for various marketable processed product yields reflect the dominant influence of fresh fruit yield that masked, to a large extent, whatever quality enhancements that may have derived from saline irrigation. The substantial tomato yield reduction that occurred in the second year of this study in plots irrigated with saline drainage water, the gradual surface accumulation of boron, as well as the significant salt buildup in lower portions of the crop root zone following drainage water irrigations demonstrate definitive limitations to the reuse approach and restrict options for the crops that can be grown in this system and the frequency of saline drainage reuse.

912

Crop Coefficient Use as a Criterion to Irrigate to Save Water on Grapevines

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Grapes are the most extensively grown crop in the agricultural area of Caborca, Sonora, Mexico (14,000 ha), and water availability is the main limitation of the crop production system. Commonly, grapevines are irrigated with 150–200 cm of water/year. Therefore, it is important to make efficient use of this resource. To demonstrate that the crop criterion (CC) to irrigate is adequate to decrease the water-use efficient, the growers criteria was compared with CC during 1990 and 1991 in a commercial plot of 'Thompson Seedless' grapes for wine production grown in a drip-irrigated system. The CC used was: 7.5%, 15.0%, 52.0%, 80.0%, 30.0%, and 7.5% at budbreak state (0–20 days), shoot elongation (21–40 days), fruit set (41–60 days), first harvest (61 days to harvest), during harvest (until 130 days), and postharvest (130–240 days), respectively. Our results indicate that water consumption using CC is 90 cm/year vs. 147–187 cm/year with growers criteria, the use of which did not affect yield.

916

Water Use Efficiency, Nutrient Use, and Soil Shading Ability of Chemically Suppressed Ryegrass and Crimson Clover Living Mulches

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Renewed interest in soil conservation over the past decade has led to greater research efforts in the area of living mulch cropping systems. However, crop/mulch competition continues to present challenges. The objective of this study was to determine what effect two types of chemical growth suppressants (Mycogen 6121—an herbicidal soap, and Royal Slo-grow—a soil plant growth regulator) had on the water-use efficiency, nutrient use, and soil-shading ability of two annual living mulches, ryegrass (*Lolium multiflorum*) and crimson clover (*Trifolium incarnatum*). Two greenhouse experiments were performed in sand culture using a modified Hoagland's soap, one rate of growth regulator, and a mechanical treatment of mowing. Significant differences in nutrient use and soil-shading ability were obtained. The second experiment (69 days) replicated the ryegrass treatments less one rate of soap and included the legume crimson clover with one rate of soap and one rate of growth regulator. Results from both experiments will be discussed.

920

Water Loss of *Nerium oleander* Planted in Two Soil types Under Two Irrigation Regimes

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Water loss of *Nerium oleander* growing in two soil types was determined from mid-June through mid-October. Plants (1 year old, 3.8 liter) were obtained from a local nursery and transplanted in May into 18.9-liter lysimeter pots containing either clay loam or bluepoint sand. Controls were lysimeter pots containing each soil type but without plants. Irrigation was applied at two rates, approximately field (pot) capacity and 50% of that amount. Irrigation frequency was determined by visual inspection of the plants and was held constant for both irrigation rates in a given soil type. Frequency ranged from 2 to 3 days for the sand and 2 to 5 days for the clay loam. Water loss was determined every 24 h. Plant water loss was higher at the higher irrigation rate. Decreasing irrigation rate by 50% resulted in a 20% to 40% reduction in plant water use in clay loam and a 15% to 30% reduction in sand without affecting plant quality. Plant water loss in the sandy soil was ≈50% greater than in clay loam 48 h after irrigation. Implications of these findings in developing an optimum irrigation model for landscape plants will be considered.

924

Effects of Controlled Water Tables on Yield and Marketability of Field Tomatoes

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In a 2-year study, tomato plants (*Lycopersicon esculentum* Mill., cv. New Yorker), grown in a sandy loam in field lysimeters, were subjected to controlled water table treatments (CWTT) of 0.3, 0.6, 0.8, and 1.0 m from the soil surface, factorially combined, in a central composite design, with 5 K–Ca fertilization combinations, replicated four times. Final shoot mass, no. fruit/plant (yield), percent marketability, fruit dimensions, and the incidence and severity of catfacing and sunscald were measured. In the first, drier year, the two higher, better-irrigated CWTT (0.3 and 0.6 m) gave higher yields, larger fruit, and higher final shoot mass, whereas in the second, wetter year, the two lower, better-drained CWTT (0.8 and 1.0 m) were best. In the dry year, the best-yielding CWTT showed the poorest marketability, while, in the wet year, the best-yielding CWTT showed the best marketability. Severity of catfacing and sunscald did not show consistent variations with CWTT. Fertilizer effects were generally not significant. Results will be discussed in the context of the use of subirrigation in field tomato production.

928

Searching for the Best Empirical Model to Estimate Turf Water Use in Kansas

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A relatively accurate estimate of turfgrass evapotranspiration (ET) using environmental parameters readily obtainable from a local weather station would be of

benefit to golf course superintendents, landscape managers, and homeowners. The Penman–Monteith model is clearly a poorer estimate than that obtained by Bellani plates or spheres. It has been suggested that, while the Penman–Monteith model is good in the drier climate of the southwestern United States, other models may be of greater practicable utility in climates such as are common in Kansas. Thus, other models have been evaluated for their suitability as turfgrass ET estimates in Kansas-like climates. Turfgrass ET was measured via lysimeters in 1992–94. Specifically, measurements were taken on three tall fescue varieties mowed at 6.35 or 7.62 cm, and zoysiagrass and perennial ryegrass mowed at 2.54 cm. Evaporation from black Bellani plates was measured simultaneously. These evaporation and ET rates were compared to those estimated by various empirical models whose data came from a weather station located within 31 m of the Bellani plates and lysimeters. Empirical models included temperature methods (e.g., FAO-24 Blaney–Criddle), radiation methods (e.g., Jensen–Haise, Hargreaves–Samani), combination equations (e.g., Priestly–Taylor, Penman), and variants. The best model(s) determined from these comparisons will likely become the method(s) of choice for estimating turfgrass ET in Kansas.

932

A Comparison of Onion Production Under Sprinkler, Subsurface Drip, and Furrow Irrigation

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Onion yield and grade were compared under sprinkler, subsurface drip, and furrow irrigation in 1992, 1993, and 1994. Furrow-irrigated onions were planted on two double rows on 1.12-m-wide beds at 352,000 seeds/ha. Sprinkler- and drip-irrigated onions were planted in nine single rows on a 2.24-m-wide bed at 432,100 seeds/acre. Drip plots had three drip lines buried 0.10 m deep in each 2.24-m bed. Soil water potential at 0.2-m depth was measured by tensiometers and granular matrix sensors (Watermark Model 200SS, Irrometer Co., Riverside, Calif.). Furrow irrigations were started when the soil water potential at the 0.2-m depth reached –25 kPa. Drip-irrigated onions had soil water potential at the 0.2-m depth kept wetter than –25 kPa by daily replacement of crop evapotranspiration (Et_c). Sprinkler irrigations were started when the accumulated Et_c reached 25 mm. Sprinkler irrigation resulted in significantly higher onion yield than furrow irrigation in 1993 and 1994. Sprinkler irrigation resulted in higher marketable onion yield than furrow irrigation in 1993. Drip irrigation resulted in significantly higher onion yield than furrow irrigation every year. Drip irrigation resulted in higher marketable onion yield than furrow irrigation in 1992 and 1994. Marketable onion yield was reduced in 1993 due to rot during storage.

936

Response of 'Lisbon' Lemons to Irrigation Frequency in the Arizona Desert

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The majority of citrus planted in southwestern Arizona are lemons. Lemons are generally more vigorous and usually produce higher yields than other citrus cultivars. However, under water stress, fruit size will be compromised and excessive fruit drop will occur. Limited information is available that addresses the issue of irrigation frequencies and the impact on fruit sizing of lemons. A field study was initiated in 1993 evaluate the response of "Lisbon' lemons to various flood irrigation intervals. Irrigation intervals were based on soil moisture depletion (SMD), as calculated from frequent neutron probe soil moisture measurements. Individual treatments were irrigated when total SMD was 25%, 40%, 55%, and 70%, respectively. The experiment is a completely random design with four replications. Results indicate that both the most-frequent (25% SMD) and least-frequent (70% SMD) irrigation regimes produced negative results. Overall, the first year's results indicate optimal fruit growth and yield is achieved at 40% SMD.

940

Water Use of Container-grown Geraniums and Petunias

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Two studies were undertaken to quantify the amount of water used by two container-grown bedding plant crops. *Petunia* x *hybrida* cv. Welby Blue and *Pelargonium* x *hortorum* cv Red Satisfaction plants were grown in 11-cm pots in a commercial greenhouse in Denver, Colo. In Expt. 1, rooted geranium cuttings and petunia seedlings were planted in Fafard #2, a growing medium containing peat, perlite, and vermiculite. Half of the plants were grown with the substrate covered. Each pot was weighed just prior to, and again 24 h, after watering. Measured amounts of water were applied to the pots. Geraniums in uncovered pots lost an average of 1.7 kg/pot over 59 days. Geraniums in covered pots lost an average of 1.6 kg/pot. Petunias, over 23 days, lost 730 g per uncovered pot and 623 g per covered pot. Experiment 2 compared water loss in growing medium amended with five different hydrophilic gels, and a control with no gel added. With geraniums, no differences were found among treatments in total water loss, initial or final plant height, or fresh or dry plant weight. With petunias, no differences occurred in initial or final height, or fresh or dry weight. There was a difference between two of the gel treatments in total amount of weight lost.

944

Stability and Effectiveness of Wetting Agents in Stored Growing Media

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Three soilless media of different composition (peat : vermiculite, bark : peat : vermiculite, peat : vermiculite : polystyrene) received one of three wetting agent treatments (AquaGro 160 at 60 ml or 120 $ml \cdot m^{-3}$; or AquaGro L at 120 $ml \cdot m^{-3}$) and were subsequently analyzed for wettability after storage for up to 4 months. The respective untreated media served as the controls. All media were stored in closed bags at 24 ±4C. Water retention was greater in wetting agent-treated media than in controls. Both wetting agents facilitated uniform distribution of water in the media. Control media became more difficult to wet over time, whereas wetting agent treatments maintained uniform wettability of media throughout the storage period. Wetting agent chemistry, treatment rate, and media composition influenced wetting characteristics during media storage. All three wetting agent treatments improved wetting of the peat : vermiculite over the 4-month test period. In bark media, AquaGro 160 applied at 120 $ml \cdot m^{-3}$ enhanced wetting throughout the study. Media containing polystyrene were difficult to wet. AquaGro 160 applied at 120 $ml \cdot m^{-3}$ improved wetting for up to 2 months.

78 POSTER SESSION 10
Genetics/Vegetable Crops

413

Heritability of Resistance to Root-knot Nematode (*Meloidogyne hapla* Chitwood) in Carrot (*Daucus carota* L.)

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The root-knot nematode (*M. hapla* Chitwood) poses a threat to carrot (*Daucus carota* L.) production in the United States. Little information is available concerning the genetic control of nematode resistance in carrot. Crosses between two inbreds, a resistant genotype (R_1) and susceptible genotype (S_1) identified in previous screening tests of carrot were studied in the F_2 and BC_1 generations to determine the heritability of resistance to the root-knot nematode. Seedlings of F_2 (R_1/S_1), BC_1S_1, and BC_1R_1 generations were evaluated for their responses to infestation of *M. hapla* Chitwood based on gall number per root, gall rating per root, and root rating per root in a greenhouse experiment conducted during 1994. Narrow-sense heritabilities were calculated according to the method of Warner (1952). Narrow-sense heritability was 0.16 for resistance based on gall number, 0.88 for resistance based on gall rating, and 0.78 for resistance based on root rating. This information may be of importance to geneticists and carrot breeders for the development of nematode-resistant carrot cultivars.

417

Inheritance of Resistance to Common Bacterial Blight in Tepary Beans

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Common bacterial blight, incited by the bacterium *Xanthomonas campestris* pv. *phaseoli* (*Xcp*), is a serious disease of common beans [*Phaseolus vulgaris* (*P. v.*)]. Some tepary beans (*P. acutifolius*) are resistant (R) to *Xcp* and used to breed *P. v.* with R to *Xcp*. The objective was to determine the inheritance of the

reaction to different strains of *Xcp* in crosses between susceptible (S) and R tepary lines. The parents, F_2, and F_3 populations from six tepary crosses involving 3 R x S, 1 R x moderately (M) R, and 2 R x R were inoculated with *Xcp* strains EK-11, LB-2, and SC-4A. Different single dominant genes controlled the reaction to different *Xcp* isolates in R x S crosses. Coupling linkage was detected between the genes controlling the reactions to each of the *Xcp* strains in the crosses NE #4B(s) x NE #19(R) and NE #4B(S) x CIAT-640005(R), except for NE #8A(MR) x NE #4B(S) with strains EK-11 and LB-2 and EK-11 and SC-4A. Transgressive segregation for S was observed in the F_2 and F_3 NE #8A x NE #8B(R), indicating that the parents possessed different genes for R. No segregation for reactions occurred n the F_2 NE #8B x NE #19 and NE #19 x CIAT-640005, indicating that these parents possessed the same genes for R to the three strains.

421

Heritability of Resistance and Associations of Leaf, Pod, and Seed Reactions to *Xanthomonas campestris* pv. *Phaseoli* (DYE) in Common Beans

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The inheritance and heritability (H) of leaf and pods reactions and seed infection of common beans (*Phaseolus vulgaris* L.) to *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye (*Xcp*) were studied in three crosses along with flower and stem color, and the association of reactions to *Xcp* in the plant organs. Recombinant inbred lines from the crosses 'PC 50' x XAN 159, BAC 6 x HT 7719, and BelNeb 1 x A 55 were used. Quantitative inheritance patterns were observed for disease reactions in leaves, pods, and seeds. Stem and flower color were inherited qualitatively. Low to intermediate and intermediate H estimates were found for pod reactions when inoculated on the same time, allowing the infection to occur in a uniform environment. Intermediate to high H estimates were found for leaf and seed reactions to *Xcp*, respectively. Significant positive intermediate to moderately high correlations were found between the reactions to *Xcp* of the first trifoliolate with later-developed leaves and pods in all three populations. The moderately high genetic correlations between leaves and pods suggested that some common genes may control the reactions to *Xcp* in these plant organs. No association was detected between flower or stem color and reactions to *Xcp*.

425

Nuclear Genome Organization of Asymmetric Intergeneric Somatic Hybrid Plants between *Lycopersicon esculentum* x *L. pennellii* and *Solanum melongena*

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Asymmetric somatic hybrids were obtained by PEG/DMSO fusion of protoplasts of a kanamycin-resistant (KmR^+) interspecific tomato hybrid *L. esculentum* x *L. pennellii* with protoplasts of *S. melongena* eggplant. Elimination of tomato chromosomes was directed by application of 100, 250, 500, 750, and 1000 Gy of γ-rays to the donor protoplasts. The hybrid nature of selected KmR^+ calli was confirmed by RAPDs, PCR amplification of the NptII gene, and Southern hybridization. Flow cytometry revealed that asymmetric hybrid plants were regenerated only from selected somatic hybrid calli that had a ploidy level close to 4n. The amount of donor DNA in three somatic hybrid plants was quantified by dot-blot hybridization with tomato species-specific probes, and was found to be 5% to 7%. Therefore, presence of four to five tomato chromosomes in asymmetric hybrid plants has been calculated. Detection of tomato-specific chromosomes in hybrid plants by RFLP analysis will be presented.

429

Using RAPD Markers to Assess Genetic Diversity in *Brassica* Germplasm and Chinese Breeding Lines

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Molecular DNA markers based on the RAPD (random amplified polymorphic DNA) assay are gaining use in germplasm assessment. RAPD markers are simple, relatively inexpensive, and highly informative. We used five primers to assess 26 *Brassica oleracea* breeding lines from the IVF and nine accessions from the PGRU. The test array included eight subspecies of *B. oleracea*. We generated 90 RAPD markers and were able to unambiguously discriminate among all 35 test entries, but could not separate subspecies within *B. oleracea*. Genetic similarity between subspecies ranged from 0.629 to 0.738. Average similarity within accessions was 0.96, confirming the suspected homogeneity of breeding lines. Nevertheless, significant genetic diversity was found among kohlrabi, broccoli, and cabbage accessions. Similarity analysis of breeding lines and hybrids confirmed their pedigree relationships. Interestingly, *B. o.* subsp. *costata* 'Couve Nabica' showed closer similarity to *B. napus* subsp. *oleifera* 'Jet Neuf' than to other *B. o.* materials and *B. o.* subsp. *italica* 'Packman' showed higher similarity to some cabbages than to other broccolis. Results provide further evidence that diversity assessment using RAPDs is broadly applicable and useful in germplasm conservation and utilization.

433

Molecular Markers and Linkage to the *Sw-5* Locus for Resistance to Tomato Spotted Wilt Virus (TSWV)

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Sw-5 is a locus introgressed from *Lycopersicon peruvianum* to some *L. esculentum* lines conferring dominant resistance to TSWV. Restriction fragment length polymorphism (RFLP) analyses positions *Sw-5* to the long arm of chromosome 9 in the sub-telomeric region between CT71 and CT220. RFLP analyses suggest the introgressed region begins distal to CT71, includes CT220, and may extend to the telomere. Randomly amplified polymorphic DNA (RAPD) analyses with >700 random 10-mer primers identified a single 2.2-kbp band with one primer (primer #72 GAGCACGGGA) that is tightly linked to *Sw-5.* However, we have also produced an equivalent 2.2-kbp band in analysis of other TSWV-susceptible tomato breeding lines. Thus, this band likely derives from *L. esculentum* DNA very near to *Sw-5* and the introgressed region. Additional analyses have recently detected a potential co-dominant RAPD polymorphism linked to *Sw-5.*

437

Simple Sequence Repeats (SSRs) in Watermelon (*Citrullus lanatus* L.)

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Simple sequence repeats (SSRs) were isolated from a size-fractionated genomic DNA library of watermelon (*Citrullus lanatus* L. cv. New Hampshire Midget). Screening of the library with five oligonucleotide probes, including $(GT)_{11}$, $(AT)_{11}$, $(CT)_{11}$, $(GC)_{11}$, and $(TAA)_8$, detected the occurrence of 96 positive colonies among ≈8000 recombinants. Automated DNA sequencing revealed the presence of SSRs. PCR primer pairs homologous to the regions flanking the SSR loci were synthesized commercially and used to screen 56 watermelon genotypes for the occurrence of SSR polymorphisms. Amplification products were separated using nondenaturing PAGE. Eighty percent of the primer pairs produced amplification products of the expected size and detected polymorphisms among the genotypes examined. The use of SSRs for watermelon germplasm characterization is discussed.

441

Ipomoea Accession Closely Related to Sweetpotato

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An Ipomoea accession from Indonesia, originally classified as *I. trifida*, was found to segregate in flower morphology. It was hypothesized to be either a very close relative of *I. batatas* (6x sweetpotato), or a hybrid between *I. batatas* (6x) and *I. trifida* (2x). Twelve seedlings of this accession were grown and precise measurements of sepal angle, corolla shape, and root morphology were taken. Samples were also compared on the DNA level using molecular markers. Based on morphological measurements, it was found that some individual seedlings of the unknown Ipomoea accession were not significantly different than *I. batatas*; others were not significantly different than *I. trifida.* The control *I. batatas* and *I. trifida* lines were significantly different from each other. DNA flow cytometry was used to determine that all seedlings were diploids with the same amount of DNA per cell. Overall plant morphology and molecular analysis confirmed that all of the seedlings were very closely related and the segregation in flower morphology was not due to a seed mixture. This data is consistent with the hypothesis that the accession is a hybrid between *I. batatas* and *I. trifida.*

445

Tests for Allelic Relationships Among Potyvirus Resistance Genes in *Cucumis sativus*

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Cucumbers and other cucurbit crops are subject to severe losses due to an array of potyviruses, including zucchini yellow mosaic virus (ZYMV), watermelon mosaic virus (WMV), and the watermelon strain of papaya ringspot virus (PRSV-W). Sources of resistance to these viruses have been identified within the cucumber germplasm, including resistance to ZYMV, WMV, and PRSV in 'TMG-1'; resistance to PRSV in 'Surinam'; and to ZYMV in 'Dina'. In this study, we sought to determine the allelic relationships between resistance to PRSV in 'Surinam' and 'TMG' and resistance to ZYMV in 'Dina' and 'TMG'. Segregation ratios among F_1, F_2, and backcross progeny of 'Surinam' and 'TMG' indicated that the alleles are at the same locus. Similarly, progeny analysis indicates that the alleles for ZYMV resistance in 'Dina' and 'TMG' are at the same locus. In each case, however, the alleles appear to differ from one another with respect to dominance relationships, symptom expression, and/or response to different viral strains. We are further characterizing these differences by screening progeny of crosses to a common susceptible parent.

449

QTL Analysis of the Production of Acylsugars Responsible for Pest Resistance in the Wild Tomato, *Lycopersicon pennellii*

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Lycopersicon pennellii, a wild relative of the tomato, *L. esculentum*, is resistant to a number of important pests of cultivated tomato due to the accumulation of acylsugars, which constitute 90% of *L. pennellii* LA716 type IV trichome exudate. An interspecific F_2 population created by crossing *L. esculentum* x *L. pennellii* was surveyed for acylsugar accumulation and subjected to RFLP analysis to determine the genomic regions associated with the levels of acylglucoses, acylsucroses, and total acylsugars accumulated, and glucose as a percentage of total acylsugars. Data was analyzed using MAPMAKER with and without $\log_{10}$ transformation and using a threshold of either 2.4 (default value for MAPMAKER) or ones calculated according to the Permutation-based Estimated Threshold (PET) method. Genomic regions were identified for each of the traits studied. Effects of analytical method on identification of QTLs, similarities between these results and results published for the genus *Solanum*, and similarities between these results and the regions transferred by a breeding program selecting for acylsugar production are discussed.

453

Directional RAPD Marker Frequency Changes in Two Divergently Selected Beet Populations

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In the past 20 years, betalain pigments found in red beet (*Beta vulgaris* L.) have been adopted for use as natural red food coloring. In an effort to develop red beet populations with elevated levels of betalain pigment, recurrent half-sib family selection for high pigment and both high and low solids was practiced for seven cycles, resulting in the development of a high pigment–high solids (HPHS) and a high pigment–low solids (HPLS) population. Thirty-one randomly selected decamer primers were chosen to assess RAPD marker frequencies on genomic DNA samples isolated from 47 randomly chosen individual plants in each of cycles 1, 3, and 6 in both HPHS and HPLS. A total of 161 RAPD markers were evaluated. Chi-square and regression analyses were performed to determine presence/absence of linear trends in marker frequencies during the selection scheme. Comparisons were made for individual cycles between HPHS and HPLS and among cycles within HPHS and HPLS. Significant linear trends were detected in both cases for key RAPD primers. Chi-square tests revealed a subset of the markers which exhibited significant frequency changes across cycles were associated with selection as opposed to genetic drift. These data demonstrate changes in RAPD marker frequencies with recurrent selection and suggest linkage of RAPD markers to genes controlling pigment and solids in red beet.

457

Morphological and Biochemical Variability in Two-species Congruity Backcross (CBC) *Phaseolus vulgaris* x *P. coccineus* Hybrids

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Two-species CBC hybrids between *Phaseolus vulgaris* and *P. acutifolius* exhibit transgressive segregation for seed color and patterning, root peroxidases, and seed proteins. CBC pedigrees between *P. vulgaris* and *P. coccineus* (differing for species-specific traits) were created to test whether variation would be similar or greater than with *P. acutifolius*. *P. vulgaris* 'Soldier' (Vermont) x 2- and 4-way intraspecific *P. coccineus* accessions were used as parents. CBC1 through CBC3 were evaluated for segregation of species-specific genes. Hybrid breakdown was evident in all CBC generations, particularly nonflowering dwarf cripples. Transgressive segregants were found as early as CBC2. One individual was found that had crossovers for species traits: a determinate, red-flowered plant with *P. coccineus* flowers and *P. vulgaris* introrse stigmas. By CBC3, all of the variation reported for three-species CBC hybrids (*P. coccineus* x [*P. vulgaris* x *P. acutifolius*]) was evident.

461

Simple Sequence Repeats (SSRs) in Sweetpotato [*Ipomoea batatas* (L.) Lam.]

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Simple sequence repeats (SSRs) were isolated from a size-fractionated genomic DNA library of sweetpotato [*Ipomoea batatas* (L.) Lam.]. Screening of the library with five oligonucleotide probes, including; $(GT)_{11}$, $(AT)_{11}$, $(CT)_{11}$, $(GC)_{11}$, and $(TAA)_8$, detected the occurrence of 142 positive colonies among ≈12,000 recombinants. Automated DNA sequencing revealed the presence of simple, compound, perfect, and imperfect SSRs. Five homologous PCR primer pairs were synthesized commercially and used to screen 30 sweetpotato clones for the occurrence of SSR polymorphisms. All primer pairs produced an amplification product of the expected size and detected polymorphisms among the genotypes examined. The potential for the use of SSRs as genetic markers for sweetpotato germplasm characterization is discussed.

465

Inheritance of Resistance to Iron Deficiency in Cowpea

H.M. Cortinas-Escobar, Douglas C. Scheuring, Thomas J. Gerik,* and *J. Creighton Miller, Jr.*, Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133.

Cowpea [*Vigna unguiculata* (L.) Walp.] cultivars differ in their response to iron deficiency when grown on calcareous soils. This response is influenced by environmental factors such as soil pH, soil texture, presence of bicarbonates, and temperature. The objective of this study was to determine the genetic basis for resistance to iron deficiency in cowpea. Crosses of 'Texas Pinkeye Purple Hull' (resistant) and 'Pinkeye Purple Hull' (susceptible) were made in the greenhouse during Spring 1994, and F_2 seeds were obtained in the summer. Reciprocal crosses were made in order to test for maternal effects. Seed of the parental, F_1, and F_2 generations were planted near Temple, Texas, during Fall 1994. The color (greenness) of 1031 F_2 plants was measured using a chlorophyll meter (Minolta SPAD-502) 35 days after planting. Chi-square analysis showed a good fit to a 3:1 ratio of susceptible : resistant plants. These results suggest simple inheritance of the response to iron deficiency in cowpea. Similar segregation of the reciprocal crosses indicated absence of maternal inheritance.

469

Inheritance of Resistance to Iron Deficiency in Dry Beans

H.M. Cortinas-Escobar, Douglas C. Scheuring, Thomas J. Gerik,* and *J. Creighton Miller, Jr.*, Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133.

Dry bean (*Phaseolus vulgaris* L.) cultivars differ in their response to iron deficiency when grown on calcareous soils. This response is influenced by environmental factors such as soil pH, soil texture, presence of bicarbonates, organic matter, and temperature. The objective of this study was to investigate the genetic basis for resistance to iron deficiency in beans. Crosses between nine resistant and three susceptible cultivars/lines were made in the greenhouse during Spring 1994, and F_2 seeds from 12 different crosses were obtained in the summer. Seed

of the parental and F_2 generations were planted near Temple, Texas, during Fall 1994. The color (greenness) of 1482 F_2 plants was measured using a chlorophyll meter (Minolta SPAD-502) 35 days after planting. Chi-square analysis showed a good fit to a 15:1 ratio of resistant : susceptible plants. The F_2 segregation suggests that two dominant genes are involved in the response to iron deficiency in dry beans, and when either dominant gene is present, resistance is expressed to some degree.

473

Nucleotide Pools in Imbibing Tomato Seeds

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HPLC was used to measure nucleotide pools in tomato seeds during the 3 h following imbibition in water. In dry seeds, nucleotides were predominantly in the form of monophosphates. During the first 2 h post-imbibition, the monophosphate levels declined and there were sharp increases in the amounts of diphosphates, followed by triphosphates. Between the 2nd and 3rd h, the di- and triphosphate levels continued to increase and the monophosphate levels began to recover, especially in the case of UMP—presumably the result of degradation of unwanted mRNAs left over from the maturation phase of seed development. The adenylate energy charge increased during imbibition and, within 3 h, reached a value close to that of normal active tissue.

477

Genetic Variation in Folic Acid Content of Red Beet Genotypes (*Beta vulgaris* L.)

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Governmental recommended allowances for folic acid have increased dramatically in recent years, especially for pregnant women. Red beet is an important vegetable source of folic acid; however, little is known about the extent of variation for native folic acid content in red beet genotypes. The objective of this investigation was to evaluate variation in folic acid content (FAC) among red beet hybrids (F_1), inbred lines (IL), plant introductions (PI), and open-pollinated cultivars (OP). Eighteen genotypes, including 12 F_1 and six OP, were evaluated in field experiments during both years. Averaged over years, highly significant differences among genotypes and between F_1 and OP were detected. FAC ranged from 3.7 mg to 15.2 mg per gram dry weight. The FAC in OP was 13% higher than in F_1. Thirty genotypes, including 13 IL and 17 PI, were evaluated in greenhouse experiments during 1993 and 1994. Highly significant differences among genotypes and between IL and PI were detected. FAC varied from 1.54 mg to 11.13 mg per gram dry weight. The FAC in IL was 43% higher than in PI. These results demonstrate an approximate 10-fold variation among red beet genotypes for FAC.

79 POSTER SESSION 11
Culture & Management/Fruits (General)

605

Root System of Plum Trees on Rootstocks of *Pr. divaricata*, *Pr. tomentosa*, and VVA

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Root systems of 6-year-old trees of plum cultivar Edinburg on seedling rootstocks of *Pr. divaricata*(I), *Pr. tomentosa* (II), and clonal rootstock VVA (*Pr. tomentosa* x *Pr. divaricata*) (III) were studied with trench-monolith method, at a depth of 100 cm. Sodpodzolic loess soil had a A horizon (0–22 mm) with 2% humus. The area of cross-section on tree trunks on I, II, and III was 72, 44, and 18 cm^2, respectively; yield efficiency was 0.22, 0.30, and 0.33 $kg \cdot cm^{-2}$, respectively. Specific length of scaffold roots of I and III was equal, but roots of I were deeper in the bed. Specific mass of scaffold roots of III was 35% less than I, but specific mass of fibrous roots of III was 84% more. All root indexes of II were many times smaller than I and III. Nearly 40% of total length of scaffold roots of all rootstocks was at the distance of 0.5–1.0 m from the trunk. Fibrous roots of II and III concentrated near the trunk. Specific mass of these roots of I at a distance of 2.0–2.5 m from the tree was twice those near the trunk.

609

Enhancing Branching of Apple Trees in the Nursery with Plant Growth Regulators

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Nursery trees of new, promising apple selections [NY-75334-35 (A), NY-75414-1 (B), and NY-75413-30 (C)] from the Geneva breeding program exhibit a distinct apical dominant growth pattern characterized by poor lateral-shoot formation (feathering).To induce feathering, the trees were foliar-treated singly or sequentially with various concentrations of Promalin (1.8%w/w GA_{4+7} + 1.8%w/w 6BAP) and Accel (0.18% w/w GA_{4+7} + 1.8% w/w 6BAP), by themselves and in combination. Regardless of branching agent, concentration, and type of application, treated trees, as compared to the control, on average, induced 11.3 vs. 2.2, 6.6 vs. 0.4, and 6.6 vs. 2.0 feathers/tree for selections A, B, and C, respectively. In most instances, higher concentrations of both chemicals induced more feathers than lower concentrations. Tree height and caliper were less affected than lateral-shoot production.

613

Potassium Nitrate Controls Pecan Sprout Regrowth in Stumps after Orchard Thinning

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Stumps remaining after tree removal during orchard thinning will characteristically produce extensive shoot growth in response to the massive root systems that previously supported large trees. A 38-year-old pecan orchard was thinned from 15 x 15 m to 21 x 21 m. Stumps ranging from 45 to 65 cm in diameter were treated in seven replications with 0.19, 0.37, and 0.75 kg KNO_3, respectively, per stump in drilled holes. Two controls consisted of stumps with drilled holes and intact stumps with no holes. Eight holes per stump were drilled with a 2.54-cm-diameter power auger to a depth of 15 cm. The number and weight of regrowing sprouts was measured annually. The 0.75 kg KNO_3 rate significantly reduced the number and weight of sprouts regrowing the first year. The drilled stumps showed a significant decrease in new sprouts over the undrilled control. The low KNO_3 rate stimulated regrowth. The key to regrowth suppression is to use a high rate of KNO_3 in sufficient holes to allow penetration. KNO_3 stump treatment should be a safe practice because no more than, perhaps, 2.25 kg of KNO_3, depending on trunk diameter, will be used per site, which will then provide nutrients to existing trees as it dissipates.

617

Chemical Defoliation of Almond in Warm Climates of Northwestern Mexico

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Almond production in hot climate areas of Mexico uses low-chilling cultivars. One problem in young almond trees is that timely leaf drop does not occur; therefore, budbreak is late and uneven. With the objective of chemical defoliation, foliar applications of different compounds [urea (5%), $ZnSO_4$ (5%), $CuSO_4$ (5%), NH_4NO_3 (5%), $ZnSO_4$ (2.5%) + urea (1.5%)], hand defoliation, and a nondefoliation control were made on 'R-633' young almond trees (2 years old). The percent defoliation was high (77% to 86%) after 6 days of the application in the majority of treatments, except for NH_4NO_3 (5%), urea (5%), and the control; but 3 days later, all treatments showed >80% defoliation. Nondefoliated trees had an uneven budbreak and occurred 3 and 6 days later. The yield was greater for $ZnSO_4$, with 435 g/tree and only 55.6 g/tree for the control. Fruit quality was the same for all treatments. No injury to branches were observed with any compounds.

621

Effect of Chemical Defoliation on the Budbreak of 'Golden Delicious' Apple

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During 1993–94, in an area with a subtropical climate, 1500 m elevation, and 300 mm of precipitation, an experiment with 'Golden Delicious' apples/MM.111 under irrigation was conducted with 11 treatments with three replications in a completely randomized complete-block design: T1, manual defoliation (27 Sept.); T2, 1% $CuSO_4$ (15 Oct.); T3, 2% $CuSO_4$ + Promesol (acido 2,3,4 trihydroxipentanodioico) (22 Oct.); T4, 1% $CuSO_4$ + 0.1% Atlox; T5, 1% $CuSO_4$ + 0.2% Atlox; T6, 1% $CuSO_4$ + 0.1% Frigate; T7, 1% $CuSO_4$ + 2% urea; T8, 2%

sulfur; T9, 500 ppm tiadizuron + 1% carboxil; T4–T9, defoliation 12 Nov.; T10, control (natural defoliation on 3 Dec.); T11, 2% $ZnSO_4$ + 0.07 carboxil (8 Nov.). All treatments received Atlox surfactant at 0.1%, except T4 and T5. On 11 Mar. 1994, trees received an application of 0.5% Dormex + 4% dormant oil.The percentage of terminal budbreak on 1-year-old wood was superior for T6, T9, and T11 compared with the control (11.7% budbreak on 2-year-old wood) for all treatments (except T1 and T3); all the treatments were superior to the control (47% budbreak), especially T2 (72.6%) and T9 (70.0%). The percentage of fruit set was similar in all treatments with the control (15.0%), except in T2 and T3, which set 7% more fruit.

625

Use of Sod Competition in Peach Production

*D.M. Glenn** and *W.V. Welker*, USDA/ARS, Appalachian Fruit Research Station, Kearneysville, WV 25430.

Planting sod beneath peach trees to control excessive vegetative growth was evaluated from 1987 to 1993 in three field studies. Peach trees were established and maintained in 2.5-m-wide, vegetation-free strips for 3 years, and then sod was planted beneath the trees and maintained for 5 to 7 years. Reducing the vegetation-free area beneath established peach trees to a 30- or 60-cm-wide herbicide strip reduced total pruning weight/tree and weight of canopy water shoots in many years. Fruit yield was reduced by reducing the size of the vegetation-free area in some, but not all, years; however, yield efficiency (kg yield/cm^2 of trunk area) was not reduced in two studies, and in only 1 year in the third study. Planting sod beneath peach trees increased available soil water content in all years and yield efficiency based-evapotranspiration (kg yield/cm soil water use + precipitation) in some years compared to the 2.5-m herbicide strip. Reestablishing sod beneath peach trees has the potential to control vegetative growth and may be appropriate for high-density peach production systems where small, efficient trees are needed.

633

The Management of Sod Proximity Increases Peach Productivity

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Mature peach trees were grown in six different-sized vegetation-free areas (VFA) (0.36 to 13 m^2) with and without stage-III drip irrigation for 6 years. As the VFA increased, so did the trunk cross-sectional area, total yield/tree, large fruit yield/tree, and pruning weight/tree. The application of supplemental irrigation increased yield of large fruit and leaf N percentage in all VFAs. Winter hardiness was not affected by either size of the VFA or irrigation. The yield efficiency of total fruit and large fruit decreased, however, with the increasing size of VFAs. The smaller VFAs resulted in smaller, more-efficient trees. Managing the size of the VFA was an effective, low-cost approach to controlling peach tree size and, when combined with irrigated, high-density production, offers a potential for increased productivity.

637

Preliminary Performance of Six Scab-resistant Apple Cultivars in Northwestern New Jersey

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Six scab-resistant apple cultivars, Enterprise (CO-OP 30), CO-OP 36, Liberty, Freedom, Nova-Ez-Grow, and NY-754 were propagated on M.26 EMLA. Trees were planted in 1990 in a randomized complete-block design with six replications, five trees per replication. 'Empire'/M.26 EMLA was the control cultivar. Tree spacing was 3 m apart in the row and 6 m between rows. Trees were individually staked and trained to a modified spindle bush. Precocity, bloom counts, tree height and width, TCA, cumulative yield efficiency, and fruit quality have been determined annually. 'CO-OP 36', 'Enterprise', and 'Liberty' had significantly higher cumulative yields in 1993–94 than the other cultivars. The same three also had significantly superior fruit quality characteristics. 'Liberty' was the most precocious of the scab-resistant cultivars, very similar to 'Empire'. 'Liberty' was also the weakest-growing cultivar, followed by 'Empire'.

641

Early Growth and Yields of Scab-resistamt Apple Cultivars

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Apple scab is the primary disease that drives commercial pesticide recommendations; therefore, the use of cultivars that are resistant to this disease would help in reducing chemical inputs in apple production. To date, there has been only limited information on the performance of the scab-resistant apple cultivars. In 1990 and 1991, apple cultivars that are resistant to apple scab were planted at two sites in Pennsylvania, one site was the Fruit Research and Extension Center (FREC) in south-central Pennsylvania, and the other was the Horticulture Research Farm (HRF) in central Pennsylvania. Horticultural characteristics measured were trunk cross-sectional area (TCSA), flowering characteristics, yields, and fruit maturity. Trees at the FREC produced fruit 1 year earlier than those at HRF. 'Enterprise'/M.26 has been the most-productive cultivar at FREC, as measured by average total weight of fruit per tree. At HRF, 'CO-OP 26'/M.26 had been the most-productive cultivar. At the end of the 1994 growing season, 'CO-OP 26' and 'Williams Pride', both on M.26, are the largest trees as measured by TCSA at HRF. At the FREC, 'Enterprise' was the largest cultivar.

645

Growth and Production of 'Bing' and 'Schmidt' Sweet Cherries on East Malling or Mazzard x Mahaleb Rootstocks

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'Schmidt' and 'Bing' sweet cherries were planted in 1982 at the W.S.U. Royal Slope orchard near Othello, Wash. 'Schmidt' was on Mazzard x Mahaleb (M x M) rootstocks 39, 97, 14, and Mazzard seedling. 'Bing' was on East Malling (E.M.) cherry rootstocks 38, 15, 21, 16, 50, and Mazzard and Mahaleb seedling. Yield of 'Schmidt'/M x M 39 was greater than all other rootstocks. Trunk diameters of 'Schmidt' were greatest on Mazzard and M x M 39. If a standard-size tree is desired, M x M 39 may be useful. 'Bing' trees on the E.M. rootstocks tended to be larger than on Mazzard or Mahaleb and are, therefore, not of great interest.

649

Rooting Systems of Semi-hardwood Olive Cuttings of Three Selected Varieties of Manzanilla, Sevillana, and Clonavis

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Propagation testing of semi-hardwood olive cuttings was conducted to ensure adequate production to meet Iranian needs. 'Clonavis', 'Sevillana', and 'Manzanilla' were selected to investigate their rooting situations. Three variables (cultivar, differential concentrations of IBA, and vertical cut in the basal end of the cuttings) were considered in a randomized complete-block factorial design test with four replications with 10 cuttings in each treatment. Cuttings 10 to 15 cm long and 0.5 to 1.5 cm in diameter were taken from each cultivar. IBA (0, 2000, 3000, and 4000 ppm) was used in two vertical cuts in basal end of half of the cuttings. Statistical analysis of the rooting capability differed for the three cultivars. 'Sevillana' and 'Clovanis' rooted better than 'Manzanilla'. IBA at 3000 ppm resulted in the highest rooting percentage in all cultivars. The maximum number of roots was obtained with IBA at 4000 ppm in roots that had the basal cuts. Basal end cuts affected considerably the rooting percentage and number of roots, but had no effect on increased root length.

653

Effects of Municipal Solid Waste (MSW) Compost Mulch on Growth, Yield, and Soil Analysis of Papaya (*Carica papaya* L.)

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Municipal solid waste compost was applied with a side delivery applicator on top of the bed as a mulch in May 1993, 6 months after transplanting at Homestead, Fla. Papaya ('Know You No1') was grown with and without compost mulch. Compost was distributed on the surface of the bed ≈90 cm wide and 5 cm thick. There were no mulch effects on trunk diameter nor plant height. Plant height was affected by papaya sex 4 and 6 months after transplanting. Hermaphroditic plants were taller than female plants. There were no mulch effects on marketable yield per plant, marketable size, or number of cull fruit. Sex, however, influenced papaya size and total cull number. Hermaphroditic plants produced larger marketable fruit and more cull fruits than female plants. Lower plant mortality rates were found after 1.5 years in the mulched plants compared to unmulched plants. Soil and tissue analysis showed no differences in N, P, K, Mg, S, Mn, Fe, Cu, and B, except for Zn. Zinc contents in soil and tissue were higher in the mulched areas than unmulched areas.

657

Selective Pruning of Young Lemon Trees to Increase Fruit Size

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Growth of young lemon trees (*Citrus limon* Burm. f.) is extremely vigorous, and is characterized by the appearance of highly vigorous upright shoots that originate in the scaffold branches and trunk of the tree. While maturing, these shoots are considered to be in competition for photosynthates with smaller fruit in the spring and with mature fruit in the fall. During 1993 and 1994, we selectively removed these shoots 12, 6, 4, and 1 (1994 only) times per year, with the objective of increasing fruit size. Neither yield nor fruit quality was affected by the pruning treatments during 1993, but pruning trees 12 times per year increased fruit size by 30% compared to unpruned trees. In 1994, lemon trees pruned 4 times per year had 50% less cull fruit than unpruned trees, and 22% more fruit of size 140 or larger. However, >99% of the flowers and small fruit on trees pruned 4 times per year were aborted, compared with 95% abortion on the unpruned trees. Trees pruned 4 times per year also had 40% less yield compared with those that were unpruned.

661

Effect of Yield and Mite Infestation in Four Strawberry Cultivars due to Rowcover Application in a Subtropical Region

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Yield and mite infestation were studied in 'Chandler', 'Milcin', 'Milsei', and 'Oso Grande' strawberry, as affected by floating rowcover application (R) inside a greenhouse in Beirut. Results showed that R reduced yield of all cultivars in comparison to noncovered (C) plants, primarily by the reduction in fruit number ($P \leq 0.05$), during the winter and spring harvests. Cultivars varied in yield, irrespective of the cover treatment ($P \leq 0.05$) and in yield distribution over the 4 months of harvest ($P \leq 0.05$). The shading effect of R offset the slight rise in soil temperature it caused. Air temperature did not drop to a level that would stop plant growth. Red spider mite infestation started after rowcover removal. Mite adult, larva, and egg populations were comparable between the R and C treatments ($P > 0.05$). Miticide sprays were the effective way to control mites. It is recommended from this study not to use rowcovers on greenhouse-grown strawberries in the Mediterranean region.

665

Yield, Growth, and Weed Control in Four Strawberry Production Systems

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Field plots of four production systems of 'Tristar' dayneutral and 'Earliglow' June-bearing strawberry *(Fragaria* x*ananassa* Duch.), established in 1993, included conventional practices (CONV), integrated crop management practices (ICM), organic practices using granulated corn gluten meal, a natural weed control product, (ORG-CGM), and organic practices using a natural turkey manure product (ORG-TM). 'Earliglow' total yield from CONV plots in 1994 was similar to ICM and ORG-CGM, but greater than ORG-TM. Average berry weight and marketable yield were greater in the CONV system than both organic systems. CONV, ICM, and ORG-CGM plots had more runners and daughter plants than ORG-TM. Plots with CONV herbicide treatments were similar to ICM and ORG-CGM for percentage weed cover 1 month after renovation. 'Tristar' crown number, crown and root dry weights, yield, and berry number were reduced when plants were grown under straw mulch in ORG-CGM and ORG-TM compared to CONV and ICM plots with polyethylene mulch.

669

Recycled Newspaper: An Effective Mulch for Micropropagated Raspberry Transplants

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Micropropagated 'Redwing' raspberry plants were grown with various mulch treatments to determine their influence on vegetative growth and fruit yield. Treatments included shredded hardwood bark mulch; degradable black plastic; sawdust; wheat straw; ground, shredded, or ground + shredded newspaper; and an unmulched control. During the year of establishment, high soil and air temperatures near the surface of the black plastic most likely reduced plant survival. The following year, vegetative growth and fruit yield of plants that were previously mulched with black plastic were also reduced. Plants mulched with bark, sawdust, straw, and all newspaper treatments had greater yields than those established with black plastic or in the unmulched control plots. Although yields were similar among plants in all newspaper mulch treatments, ground newspaper was lost under windy conditions and tended to mat down after rainfall, resulting in soggy soil conditions.

673

Weed Management Methods Influence Growth of 'Navaho' Blackberries

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In Sept.1993, 'Navaho' blackberries were planted in raised beds in a converted bermudagrass hay meadow. Tall fescue was planted between the beds. There are three plants per plot and nine replications with 1.3 m between plants, 3 m between plots, and 5 m between rows. Each row is one replication. The plots are 3 m wide and 3.9 m long. Weed management treatments were applied in a randomized complete-block design, and included: alfalfa (*Medicago sativa*) cover crop, rye (*Secale cereale*) cover crop, herbicide (simazine and oryzalin) and hoeing, mowing volunteer vegetation, and hardwood sawdust mulch 8 to 10 cm deep. In Spring 1994 and 1995, data were taken on weed populations in each of the plots. In early 1995, the blackberry plants were measured. Data taken included cane number, cane length, and cane diameter. Early results indicate that the best blackberry plant growth occurred when rows were maintained with no mulch or vegetation by application of herbicides and hoeing. However, these plots sustained significant soil erosion, which may result in decreased plant productivity over time.

677

Effect of Irrigation and Fertilization on 'Tifblue' Rabbiteye Blueberry

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The effects of varying rates of a complete fertilizer and trickle irrigation on the growth an fruit yield of 'Tifblue' rabbiteye blueberries were determined in a 6-year field study. For the first 3 years, plants fertilized with the lowest rate (150 g/plant per year) had lower plant volume and fruit yield than plants receiving the higher rates (300, 600, and 1200). For the remainder of the study, fertilizer rates did not influence plant growth or fruit yields. The influence of irrigation rates (3 to 27 liters/plant per week) on growth and yields was less evident during the 1st and 2nd years, but became more pronounced in the 3rd and 4th years of the study. In general, plants receiving the lowest irrigation rate grew and yielded less than plants irrigated at the other rates. By the 6th year, however, there were no significant differences in fruit yield due to irrigation rates or fertilizer levels.

681

Minimal Pruning Influences Vegetative and Reproductive Growth of 'Ruby Cabernet' Grapevines

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Grape growers in the southern San Joaquin Valley of California are increasingly concerned about production costs. Reduced demand for wine grapes from this district has resulted in low prices and a decline in grower profitability in recent years. Minimal pruning is a low-cost production system that was developed in Australia more than 20 years ago. This system offers complete mechanization of pruning and harvesting. In general, there is little information available on the use of minimal pruning in California vineyards. The propose of the experiment was to compare the effects of hand and minimal pruning on growth, yield, and fruit composition of 'Ruby Cabernet' grapevines. This experiment was conducted in a commercial vineyard near Huron, Calif., during the 1993 and 1994 seasons. Minimally pruned vines had more shoots and fewer mature nodes than hand-pruned vines. Yield and components of yield were also significantly altered by pruning method. Minimal pruning produced the highest yield and number of clusters, while hand-pruning resulted in larger berry weight, cluster weight, and number of berries per cluster. Pruning method did not significantly affect fruit composition.

685

Relative Vigor Following a Severe Freeze of 18 Wine-grape Varieties at Brownfield, Texas

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Texas Tech Univ., in collaboration with the Texas Agricultural Experiment Station, Lubbock, maintains a research vineyard at Brownfield. Texas. Thirty-one wine-grape varieties are being evaluated for performance on the Texas High Plains. The vines were planted on their own roots in a completely randomized design with four replications and two plants per replication. The average rainfall, including supplemental irrigation, was ≈550 mm/year. Sufficient data exist for comparison of 18 varieties during the 1992–1994 seasons, following a severe freeze in Nov. 1991. The vines were trained to a horizontal bilateral cordon and spur-pruned with two buds per spur and 10 to 12 spurs per vine. Pruning weights were taken from the surviving vines during the 1993–1995 dormant seasons. Pruning weights were used as a direct estimate for plant vigor. The varieties exhibiting lowest vigor included 'Carmine', 'Pinot Blanc', 'Pinot Noir', and 'Ruby Cabernet', while those exhibiting highest vigor included 'Semillion', 'Chenin Blanc', 'Muscat Canelli', and 'French Columbard'.

689

A Decision Support System for Designing the Spatial Characteristics of Field Plantings at Any Global Location to Optimize Available Canopy Insolation during Any time Period

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A decision support system (DSS) is described that quantitatively analyzes certain important light climate characteristics of crops planted in discrete canopy, hedgerow, or trellis cropping systems. The DSS facilitates rapid and efficient calculation of the theoretical maximum shading (or, conversely, the theoretical minimum level of insolation) for use in determining the planting pattern that minimizes canopy shading during user-specified temporal intervals. It addresses canopy shading in field plantings within a wide variety of geometric patterns, interplant spacings, canopy sizes and forms, global latitudes, pattern orientations, site reliefs and aspects. Calculations describe insolation characteristics during any hour(s) of the day or day(s) of the year within the range of planting parameters. The DSS functions as a systems tool, or module, for design of the spatial subsystem component of a particular cropping strategy where horticulturally important traits are regulated by the light climate.

693

Repeated Measures Analyses for Tree Fruit Experiments

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Experiments with perennial crops often span several years, and a response variable may be measured on the same plant at several points in time. Such data are often analyzed as a split-plot design, taking time as the split-plot factor. In other cases, separate analyses are performed for each time. The mathematical conditions required for validity of these types of analyses might not hold because measurements repeated on the same plant are not independent. Annual trunk cross-sectional-area (TCSA) measurements from a peach tree training experiment will be used to compare two methods of analyses. The 6-year experiment was a factorial of two heading heights at planting (low vs. high) and two tree forms (central leader vs. open vase). Univariate analysis of variance (ANOVA) and a multivariate repeated measures analysis (MANOVA) was performed. Main effects and interactions were more often significant with ANOVA than with MANOVA. ANOVA performed each year inflated the probability of falsely rejecting a true null hypothesis (Type I error), and was not appropriate for this data set.

697

Protective Rain Covers Influence the Rain-inducing Cracking and Quality of Sweet Cherries

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For many years, researchers and growers have attempted to find methods to alleviate the rain-induced cracking of sweet cherries. Cracking is thought to be caused primarily by the osmotic uptake of rain water through the fruit skin. A 3-year study was conducted at East Malling to test the hypotheses that rain covers reduce, while irrigation increases, fruit cracking. Two types of rain shelters, with and without trickle irrigation, were compared against control treatments on 8-year-old 'Merchant'/Colt trees. Covers reduced cracked fruit by up to 11% in 1991, 7% in 1992, and 25% in 1993 when natural cracking on uncovered trees was ≈20%, 25%, and 40%, respectively. Trickle irrigation was associated with a 6% increase in fruit cracking in all 3 years. Tree covers and irrigation also tended to increase fruit size and maturity. Fruits from beneath covers were lower in soluble solids concentration and were firmer in comparison with fruits from uncovered trees. This study indicates that tree covers, while affording some protection against rain-induced cracking, do not altogether prevent the problem. Furthermore, irrigation appears to aggravate cracking when used with tree covers. A mechanism for cracking under covers will be discussed in relation to rainfall, fruit transpiration, and tree water relations.

705

Effect of Hydrogen Cyanamide (Dormex) on Replacing Lack of Chilling in Kiwifruit (*Actinidia deliciosa*)

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It has been shown that the 'Hayward' kiwifruit requires ≈1000 chilling hours for satisfactory production of female flowers, leading to full cropping in the southeastern United States. Part of the area along the Gulf Coast frequently suffers from inadequate winter chilling, resulting in poor cropping of 'Hayward'. Studies were conducted over a 4-year period in a mature 'Hayward' planting near the Gulf Coast to evaluate the efficacy of hydrogen cyanamide sprays in replacing lack of chilling and improving cropping. Rates of 2%, 3%, and 4% (v/v) of 50% Dormex significantly increased yield, with the highest rate providing the maximum yield. Fruit size and overall fruit quality from Dormex treatments were good. Dormex sprays performed quite well when only 600 to 700 chilling hours were received in the test area.

82 POSTER SESSION 12
Greenhouse Management/Cross-Commodity

885

Iron Chelate Photodegradation in Fertilizer and Nutrient Solutions Affect Iron Acquisition

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Iron chelate photodegradation is a problem in tissue culture where limited soluble Fe in agar reduces callus tissue growth. Our objectives were to determine if Fe chelate photodegradation occurs in commercial fertilizers used in greenhouse plant production and, if so, the effects on plant Fe acquisition. Commercial 20N–10P–20K soluble fertilizers containing Fe-EDTA were prepared as 100x stocks based on a 100 mg N/liter (1x) concentration. A modified Hoagland's solution with Fe-DTPA was prepared as a 10x stock based on a 200 mg N/liter (1x) concentration. Samples then were kept in darkness or were irradiated with 500 $\mu mol \cdot m^{-2} \cdot s^{-1}$ from fluorescent and incandescent sources for ≤240 hours. Soluble Fe in the irradiated commercial fertilizer solutions decreased 85% in 240 h. Soluble Fe in the Hoagland's solution, prepared in the lab, decreased 97% in 72 h. There was no loss in soluble Fe in any dark-stored treatment; demonstrating photodegradation of Fe-chelates under commercial settings. Excised roots of marigold (*Tagetes erecta* L.), grown hydroponically in the irradiated solutions, had Fe(III)-DTPA reductase activity 2 to 6 times greater than roots of plants grown in solutions kept in darkness. Plants growing in irradiated solutions acidified the rhizosphere more than plants growing in solutions kept dark. The increase in Fe reductase activity and rhizosphere acidification are Fe-efficiency reactions of marigold responding to the photodegradation of Fe-chelates and subsequent decrease in soluble Fe in both commercial fertilizers and lab-prepared nutrient solution.

889

Endosulfan Sprays on Bract Disorders of Poinsettia Gross Supjibi

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Bract edge burn (BEB) has been observed in different greenhouse operations

across North America over the past 10 years. The symptoms develop at anthesis or shortly after shipping. Varieties such as 'Supjibi', 'V-14 Glory', and 'Celebrate 2' are considered susceptible cultivars. A number of trials using endosulfan (Thiodan) have been conducted. In 1993, 'Supjibi' branched poinsettias were sprayed with either Thiodan, Decis, Thiodan + Decis, or water or remained unsprayed. The sprays were applied in week 39, 42 or 45. For each treatment period, plants were treated three times at 4-day intervals at label recommendations. At anthesis (week 47), plants sprayed with Thiodan or Thiodan + Decis during week 39 showed necrosis in the margin of the transitional bracts. In 1994, single spray applications in week 39, 40, 41, 42, or 45 of Thiodan, Ca (400 ppm), Thiodan + Ca in a tank mix, unsprayed, or Thiodan followed by four calcium sprays (weekly) in November. At week 48, all treatments except the latter showed necrosis, except this time it was marginal flecking in the transitional or primary bracts. In Spring 1995, single vs. multiple Thiodan applications were compared.

893

Effect of Double Anti-fog Claddings on Greenhouse Energy Consumption, Microclimate, and Cut-flower Growth

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qA 3-year study was undertaken to quantify the effect of four greenhouse covering materials on energy consumption, microclimate, and the growth and production of cut flowers *Matthiola incana* (Stocks) and *Antirrhinum majalis* (Snapdragons) in the greenhouse. The four materials are single glass (GL), polyethylene (PE) + anti-fog 1-year polyethylene (AF1), polyethylene + antifog 3-year polyethylene (AF3), and polyethylene + anti-fog thermal polyethylene (AFT). The effect of thermal screen and supplementary lighting (60 $\mu mol \cdot m^{-2} \cdot s^{-1}$) also are discussed. This study indicated that AFT film is the most energy efficient material and AF3 film is the most transparent to photosynthetic active radiation (PAR). For stocks, good quality can be obtained in GL and AF3 in terms of spike length, stem diameter, as well as number of buds and flowers. The stocks in GL, however, always possess the highest photosynthetic capacity, regardless light treatment. For snapdragons, the growth and flowering in PE houses were significantly improved by supplementary lighting

897

Effects of Chlormequat Chloride Rate on Growth and Development of Several Aster Cultivars

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Our purpose was to determine growth regulators rate effects on growth and development of aster *Callistephus chinensis.* During Spring 1993 and 1994, six aster cultivars were sown into 200-unit plug trays containing Pro-Mix PGX. Seedlings were transplanted into 10-cm pots containing Pro-Mix. Two weeks after transplanting, seedlings were sprayed with chlormequat chloride (CCC) at 750 or 1500 ppm and were compared to nontreated plants. A second application was applied 2 weeks later. Growth and development of asters were affected differently depending on cultivars and experimental season. During Spring 1994, a CCC treatment of 750 and 1500 ppm significantly reduced height and width of Dwarf Carpet Mix and Dwarf Spider Mix without affecting the number of flowers and total production time compared to nontreated plants. Growth regulator treatments had no effect on height and width of 'Milady Mix' and 'Starlight Rose'. However, the 750 ppm CCC treatment reduced the number of flowers produced by these two cultivars. Results obtained in 1993 also are presented.

901

Evaluations of Organic Residues for the Production of Flowering Pot Plants

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During Spring–Summer 1994, seedlings of *Impatiens walleranc* 'Accent Coral' and *Pelargonium* x *hortorum* 'Orbit Hot Pink' were grown in a commercial substrate (PRO-MIX BX) or in one of two substrates composed of six organic residues (composted water treated sludge, forestry compost, fresh or composted used peat extracted from a biofilter during treatment of municipal water, and fresh or composted paper sludge). These residues were incorporated with peatmoss and perlite at 5%, 10%, 25%, and 40% by volume to obtain the 24 substrate combinations. Plants were watered and fertilized by flooding ebb-and-flow benches. Growth measurements (growth index, top and root dry weight, number of flowers and buds, visual quality) varied considerably depending or the percentage of residue incorporated into the substrates. Moreover, substrates containing 40% of organic residues are not recommended for the production of impatiens and geraniums.

905

Factors Contributing to Cuticle Cracking in Greenhouse Tomato Fruit

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Cuticle cracking (also known as russeting, rain checking, or shrink cracking) can significantly reduce the quality of greenhouse-grown tomatoes, adversely affecting appearance and shelf-life. In this study, the effects of several environmental and cultural factors on cuticle cracking were assessed. Plants ('Trust') were grown at one of three nutrient feed concentrations, with electrical conductivities (ECs) of 0.7, 2.0, and 4.0. Higher EC initially reduced the amount of cuticle cracking. Over 14 weeks, the amount of cracking increased in all treatments and the differences due to EC became less evident. Over this same interval, 24-h average relative humidity (RH) gradually increased and was correlated with the increase in cracking. Further analysis showed that this relationship was due primarily to an increase in nighttime RH. No other climatic conditions were related to cracking. To test the possibility that the increasing age of the crop also could have contributed to the increased cracking over time, two crops of different ages grown in the same greenhouse were evaluated for cuticle cracking. The older crop consistently showed a greater amount of cracking than the younger crop. Our data suggest that EC is useful in controlling cuticle cracking under some conditions, but that nighttime RH or possibly some factor associated with crop maturity may override the effects of EC.

909

Vapor Pressure Deficit (VPD) Effects on the Physiology and Yield of Greenhouse Tomato

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Tomato production represents >70% of all greenhouse vegetables produced in Quebec, Canada. To obtain high yields and high quality fruit, an adequate control of greenhouse environmental characteristics, including the vapor pressure deficit (VPD), is necessary. Our study examines four VPD treatments (0.5 kPa day and night, 0.8 kPa day and night, 0.8 kPa day 0.5 kPa night, and automatic VPD management according to transpiration) and three photoperiods [12 h, 14 h, and variable-12 h (summer) 16 h (winter)] on growth, yield, and photosynthetic capacity of tomato plants. Greenhouse temperature was maintained at 22C day/18C night. Pure CO_2 was injected into the greenhouse to maintain a constant atmospheric concentration of 800 ppm throughout the experiment. Growth, yield, and leaf mineral composition were determined monthly for each treatment during the experiment. The photosynthetic rate of the 5th and 10th leaves also were measured in addition to the content of chlorophyll a and b. Our results indicated an increase in total yield and photosynthetic rate under a VPD of 0.8 kPa during day and night. An increase in leaf mineral concentration also was noted in plants grown under high VPD. Differences in yield and photosynthetic capacity were not found between the three photoperiods studied. However, there was a tendency to have higher yields under longer photoperiods.

913

The Harrow Expert System for Greenhouse Vegetables

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Greenhouse crop production technology is advancing rapidly, and the management of greenhouse crops has become increasingly difficult. Computerized environment and fertigation control of greenhouse crops grown in soilless media offer opportunities for unparalleled manipulation of crop growing conditions. However, the optimization of crop growing conditions for maximum productivity must be practiced with an eye on environmental regulations; worker health concerns; consumer demands for safe food; and ultimately on energy, water, fertilizer, and pesticide use economy. Managing the complex greenhouse cropping system requires a multidisciplinary approach that integrates pest and disease protection strategies with routine cultural practices and environmental and

fertigation regimes into a common decision-making process or Integrated Crop Management strategy. This poster describes an Expert System for greenhouse cucumber management based on a general model of Integrated Crop Management for greenhouse crops.

917

A Comparison of Cucumbers Grown in Rockwool and Perlite at Two Leachate Percentages

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Cucumbers (*Cucumis sativus* L. 'Vetomil') were grown in rockwool or perlite to evaluate these media for efficient hydroponic cucumber production under Florida greenhouse conditions. Plants were grown using a double-stem training method, and the frequency of irrigations was controlled by a weighing lysimeter for each treatment. In experiment 1, plants were grown in rockwool with 29% or 17% leachate and in perlite with 17% leachate. Nutrient concentrations in the solution were N, P, and K at 175, 50, and 180 mg·liter^{-1}, respectively. In Expt. 2, nutrient concentrations were increased to N, P, and K at 225, 60, and 225 mg·liter^{-1}, respectively. Other nutrient concentrations and leachate percentages remained as in Expt. 1. When nutrients were limiting, as in Expt. 1, yields (number and total weight of fruit) were higher from plants grown in rockwool at 29% leachate than from plants grown in rockwool or perlite at 17% leachate. However, when nutrient concentrations were increased in Expt. 2, higher total fruit weight was harvested from plants grown at the lower percent leachate and there was no difference in fruit number. In both experiments, cucumbers did not differ in yield when grown at the same percent leachate in either rockwool or perlite.

921

Effect of Humidity on the Transpiration of Greenhouse Tomato Crops

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Experiments were conducted in four independently controlled greenhouses. The purpose of these experiments was to measure the effect of humidity on transpiration and yields. Four different humidity treatments were evaluated: 1) high night and high day humidity levels (vapor pressure deficits <0.4 kPa), 2) high night and low day humidity levels (VPD >0.8 kPa), 3) high night and low day humidity levels, and 4) variable greenhouse humidity to maintain a set hourly transpiration rate. Transpiration rates were measured in the four greenhouses at 15-min intervals from Nov. 1993 to May 1994. Results show that high humidity reduces the hourly and daily transpiration levels significantly and has an impact on crop yields. Results also show that it is possible to regulate crop transpiration by calculating the transpiration rate for a set of VPD and solar radiation levels.

925

Energy Consumption Due to Dehumidification of Tomato Greenhouses under Northern Latitudes

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Transpiration and water uptake play an important role in the growth of horticultural crops, such as tomatoes. Water uptake ensures the transport of nutrients. However, the transpiration rate is affected by the humidity level in the greenhouse. High levels of humidity restrict transpiration and lead to fungal diseases resulting in yield losses. Under northern latitudes, using more airtight structures combined with high levels of artificial lighting increase the humidity level inside the greenhouses. To decrease humidity, growers have to dehumidify by ventilating and heating at the same time, leading to increased energy consumption. However, to our knowledge, the literature does not report on the energy consumption needed to dehumidify. To evaluate this energy consumption, we used a greenhouse simulation model of heat and mass exchanges integrated into a general greenhouse control and management software system (GX). Evapotranspiration, condensation on the cladding, and infiltration and ventilation rates were taken into account for the water balance. Based on 1 year of climatic data, three sets of simulation were realized: 1) no dehumidification; 2) standard dehumidification by ventilation and heating; 3) dehumidification with heat exchangers. Results indicate that for an acceptable level of humidity within a greenhouse tomato crop (vapor pressure deficit >5 kPa), the energy consumptions with standard dehumidification and with heat exchangers are 25% and 15% higher, respectively, than without dehumidification. These results are being used to establish recommendations for the management of humidity under northern latitudes.

929

Effects of Cultivars and Culture Systems on Yield and Postharvest Quality of Greenhouse Tomato

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Our purpose was to determine cultivar and culture system effects on yield and postharvest quality of greenhouse tomato *Lycopersicon esculentum.* Nine tomato cultivars were sown into rockwool cubes on 2 Feb. 1994. The plants were transplanted into peat bags or nutrient film (NFT) systems on 9 Mar. Harvesting began on 2 May until 26 Sept. for a total of 21 harvest weeks. Fruit yield, rejected or nonmarketable fruit and four fruit quality indicators (fruit texture, color, titrable acidity, and soluble sugars) were measured during the harvest period. In addition, these indicators were further evaluated every 7 days during 28 days of storage at 20C and 90% RH for 'Trust' and 'Cencara', a long shelf-life cultivar. 'Bounty', 'Panther', and 'Cencara' gave higher yields on rockwool but 'Irazu', 'Correct', '73-53', and 'Medallion' gave better results on NFT. 'Trust' produced the best yield for either rockwool or NFT. Culture systems (peat bags or NFT) did not affect fruit quality. 'Cencara', which is a long shelf-life cultivar, kept high texture quality until 28 days of storage. However, titrable acidity of 'Cencara' was higher and soluble sugars content was lower than that of 'Trust'

933

Development of a Greenhouse IPM Program in Pennsylvania

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The dramatic reduction in available greenhouse insecticides and the potential for increased insect resistance has necessitated a change in insect control techniques. Because of the large acreage of greenhouse production in Pennsylvania and the need for a more environmentally effective method of controlling insects in greenhouses, an aggressive Integrated Pest Management research program was initiated and has been on-going since 1989. Our objectives were to develop a bibliography of major insect pests; to determine effectiveness of parasitoids on greenhouse and silverleaf whitefly, western flower thrip, and aphids; to reduce pesticide usage; and to comply with worker protection standards. The program was implemented by a joint venture among the Pennsylvania State Univ. faculty and technical staff, grower cooperators, the Pennsylvania Dept. of Agriculture, and the Pennsylvania Vegetable Growers Association. The IPM program was started with an active scouting and monitoring program in commercial houses to determine threshold levels. Control measures were implemented with biological controls, cultural management, and lastly chemical. In addition, the implementation of the results of this research to commercial growers has resulted in the formation of a Greenhouse Crop Management Association. Results of the 5-year research program are discussed.

937

Computer-based System for Dynamic Control of Greenhouse Tomato Grown in NFT System

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To achieve high yield and better quality of soilless greenhouse tomato, it is necessary to keep the nutrient concentrations in the root environment at the target levels. Dynamic control of the nutrient solution composition can be used for this purpose. We developed a computer program that dynamically adjusts nutrient solution compositions based on various climatic and agronomic characteristics. The program integrates nutrient uptake and crop transpiration models and is part of a general-purpose greenhouse management and control software system developed at Laval University (GX). The architecture of the system and some simulation results comparing the effect of various control scenarios on the evolution of the composition of nutrient solutions are presented.

89 POSTER SESSION 13
Temperature Stress/Cross-Commodity

482

Low-temperature Tolerance in *Vaccinium Angustifolium* L.: Variation within Two Wild-managed Populations

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During the winters of 1993–94 and 1994–95, 54 clones of *Vaccinium angustifolium* were evaluated for low-temperature tolerance of inflorescence buds. During both seasons, clones were tested periodically, starting right after leaf drop, continuing through mid-winter, and finally through spring loss of low-temperature tolerance. Plants showed greatest variation in lowest survival temperature (LST) during fall and spring sampling dates, and the least variation on the mid-winter dates. In the 1993–94 study, clonal LSTs for November buds ranged from –5 to –27C; January buds showed LST variation of 6C. April buds showed a similar trend to that observed in late November. LST variation is discussed relative to clonal selection for ornamental and commercial use.

485

Irrigation Scheduling, Nutrient Application Frequency, and Freezing Acclimation of 'Hamlin' Orange Trees in Florida

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'Hamlin' orange trees [*C. sinensis* (L.) Osb.] from a commercial nursery were planted into raised beds on a site that simulated conditions typical of the flatwoods region of the citrus industry. A factorial experiment with three irrigation schedules, based on growth flushes and three nutrient application frequencies (total N, 0.136 kg/tree per year), was conducted in 1994. Trees were irrigated using 90° microsprinklers, and soil moisture content was monitored using a neutron probe. Eleven replicate trees of the nine treatments were included in a completely randomized block design. Weekly freeze tests using the electrolyte leakage method were conducted at –4, –6, and –8C. Electrolyte leakage was determined using a conductivity meter. Different irrigation scheduling based on growth flushes had no significant effect on freezing acclimation. However, increased frequency and lower amounts of fertilizer per application significantly ($P = 0.05$) increased freeze hardiness from 4.2 to –6.10C by the end of November. Morphological data including trunk diameter, tree height, and flushing status also were recorded. Increasing frequency of nutrient application resulted in a more rapid acclimation of young 'Hamlin' orange trees.

489

Sensitivity of Seedling Radicles to Chilling and Heat-shock-induced Chilling Tolerance

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Chilling sensitivity increased as the radicle of germinating corn (*Zea mays* L. 'Jubilee' hybrid), cucumber (*Cucumis sativus* L. 'Poinsett 76'), mung bean (*Phaseolus aureus* Roxb. 'Berkin'), and tomato (*Lycopersicon esculentum* Mill. 'Rio Grande') seeds increased in length from 1 to 7 mm. In contrast, radicles of germinating okra (*Hibiscus esculentus* L. 'Clemson' spineless) seeds exhibited similar levels of chilling sensitivity at all radicle lengths. The degree of chilling sensitivity varied among the species in relation to time required to elicit a significant response and the magnitude of the elicited response. Based on subsequent radicle elongation, okra and cucumber were the most sensitive species to chilling at 2.5C for 96 h; tomato and corn were relatively less sensitive, and mung bean was the least sensitive. This pattern of sensitivities changed when other criteria were used to evaluate chilling sensitivity. The development of lateral roots decreased with prolonged chilling in all species, except for corn in which the apical tip remained viable even after 192 h of chilling. Heat shock (0 to 10 min at 45C) induced chilling tolerance in all species, except okra. In okra, neither increasing the heat shock temperature nor decreasing the severity of chilling (i.e., temperature and duration of exposure) resulted in a significant reduction in chilling injury. The differential induction of heat shock proteins in okra and the other species is discussed.

490

Controlled Freezing of Herbaceous Perennials

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Fifteen perennials were subjected to four to six (depending on species) levels of controlled freezing in chest freezers to determine killing temperatures. Average potting medium temperatures in six 1-liter pots of each species per freezing treatment were allowed to drop to target temperatures before plants were removed from freezers. Plants were held at 5 ± 2C for 3 months before freezing and for 24 hours after freezing before placing at 1 ± 2C. Two weeks after freezing, plant regrowth was rated on a scale of 1 to 5, 1 being dead, 3 being salable, 5 being normal (as controls of no freezing). Temperatures at which plants dropped below a 3 rating—not reliably hardy at that temperature—were –2C for *Aster lateriflorus horizontalis* and *Tricyrtis formosana* 'Amethystina'; –6C for *Caryopteris* x*clandonensis* 'Longwood Blue', *Phlox paniculata* 'David', *Tiarella cordifolia collina* 'Oakleaf', *Tricyrtis hirta* 'Miyazaki', and *Veronica* 'Sunny Border Blue'; -9C for *Astilbe* 'White Gloria', *Hemerocallis* 'Joan Senior', *Leucanthemum* x*superburn* 'Alaska', and *Tiarella c.c.* 'Dunvegan' and ≤13C for *Monarda* 'Marshall's Delight', *Phlox paniculata* 'White Admiral', *Tiarella c. c.* 'Laird of Skye', and *Achillea* 'Coronation Gold'.

494

Cold Hardiness of Evergreen Azaleas Increased by Water Stress Imposed at Three Days

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The effect of water stress on cold hardiness was examined in evergreen azaleas, 'Coral Bell' (CB), 'Hinodegiri' (HD), and 'Red Ruffle' (RR). Plants were well-watered between 8 Aug. and 1 Nov. (wet) or were subjected to 3 weeks of reduced water supply starting on one of three dates, 1 Aug. (dry 1), 29 Aug. (dry 2), and 19 Sept. (dry 3). Cold hardiness of leaves and lower, middle, and upper stems was tested on 29 Aug., 19 Sept., 10 Oct., 1 Nov. By the end of each 3-week period, water potential of water stressed plants reached –1.5 to –1.8 MPa compared to around –0.8 MPa of well-watered plants. Reducing the water supply significantly increased cold hardiness of all tested plant parts in all cultivars regardless of timing of watering reduction, with two exceptions, CB middle stems on 29 Aug. and HD leaves on 19 Oct. Three weeks after rewatering cold hardiness of water-stressed plants did not differ significantly from well-watered plants, except for HD plants under dry three treatment, which continued to be 1.0 (middle stems) to 4.3 (upper stems) more cold hardy.

498

The Interaction of Photoperiod and Temperature on Cold Hardiness and the Accumulation of Soluble Sugars in Two Cultivars of Southern Magnolia (*Magnolia grandiflora* L.)

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Decreasing photoperiods and decreasing temperatures induce cold acclimation and the accumulation of soluble sugars in many plants. Two cultivars of southern magnolia differing in cold hardiness and acclimation patterns, were monitored to determine photoperiod x temperature interaction on cold hardiness and soluble sugar content. Cold hardiness increased with low temperatures and short photoperiods. Total soluble sugars, sucrose, and raffinose consistently increased in the leaves and stems of both cultivars in response primarily to low temperature. 'Little Gem' was less responsive to photoperiod than 'Claudia Wannamaker'

502

Morphological Characteristics of Evergreen Azaleas Correlate with Freezing Survival of Flower Buds

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Frequent winter injury to flower buds is a major deterrent to the widespread landscape use of evergreen azaleas in the northern United States and southern Canada. Field observations indicate that azalea cultivars differ greatly in their capacity for cold acclimation during the fall. Azaleas also express wide variation in morphological features, such as leaf number, density, percent abscission, twig length, flower bud development rate, number or bud scales, and petal color. We attempted to correlate these characteristics with the establishment of flower bud cold tolerance during the fall season. Young (3-year-old) plants of more than 60

azalea cultivars were investigated under nursery conditions. Twigs were subjected to controlled freezing to quantify frost tolerance of flower buds. Percent live florets per bud and number of dead florets per bud were correlated with morphological characters. Floret development (floret length and style length) correlated positively with cold acclimation. Stem and leaf characters showed no consistent correlation with bud cold tolerance. Petal coloration, although not expressed at time of study, also correlated with cold acclimation. The extent of flower bud development proved to be the best indicator of fall and early winter frost tolerance.

506

Low-temperature Exotherms and Freeze Tolerance in Three Taxa of Deciduous Trees

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Although differential thermal analysis has been routinely used to evaluate cold hardiness, the relationship between deep supercooling ability and plant survival is not clear. We compared seasonal profiles of changes in low-temperature exotherm (LTE) occurrence and visually determined lowest survival temperature (LST) of *Acer rubrum* 'Armstrong', *Fraxinus americana* 'Autumn Purple' and *Zelkova serrata* 'Green Village' growing in three locations representing plant cold hardiness zones 8, 7 and 5. Between December and February, LTE in *Acer rubrum* and *Fraxinus americana* occurred at temperatures 10 to 25C lower than the LST. The difference between LTE and LST was not significant for *Zelkova serrata* from January to April, and for *Acer rubrum* and *Fraxinus americana* in March. Data indicate that LTE could be used as an estimate of LST in *Zelkova serrata* but not in *Acer rubrum* and *Fraxinus americana.* This study demonstrated that LTE does not provide a reliable estimate of cold hardiness in all species that deep supercool.

510

Survival of Zoysiagrass Genotypes Following Low-temperature Exposure

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Zoysiagrass rhizomes were sampled at various intervals, from October through March, to determine their susceptibility to low-temperature injury. Five-node rhizome sections of the following genotypes were subjected to sub-freezing temperatures at each date: 'Belair', 'DAL 8507', 'El Toro', 'Emerald', 'Korean Common', and 'Meyer'. Rhizome sections of each cultivar were wrapped in moistened cheesecloth, enclosed in aluminum foil, and placed in a freezing chamber at –2C. After 2 h at –2C, samples then were cooled at 1C/h to temperatures estimated to result in tissue injury. Fifteen rhizomes of each genotype were removed from the chamber at each test temperature. After thawing for 12 h, rhizomes were planted and regrown in a growth chamber at 34C day/28C night for 4 weeks. In the freezing test conducted on 12 Oct. 1994, rhizomes of 'Meyer' and 'Emerald' had greater shoot regrowth than those of 'El Toro' after exposure to –6C. The only rhizomes that produced shoot growth after exposure to –8C were those of 'Korean common', 'Meyer' and 'Belair'.

514

Frost Tolerance of Black Spruce Seedlings (*Picea Mariana*) during Budbreak

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Spring frosts frequently cause significant damage to conifer seedlings during bud flushing and shoot elongation in forestry nurseries. To ensure adequate protection, levels of frost sensitivity must be known during these stages of development. Eight-month-old, containerized, black spruce seedlings were submitted to freezing temperatures of 0, –4, –6, –8, and –10C for 1, 2, 3, 4, 5, and 6 h at the following stages: 1) nonswollen buds; 2) swollen buds; 3) bud scales bursting, needle tips emerging; and 4) shoot elongation, 1 to 5 cm. After the treatments, seedlings were grown for 90 days in a greenhouse. Seedling survival then was estimated; dead seedlings discarded; and damage to buds, needles, and roots and shoot increment and diameter were measured on the remaining seedlings. Results show that frost sensitivity increases with the developing bud and shoot. A decrease in seedling and bud survival was noted with an increase in time of exposure (stages 2, 3, 4); otherwise, time exposure has no effect. Damage to needles and roots increases and diameter decreases with decreasing temperatures at all stages. Shoot increment was influenced by decreasing temperatures at stages 2 and 3 only.

518

Evaluation of a Green Roof System in a Northern Climate: The Effects of a Roof Microclimate on Growth and Development of Six Herbaceous Perennials

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Green roof systems are now common in many European countries. Aside from aesthetic considerations, these systems present many environmental advantages in urban planning ecology. A flat roof surface (250 m^2) was rebuilt on the top of a 30-year-old building. Our objective was to determine the effects of roof microclimate on the growth and development of six herbaceous perennials: *Ajuga reptans*, *Arenaria verna* 'Aurea', *Armeria maritima*, *Draba aizoides*, *Gypsophila repens*, and *Sedum Kamtschaticum.* Rooted plants were transplanted into an artificial substrate at three depths (5, 10, and 15 cm) in a 36-m^2 area. A special protective covering (Soprafiltre) was installed over the growing area. The following result are presented: temperature variations (winter–spring–summer) at crown and root-zone level, plant hardiness, growth index (height x width), and flowering.

522

Low-temperature Limits for Selected Garden Mums

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Controlled-freezing tests were conducted in Dec. 1994 and Jan. 1995 to determine cold hardiness of garden mums (*Dendranthema grandiflora* Tzvelev.) 'Baby Tears', 'Debonair', 'Emily', 'Megan', 'Ruby Mound', and 'Triumph' grown outdoors in central Iowa. Dormant, intact crowns were harvested from the field on 3 Dec. and held at 2 ± 2C until freezing tests began. Crowns were placed in moist cheesecloth, wrapped in aluminum foil, and subjected to –12, –18, –24, or –30C. Cooling was initiated from the storage temperature (2C) at 2 ± 0.5C/h. Treated crowns were allowed to thaw for 24 h at 2 ± 2C. Control and treated crowns then were planted in 3.5-liter (#1) plastic containers using a medium of 2 Canadian sphagnum moss : 2 perlite : 1 field soil (by volume), and transferred to a 21 ± 3C glasshouse for forcing under natural photoperiod. Regrowth data indicate 'Ruby Mound' was the least cold hardy selection as most failed to resume growth after exposure to –12C. 'Emily', 'Megan', and 'Triumph' survived exposure to –12C; however, vegetative regrowth was diminished compared to controls. 'Baby Tears' and 'Debonair' demonstrated no diminution of ornamental utility after exposure to –12C.

526

Cold Hardiness of Three Woody Plants

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To examine injuries caused by freezing temperatures, three woody plants were placed under temperatures ranging from 0 to –20C. Control plants were placed at 0 or –2 C, depending on the field sampling period. Freezing tests were done three times during the fall: Sept., Oct. and Nov., 1993. *Spiraea* x *bumalda* 'Flamingmount', *Spiraea callosa* 'Alba', and *Spiraea* x *bumalda* 'Crispa' were tested. After freezing tests were complete, all plants were stored at –2C for the remainder of winter. In May, plants were repotted into containers. Effects of freezing temperatures on plant growth were recorded at the end of the summer. Results indicated that the most sensitive species to cold temperatures is *Spiraea* x *bumalda* 'Crispa'. Moreover, the response of plants to the September freezing test was too variable to give a valid statistical analysis. Regression analysis was used as a tool to determine the temperature at which there is a 25% reduction in growth of the stem and the root dry matter, respectively. Results obtained in October are as follows: *Spiraea* x *bumalda* 'Crispa', –6 and –7.6C; *Spiraea* x *bumalda* 'Flamingmount', –10 and –8.7C; and *Spiraea callosa* 'Alba' –10.7 and –11.5C. Results obtained in November are as follows: *Spiraea* x *bumalda* 'Crispa', –7.1 and –8C; *Spiraea* x *bumalda* 'Flamingmount', –12.2 and –12.3C; and *Spiraea callosa* 'Alba', –8.5 and –8.7C. The reduction in cold hardiness observed for *Spiraea callosa* 'Alba' is caused by warmer conditions (20C) in which plants were placed 2 days before the freezing test.

530

Fatty Acid Composition of Plasmalemma Lipids Associated with Cold Tolerance of Sweetpotato (*Ipomoea batatas* L. Lam.)

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Plasmalemma lipid fatty acid changes due to low temperature (12C) were

observed in M521-1 and 'Travis', chilling-tolerant and -sensitive, respectively, genotypes. Lipid fatty acid changes found in both genotypes after exposure to chilling included decreased palmitic acid (16:0) and an increased unsaturated : saturated fatty acid ratio. Changes detected only in the tolerant genotype were increased linoleic (18:2), linolenic (18:3) and erucic (22:1). Monogalactosyldiglyceride and phosphatidylglycerol were the only lipids with >50% of their fatty acids unsaturated; therefore, it was concluded that these lipids were involved in the chilling tolerance of M521-1. A reduction in arachidonic (20:4) on phosphatidylinositol from 'Travis' exposed to 12C resulted in <50% unsaturation of this lipid. This change could be associated with the chilling sensitive response of 'Travis'.

534

Heat Tolerance in *Phaseolus lunatus*

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Heat stress on field grown *Phaseolus lunatus* (lima bean) can have a significant influence on yield. Lima bean crops grown in Delaware typically yield less pounds per acre than the same cultivars grown in California. Part of this effect may be due to extreme heat conditions or fluctuations during Delaware's summers, which can affect blossom and pod set. Our purpose was to analyze the heat tolerance of various cultivars of *P. lunatus* using quick bioassays and to establish a relationship to yield in greenhouse temperature trials. Two assays were used. The first, a hypocotyl extension assay, consisted of a treatment of germinated seedlings at 25, 35, or 42 for 2 h and observations of hypocotyl extension at 72 and 96 h posttemperature treatments. Three cultivars ['Fordhook' 1072 (heat-sensitive), 'Jackson Wonder' (heat-tolerant), and 'Early Thorogreen' (heat tolerant)] were analyzed. Initial results indicated that 'Jackson Wonder' and 'Early Thorogreen' are capable of surviving the 42C heat shock, but 'Fordhook 1072' is not. In the second assay, we measured electrical conductivity of a solution containing hypocotyl sections following incubation at various temperatures (R_1). Tissue samples then were boiled and conductivity was measured again (R_2). The ratios of R_1/R_2 x 100 were determined as percent injury. Preliminary data suggests that 'Jackson Wonder' is more heat-tolerant in this assay than 'Fordhook 1072'. Subsequent experiments will analyze the induction of specific heat shock proteins as a function of cultivar-specific heat tolerance.

538

Soil Temperature and Tomato Root Growth Under Black Polyethylene and Hairy Vetch Mulches

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Temperature and root length at selected locations within a raised bed under black polyethylene (BP), hairy vetch (*Vicia villosa* Roth) residue (HV), or bare soil (BS) were measured and correlated with tomato (*Lycopersicon esculentum* Mill.) growth. Early in the season, before the tomato leaf canopy closed, soil temperature was influenced more by vertical depth in the bed than by horizontal location across the bed. Maximum soil temperatures under BP averaged 5.7 and 3.4C greater than those under HV at 5- and 15-cm depths, respectively. More hours at temperatures >20C during the first 4 weeks probably accounted for greater early root and shoot growth and greater early yield of tomatoes grown in BP rater than in HV or BS. After canopy closure, soil temperatures under tomato foliage were reduced compared to those on the outer edge of the beds. Most tomato roots were in areas of the bed covered by the tomato canopy where temperatures in all treatments remained in the optimum 20 to 30C range almost continuously. Soil temperature, therefore, did not explain why total yield was higher in the HV than the BP or BS treatments.

542

Thermal Analysis of Dormant Muscadine Grape Buds

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Thermal analysis was used to determine if muscadine grape (*Vitis rotundifolia* Michx.) buds supercooled and to determine the seasonal cold hardiness of several grape cultivars. Buds of the muscadine cultivars 'Carlos' and 'Summit', sampled from vines grown at Clarksville, Ark., produced low-temperature exotherms consistent with the number of buds tested. Apparent hardiness of the buds increased from 5 Nov. 1993 through 7 Jan. 1994. Mean low-temperature exotherms (MLTE) were lowest on 7 Jan. and were –21.5C for 'Carlos' and –23.4C for 'Summit'. Mars (*V. labrusca* L.) buds, sampled at Clarksville and Winchester, Va., were included in the study, and increased in hardiness during the same period. MLTE temperatures for 'Mars' from Arkansas were similar to those of the muscadine cultivars on 7 Jan.; however, 'Mars' attained lower MLTE temperatures with vines grown in Virginia compared to those in Arkansas. Location differences may be due to cultural conditions, sample handling, environment or other reasons.

546

Effect of Elevated Medium Sucrose Levels on Cold Hardiness of 'Festival' Red Raspberry in Vitro

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Low tissue-water content and increased osmotic concentration of cell sap are associated with frost resistance. Changes in total osmotic concentration of cell sap are due mainly to changes in concentration of sugars. Generally, sugar content increases with hardening and decreases with dehardening. This study examined the effect of elevated sucrose levels (3% to 15%) in the medium on the cold hardiness of 'Festival' red raspberry (*Rubus idaeus* L.) shoots in vitro. To determine whether expected hardening is caused by elevated sucrose levels or by osmotic stress, different levels of mannitol in the media have been tested. After growing raspberry shoots on media with different levels of sucrose and mannitol for 2 weeks, shoot moisture content (percent) was determined. Cold hardiness of the shoots was determined by using differential thermal analysis or artificially freezing the shoots and assessing the survival by regrowth test and visual rating.

550

The Occurrence of Blackheart Injury in Dwarfing Apple Stembuilders

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Apple trees of the tender cultivar Gravenstein were grown on four promising, dwarfing, stembuilders and two known hardy rootstocks to evaluate hardiness. After eight growing seasons and a "test winter" from 1992 to 1993, trees were subjected to a destructive harvest to assess the amount of blackheart. The extent of blackheart was used as an indicator of sublethal winter injury. The amount of blackheart in the stembuilder trunk was significantly different among stembuilders but not between rootstocks. The stembuilder Bud 9 had more blackheart than Dudley, Lobo, KSC 28, and Ungrafted (Dudley). Similarly, the percentage of blackheart in the scion part of the tree showed differences due to cultivars and stembuilders but no difference due to rootstocks.

554

Occurrence of Winter-kill to Apple Trees in the Okanagan Valley of British Columbia and Its Relation to Autumn and Winter Temperatures

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Winter freeze events, identified by horticulturists to lower yields or kill trees (estimates vary by year from 1000 to >200,000 trees), have occurred in the Okanagan Valley of British Columbia 18 times in 94 years (1 in 5 years). To determine the association of winter temperatures and production, 72 years (1920–91) were separated into quartiles by level of production. Then, a maximum χ^2 value was produced by a scanning iterative technique comparing each of the extreme quartiles with the combined mid-quartiles. A strong association was found between level of production and the low minimum temperatures in November, December, and February but not January. This result agrees with the historical records that indicate three winter-kill events occurred in November, five in December, one in January, and three in February during the same time period. Warm temperatures in September were associated with low production, indicating the possibility that warm temperatures at this time delay acclimation. Warm temperatures in January also were associated with low production, indicating a possible effect in hastening deacclimation.

558

Seasonal Patterns of Dehydrins in Bark Tissue of Eight Species of Woody Plants

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Studies with herbaceous crops have indicated a similarity in the types of proteins that accumulate in response to environmental stresses and ABA. Many of these proteins belong to a group called dehydrins. We have identified a 60 kDa dehydrin-related protein (PCA 60) in peach associated with cold hardiness. Our objective was to determine if seasonal induction of dehydrins are a common feature in a wide array of woody plants Bark tissues from eight species of woody plants were collected monthly for 1.5 years. The species included: *Prunus persica* 'Loring'; *Malus domestica* 'Golden Delicious'; *Rubus* sp. 'Chester'; *Populus* sp.; *Salix babylonica*; *Cornus florida*; *Sassafras albidum*, and *Robinia Pseudo-acacia*. Protein extraction, SDSPAGE, and immunoblotting were performed as previously reported. Immunoblots were probed with a polyclonal antibody recognizing a conserved region of dehydrin proteins (provided by Timothy Close). Although some proteins, immunologically related to dehydrins, appeared lo be constitutive, distinct seasonal patterns associated with winter acclimation were observed in all species. The molecular weights of these proteins varied, although there were similarities in related species (willow and poplar). Although this study represents a precursory examination of dehydrins, the results indicate that these proteins are common to woody plants and that further research to characterize their function is warranted.

562

Vegetative Growth and Gas Exchange of Apple at High Temperature

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Our objective was to determine the potential for acclimation to high temperature in apple. 'Imperial Gala'/Malling 26 EMLA and ungrafted Malling 26 EMLA tree were grown in growth chambers under four temperature regimes: 1) 25C for 42 days; 2) 35C for 42 days; 3) 25C for 21 days, followed by 21 days at 35C; and 4) 35C for 21 days, followed by 21 days at 25C. Response of net CO_2 assimilation (A) to leaf temperature from 20 to 35C was measured at 21 and 42 days. Response to CO_2 from 0 to 1000 ppm was measured at 42 days. Trees were separated into leaf, stem, and root fractions; dried; and weighed. High temperature increased the number of leaves per tree and reduced leaf size and leaf dry weight but did not affect leaf area, stem, and root dry weight. The apparent and minimal acclimation of A to high temperature is discussed.

566

Temperature Stress Enhances Antioxidant Enzyme Activities Associated with Budbreak in Woody Plants

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The ability of low and high temperatures to overcome endo- and paradormancy along with the possible mechanisms involved in these treatments for breaking apple (*Malus domestica* Borkh. 'Anna') bud dormancy were studied. All these treatments induced budbreak in paradormant (in July) and endodormant (in October) buds. Cold and heat treatments increased ascorbic acid, the reduced the form of glutathione (GSH), total glutathione, total non-protein thiol and non-glutathione thiol, whereas dehydroascorbic acid and oxidized glutathione (GSSG) decreased. The treatments also increased the ascorbic acid : dehydroascorbate and GSH : GSSG ratios and the activity of ascorbate-free radical reductase, ascorbate peroxidase, dehydroascorbate reductase, ascorbate oxidase, and glutathione reductase in the buds. These results indicate that budbreak induced by cold and heat treatments is associated with the removal of free radicals through activated peroxide-scavenging systems.

570

Cabium Browning of Cold-damaged Peach Trees in the Nursery

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One-year-old peach trees in nurseries at McMinnville, Tenn., were exposed to –11C on 5 Nov. 1991 before digging. The nursery owners were concerned about the relationship of tree cambium browning to potential tree performance after planting. A color scale [0 = nondamage (white) to 6 = severely damaged (brown)] showing discolored cambium of peach nursery trees was developed to rate damage. Browning was rated at 8 cm above graft union. Five trees each of nine cultivars with chill hour requirements ranging from 175 to 1050 were rated. Cultivars with <500 chill hour requirement had higher ratings. Ten 'Harbite' trees from each of six size grades were rated. Trees in grades of 30- to 90-cm height had less cambium browning than trees in grades of 90 to 152 cm height. In Dec. 1992, 1-year-old 'Red Globe' trees were exposed to –6 (minimum field temperature), –15, –18, –24, –30, or –35C in a programmable freezer. A subsample of five trees per treatment was rated for browning 1 day after treatment and a second subsample rated in mid February. Trees in a third subsample were grown in a nursery the following summer. Slight browning (rating = 1.6) was evident soon after exposure to –24C; however, severe browning was evident on trees exposed to –30 or –35C. Trees exposed to temperature more than –24C did not differ in height, trunk diameter, or dry weight at the end of the growing season, however trees exposed to –30 or –35C did differ. In a similar experiment, 'Juneprince' trees exposed to –18C had slight cambium browning (rating = 1.2) but trees died.

574

Pecan Cold Hardiness Determined by Differential Thermal Analysis

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Our objectives were to 1) Determine acclimation and deacclimation patterns of buds and stems of four pecan cultivars in Mississippi and 2) to determine the relationship between cold hardiness, based on DTA, and tissue injury, based or viability tests. Stem critical temperatures for September showed that 'Hughes' was slower in acclimating than 'Jackson'. Maximum hardiness for all cultivars occurred in January, except for 'Desirable', which reached maximum hardiness in December but started deacclimating in January. Deacclimation for the remaining cultivars started in February. Bud critical temperatures for September and October also show that 'Hughes' was slower in acclimating compared to the remaining cultivars. Maximum bud hardiness for 'Desirable' occurred in December, with the remaining cultivars reaching maximum hardiness in January. Bud deacclimation for all cultivars occurred in March. The LD_{50} for the tetrazolium and electrolyte leakage tests occurred at about –32 and –30C, respectively. In buds, LT50 for the tetrazolium test was –18C. The LT_{50} electrolyte leakage and browning test was –20C.

578

The Effect of Heat Shock on the Induction of Chilling Tolerance in Cucumber Seedling Roots

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Heat shock was applied to 32-h-old cucumber seedlings before chilling at 2.5C. Two cultivars, 'Poinsett 76' and 'Ashley', with different chilling tolerances, were tested. Using root growth after chilling as a measure of chilling tolerance, three heat shock regimes were found to induce chilling tolerance in both cultivars, with the most effective and uniform induction by heat shock at 40C for 3 h. 'Ashley', the more chilling tolerant cultivar, exhibited a greater response to heat shock induction of chilling tolerance than 'Poinsett 76'. Protein samples from roots were subjected to SDS-PAGE. Three low molecular weight heat shock proteins accumulated to a greater extent in the protein profile of heat-shocked 'Ashley' roots. No such increase was found in the 'Poinsett 76' roots. The induction of low molecular weight HSPs are discussed in relation to the heat-shock induction of chilling tolerance.

90 POSTER SESSION 14
Growth Regulators/Cross-Commodity

660

Propagation of Cretan Silver Bush (*Ebenus cretica* L.), A Potential New Flower Crop

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Ebenus cretica, Leguminosae, is a characteristic endemic plant of the Mediterranean island of Crete. It is a perennial bush up to 1 m tall with composite pubescent leaves and pinky red or purple flowers on 5- to 20-cm-long racemes.

The fruit is surrounded by the calyx and contains one seed. The plants grow on rocky hillsides in alkaline soils at an altitude of up to 600 m and flower from April to June. *Ebenus* has the potential for use as a container or landscape flowering plant, and this study was aimed at finding methods to propagate it either by seed or by shoot cuttings. Seed collected from native plants in late July/Aug. 1992 germinated well (70% to 90%) without scarification in a commercial potting mix. Fifty percent of the seed germinated in vitro between 13 and 25 days, depending on temperature and substrate used. Temperatures of 25 or 30C in light at a pH ≈6.0 favored germination. Removal of the dry calyx coating the seed enhanced germination and emergence. For rooting *Ebenus* cuttings, several concentrations of IAA, IBA, and NAA were used in combination with different types of cuttings (soft or hardwood, tip or basal, cultivated or wild). Best results were obtained by wounding the base and dipping shoot-tip cuttings (12 cm long) in 600 mg IBA/liter for 16 hours. Significant differences, however, were observed among germination and rooting percentages when seeds or cuttings were taken from different plants due to genetic diversity. Therefore, selection is required for optimal results.

664

Bird Pepper (*Capsicum annuum* L. var. *aviculare*) Growth and Fruiting Response to Pinching and Uniconazole Sprays

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Preliminary experiments using uniconazole (UNZ) sprays at 5 and 10 ppm on bird pepper indicated that UNZ could be used to enhance appearance and improve fruiting of bird pepper, but some refinement of UNZ rates needed to be made. A final experiment was conducted to determine rates of UNZ and pinching level required to maintain a suitable plant size and increase yield and total number of red fruits. Best overall effects were on plants single-pinched 4 weeks after sowing and treated with a foliar spray of 4 to 6 ppm UNZ. Higher UNZ levels produced overly compact plants that required staking of individual branches. Attractiveness of double-pinched plants may be enhanced by delaying UNZ application after the second pinch. Bird pepper, therefore, can be produced as a dual-purpose pot plant by single-pinching followed by foliar applications of UNZ at 4 to 6 ppm.

668

Stem Elongation Response of 'Stargazer' Oriental Lily to Bulb Dips in Uniconazole

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Shoot elongation of 'Stargazer' lily is rapid during the first 15 to 20 days after planting (1 to 2 cm·day^{-1} is common). Lower stem leaves are small, separated by long internodes. We determined if dipping 'Stargazer' bulbs in uniconazole (5-, 10-, 20-, or 40-ppm solutions for 1 min) before planting would slow initial stem elongation, decrease final height, and improve appearance. Emergence, visible bud, anthesis dates, and flower bud count were recorded. Plant height was measured three times per week until anthesis. Uniconazole did not affect time to emergence, visible bud, anthesis, or flower bud count. Compared to the final height of 48 cm (untreated plants), height was reduced 7, 17, 22, and 30 cm (5%, 35%, 46%, and 62%) at anthesis for plants in the 5-, 10-, 20-, and 40-ppm treatments, respectively. The uniconazole bulb dips did not affect stem elongation rate for the first 10 days after treatment or from 45 days after treatment through anthesis (day 65). Relative to untreated plants, stem elongation rate of treated plants decreased linearly from 10 to about 35 days after treatment, with a maximum reduction of 55%, 75%, 85%, and 100% for plants in the 5-, 10-, 20-, and 40-ppm treatments, respectively.

672

Varietal Differences between Two Cultivars of *Viola tricolor* 'Blue'

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Seeds of 'Majestic Giant Blue Shade' and 'Medallion Blue/Blotch' were initially begun in plug trays and later transplanted into flats of 32s. Observations included percent germination, rate of emergence, plant heights before treatment of plant growth regulators (PGR), plant fresh weight, plant dry weight, plant height after treatments, and visual appearance. PGR treatments included paclobutrazol at 16 and 25 ppm, uniconazole at 2 and 4 ppm, and B-Nine as the control. 'Majestic Giant' had a higher percent germination rate and rate of emergence than 'Medallion'. Overall growth of Medallion seemed to be behind by ≈5 days when compared to that of 'Majestic Giant'. The 'Medallion' group showed more of a response to PGR treatments than 'Majestic Giant'.

676

Susceptibility in the Growth of *Viola tricolor* 'Blue' to Plant Growth Regulators and Fish Emulsion

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A one-time application of fish emulsion 2 days before the application of plant growth regulators (PGR) showed an overriding effect on the growth of pansies. Blue/blotch shades of 'Medallion' pansies were placed on a constant feed program of 100 ppm Peat Lite 20N–10P–20K, with half of the pansies receiving an additional one-time supplement of fish emulsion. PGRs and rates included B-Nine, 0.5% (used as the control); uniconazole, 2 and 4 ppm; and paclobutrazol, 16 and 25 ppm. Parameters taken included plant height, top fresh weight, top dry weight, days to anthesis, and visual appearance. Significant differences were noted in the plants receiving the supplement for plant dry weight, plant height, and visual appearance. Plants receiving fish emulsion grew taller and denser than those on constant feed alone despite the effects of the PGRs.

680

Peach Blossom Thinning with Armothin

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Blossom thinning trials with AKZO Co. surfactant Armothin were carried out on fruitful peach cultivars Early Grande and Babcock during 1993–94. Effective thinning occurred before "full bloom" (40% to 90% FB) at 3% Armothin, increasing between 2% and 4%. However, an improved fruit distribution of 'Early Grande' was achieved by repeated application (35% + 75% FB) at 2%. A second spray at 3%, just after FB, thinned some late-blooming flowers on 'Babcock' trees, but a temporary leach scorch occurred, as well as with 4% Armothin (single spray) on both cultivars. For a single spray, the optimal stage was found within 60% to 90% FB, at 3% Armothin. Flower biology studies showed susceptibility of the petals to increasing Armothin concentrations at all stages, but pollen tube penetration into the pistils and subsequent fertilization failed only after an earlier application, before anthesis or pollination of the stigma. Within this range of concentration and timing, no damage occurred to the vital fruit set and to commercial yield, provided that weather conditions were favorable during bloom (and spray). Some corrective hand-thinning (20% to 60%) should be applied to the fruitful trees 3 to 4 weeks later to achieve optimal fruit size at harvest. Blossom hand-thinning is still practical in Israel.

684

Benzyladenine Effects on Cell Division and Cell Size during Apple Fruit Thinning

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Benzyladenine (BA), carbaryl (CB), daminozide (DM), and naphthaleneacetic acid (NAA) were applied postbloom, as fruitlet thinning agents, to mature 'Empire' apple trees. Although fruit set and yield were similar for BA, NAA, and CB, BA-treated fruit were larger, indicating BA increased fruit size beyond the effect attributable to thinning. BA applied at 100 mg·liter^{-1} increased the rate of cell layer formation in the fruit cortex, indicating that BA stimulated cortical cell division. The maximum rate of cell division occurred 10 to 14 days after full bloom (DAFB) when fruit relative growth rate and density reached a maximum and percent dry weight reached a minimum. Cell size in BA-treated fruit was similar to the control. Cell division ended by 35 DAFB in the control and BA-treated fruit when percent dry weight and dry weight began to increase rapidly and fruit density changed from a rapid to a slower rate of decreased density. These data support the hypothesis that BA-induced fruit size increases in 'Empire' apple result largely from greater numbers of cells in the fruit cortex, whereas the fruit size increase due to NAA or CB is a consequence of larger cell size.

688

Effect of Temperature on Chemical Apple Thinning Results

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An analysis of daytime high temperatures for the 10-year period from 1984 to 1993 indicated that, in the 21 days after full bloom (AFB) in 7 of 10 years, there were 3 days or more above 29.5C. In the 15- to 21-day period AFB, when fruit are considered at their optimum diameter (8 to 12 mm) for thinning, only 3 days

above 29.5C were recorded. In the 15 to 21 days AFB, the high temperature was only 24C for 7 out of 10 years. Thus, growers would have to spray at temperatures 5.6C degrees lower if they were to choose to spray the warmest 3 days during the 15- to 21-day period when fruit are 8 to 12 mm in diameter. NAA caused thinning of 'Golden Delicious' fruit at 8-mm fruit diameter. Tank mixing of one of several pesticides (regulaid or guthion, captan, carzol, imidan, polyram, lorsban, omite, or lannate) had no effect on NAA efficacy. Comparison of identical chemical thinning treatments (carbaryl + Accel + oil) applied to 'York' and 'Red Delicious' apple trees indicated that more thinning occurred with the PF treatments than at 8 mm. Average 2-day high temperatures at PF were 7.1C higher at PF for the 'Red Delicious' experiment and 5.6C higher for the 'York' experiment. The higher temperatures at PF could account for the differences in thinning response and not the spray timing. Pollination and fertilization inhibitors caused some fruit thinning at the highest rates and multiple applications. The MYX4801 caused more thinning and more injury to fruit than other materials. Endothall gave good thinning without fruit injury. Wilthin (GWN-6592) did cause some thinning, but fruit injury was a problem in one experiment.

692

Thinning Ontario Apples with Accel

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The use of chemical thinners is an essential component of commercial apple production in Ontario. As chemical thinning options decrease, due to environmental concerns, newer and less toxic alternatives must be found. Benzyladenine (BA), available in the United States as Accel, shows promise as a thinning agent. During the 1994 growing season, Accel was applied under commercial conditions to seven apple cultivars—'McIntosh' (spur), Delicious 'Starkrimson', 'Empire', 'Jonagold', 'Golden Delicious', 'Jonamac', and Gala 'Royal Gala'. Application concentrations ranged from 50 to 75 ppm (a.i. BA), depending on cultivar. Mean king fruitlet diameter at time of application ranged from 9 to 12 mm. The thinning response of Accel was compared with that of traditional chemical (e.g., carbaryl, NAA, or both) or mechanical thinning treatments. At the concentrations used in this experiment, thinning with Accel was comparable or better than traditional methods in the case of 'Gala', 'Jonagold', 'Empire', and 'Golden Delicious'. In those cultivar trials displaying an acceptable Accel thinning response, a significant fruit size increase also was observed.

696

Thinning and Enhanced Fruit Quality of Stone Fruits with Gibberellins

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Release LC (Abbott Laboratories), a commercial formulation of gibberellins, was applied to apricot, cling peach, freestone peach, nectarine, and plum varieties. Application was by commercial airblast sprayer. Fruit firmness was increased in the season of application in all crops. Meta analysis of the data indicated a maximum response for each crop differed over the rate range of 16 to 48 g a.i./acre. Changes in fruit soluble solids were slight. No differences in fruit color were observed. Reduction in flower bud density (thinning) was observed the following season. The reduction in bud density reduced the time required to hand-thin to a commercially acceptable level. A difference in thinning sensitivity to gibberellin was evident between crops.

700

Floral Response of Lime (*Citrus latifolia* Tan. cv. Tahiti) to Foliar Sprays of Hydrogen Cyanamide

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Flowering of 'Tahiti' lime/*C. volkameriana* Pasq. was studied in response to several levels of hydrogen cyanamide sprayed on isolated terminal twigs of 3-year-old plants growing under field conditions. The study was performed in the central region of Venezuela at 180-m altitude (lat. 9°43'N). Hydrogen cyanamide had significant effects on floral and total activity, and on generative, mixed, floral, and total shoot flux density, as well as on defoliation of sprayed twigs. Conversely, it did not show any significant effect on vegetative development, either as activity or shoot flux density.

0704

Effect of GA_3 Bloom Sprays on Fruit Set and Yield of Rabbiteye Blueberry

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Field and growth chamber experiments, and grower trials, were conducted to determine the effects of GA_3 sprays on yield and fruit quality of rabbiteye blueberry (*Vaccinium ashei* Reade) in northern Florida and southern Georgia. Multiple GA_3 sprays at various stages of flower development increased fruit set and yield in field experiments (Florida) and grower trials (Georgia) when compared to controls. Nonpollinated rabbiteye flowers sprayed with GA_3 had greater percent fruit set and delayed fruit development compared to hand pollination. Percent fruit set and average fruit weight were reduced at 21C night temperature when compared to 10C night temperature for both hand-pollinated and GA_3-treated fruit. Overall, yields were increased by multiple applications of GA_3 during bloom, but average fruit size was reduced and the fruit development period was lengthened.

708

Use of Ethephon as a Controlled Abscission Agent on Paprika Pepper

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Our objective was to increase the percentage of marketable red fruit at harvest time on paprika pepper (*Capsicum annuum* L.) plants intended for mechanical harvest by using ethephon [(2-chloroethyl)phosphonic acid] to remove late-developing blooms and green fruit. We conducted three experiments on field-grown plants in southwestern Oklahoma. We tested ethephon solutions of 0, 1000, 2000, 3000, and 4000 $\mu l \cdot liter^{-1}$ as a one-time foliar application on various dates. Total dry weight of harvested fruit decreased linearly with ethephon rate in all three studies. Marketable fruit as a percentage of total harvested fruit weight increased linearly with ethephon rate in two studies. There was no consistent effect of ethephon on the intensity of red pigment extracted from dehydrated marketable fruit. With proper timing, as little as 1000 µl ethephon/liter was enough to alter the distribution of total harvested fruit weight toward marketable fruit and away from green fruit. A target spray "window" of the last 10 days in September seemed appropriate for southwestern Oklahoma, and the recommended rate of ethephon was between 2000 and 3000 $\mu l \cdot liter^{-1}$.

712

Plant Growth Regulators and Yields of Seed Potatoes

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Seed potato growers seek to maximize yields of desirable sized tubers. This study examined how foliar applications of plant growth regulators influence yields of drop or single-cut seed tubers under field conditions. In 1993, paclobutrazol (PTZ; 300, 450, and 600 $mg \cdot liter^{-1}$), kinetin (KIN; 10 and 20 $mg \cdot liter^{-1}$), and methyl jasmonate (MJ; 10^{-7}, 10^{-6}, 10^{-5}, and 10^{-4} M) were applied to 'Norland' (NOR) and 'Russet Burbank' (RB) potatoes. In 1994, PTZ (300 $mg \cdot liter^{-1}$), KIN (both rates), and MJ (10^{-7} and 10^{-6} M) treatments were eliminated, and GA_3 at 250 $mg \cdot liter^{-1}$ or KIN at 20 $mg \cdot liter^{-1}$ was applied to some of PTZ treatments. In 1994, the cultivar Shepody (SH) also was included. Plants were treated at two growth stages; NOR (1993), RB (1993 and 1994), and SH (1994) were treated when tubers were <10 mm or <20 mm in diameter. NOR (1994) was treated at stolon initiation (no tubers) or early tuber initiation (<8 mm in diameter). PTZ had no effect on seed tuber (25–50 mm in diameter) yield in NOR in either season. PTZ increased seed tuber number (STN) in RB by 29% to 40% and in SH by 57% to 70% over the controls. KIN had no effect on STN in any cultivar. MJ had no effect on STN in NOR (1993) or in RB in either season or in SH in 1994. In 1994, the highest rate of MJ (10^{-4} M) increased STN in NOR by 40% over the controls. GA_3 had no beneficial effect on STN when applied after PTZ. This study suggests that, under field conditions, PTZ can increase seed tuber production in RB and SH while MJ was effective in NOR potatoes.

716

Apical and Distal Pieces of Aged Potato Tubers Respond Differently to Paclobutrazol

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The influence of paclobutrazol, an inhibitor of GA synthesis, on kindertuber

formation was studied using 13.5-month-old 'Russet Burbank' potato (*Solanum tuberosum*) tubers. Suberized apical and distal tuber pieces of equal weight were sprayed daily with distilled water (control), 0.001 and 0.01 mg paclobutrazol/liter with or without 2.5 mg kinetin/liter, and 2.5 mg kinetin/liter alone. The tuber pieces were held in the dark (20C) and harvested 8, 16, and 22 days after the first treatment. Only sprouts developed from control apical piece eyes after 22 days. There was an average of 3.6 sprouts/eye, which, in total, weighed 735 mg. Sprouts (2.4/eye) from treated apical piece eyes averaged 46 mg. By 22 days, 0.001 mg paclobutrazol/liter plus kinetin applied to apical pieces resulted in the most kindertubers, 1.9/eye. The largest kindertubers (1.2 g) were produced from apical pieces treated with 0.001 mg paclobutrazol/liter. At each harvest and regardless of treatment, distal tuber pieces produced larger sprouts and more sprouts per eye than apical pieces. Kindertubers developed from distal piece eyes only with the paclobutrazol plus kinetin treatments. Distal eyes produced half as many kindertubers as apical eyes treated similarly. Apical pieces treated with kinetin alone produced fewer sprouts than control pieces, and fewer tubers than paclobutrazol-treated pieces. Sprout weight per eye of kinetin-treated apical pieces was one-third that produced by control pieces and 5.1-fold greater than that of paclobutrazol-treated pieces. A similar trend was observed with sprout weight from distal eyes. Results suggest lowered GA levels are involved in kindertuber formation on aged potato tubers, and GA content or metabolism of distal pieces is unlike that of apical pieces. Distal tuber pieces do not form kindertubers as readily as apical pieces.

720

Chemical Growth Regulation of Landscape Groundcovers

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Landscape maintenance in Hawaii occurs year round. Many popular groundcovers are pruned monthly, some twice monthly. This increases labor costs and creates large amounts of waste. Several rates of five commercial growth regulators (cimectacarb, flurprimidol, mefluidide, paclobutrazol, and uniconazole) were applied to several groundcovers commonly grown in Hawaii. Species used include *Cuphea hyssopifolia*, *Evolvulus glomeratus*, *Lantana montevidensis*, *Myoporum* spp., and *Wedelia trilobata*. Studies were conducted in the shadehouse with potted plants and in the field with established plants. Rates, response, and method of application (spray or soil drench) for each product were evaluated. Growth, length of control, and phytotoxicity were measured. Flurprimidol, paclobutrazol, and uniconazole showed the greatest control for the most species. Flurprimidol and paclobutrazol controlled growth for the longest time, up to 4 months for some species. However, these materials resulted in the greatest amount of damage, even at low rates. Cimectacarb controlled growth of fewer species, while mefluidide caused the least growth reduction for all species.

722

Chemical Fruit Thinning with Armothin® Sprays to Reduce Fruit Set in 'Loadel' Cling Peach

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Hand-thinning is required every season to ensure large fruit size of 'Loadel' cling peach in California. Hand-thinning is costly. Chemical thinning could help to lower costs of hand-thinning. Armothin® {[*N*,*N*-bis2-(omega-hydroxypolyoxyethylene/polyoxypropylene)ethyl alkylamine], AKZO-Nobel, Inc., Chicago; AR} was sprayed at 80% of full bloom (FB), FB and FB + 3 days. The spray volume was 935 liters·ha^{-1}. Concentrations of AR were 1%, 3%, and 5% AR applied at FB. No damage to fruit was noted. Leaf and fine shoot phytotoxicity were seen at 5% AR. The amount of time needed and number of fruits thinned were reduced by those same treatments. Salable yield and fruit size after AR treatments equaled those found on hand-thinned controls. Armothin® shows promise for chemical thinning of peach when used as a bloom spray that damages flowers, thereby reducing fruit set. An experimental use permit was issued for use of AR for stone fruit thinning in California during 1995.

724

Controlling Vegetative Growth and Flowering of Four Azalea Cultivars with Uniconazole and GA

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Four azalea cultivars [*Rhododendron* x 'White Lace' (WT), 'Southern Charm' (SC), 'Formosa' (F), and 'George Tabor' (GT)] with different growth and flowering habits were treated with a foliar spray of uniconazole (U) at 0, 10, or 15 mg·liter^{-1} with or without a surfactant. GA was applied at 0 or 15 mg·liter^{-1} as a foliar spray to half of the plants on 23 Sept. 1993, 53 days after the uniconazole application. U reduced number, length, and dry weight of bypass shoots, and increased number of flower buds for all cultivars by Dec. 1993. Application of GA after U further increased the number of flower buds on SC and GT, which otherwise had few flowers. At the final evaluation in Mar. 1994, time to anthesis for cultivars F and GT was not affected by any treatment. Anthesis of SC and WL treated with 15 mg U and GA/liter started 6 days earlier than those treated with 15 mg U/liter. Number of flowers at anthesis and number of flower buds was increased two to four times on U-treated vs. nontreated plants. U decreased plant height, size, leaf area, and shoot dry weight of all cultivars. Shoot elongation of F and GT was further reduced with the 15 vs. 10 mg U/liter treatment. Application of GA increased the retarding effects of U on plant height for WL, SC, and GT, and on leaf area and shoot dry weight for WL.

728

Shading and DCPTA Interactively Influence Shoot Growth of *Hypoestes*

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The objective of this study was to determine if shading and DCPTA application interactively influence seedling emergence and shoot growth of *Hypoestes phyllostachya* Bak. seedlings. *Hypoestes* 'Carmine Red' seeds were soaked for 6 h in distilled water, and then soaked 6 h in solutions containing' 10 mg DCPTA/liter (30 mM) and 0.1% Tween-80, 0.1% Tween-80, or distilled water. Date of seedling emergence was recorded after sowing (0.5 cm) in 9-cm (460 ml) pots filled with 440 ml of a 5 pine bark : 4 Florida sedge peat : 1 sand medium. Forty pots from each of the three seed-soak treatments were grown under 30%, 63%, or 84% shading, provided by saran-type shadecloth, using natural photoperiods (completely randomized design). Shoot heights and dry weights were recorded 75 days after sowing. Neither shading nor DCPTA influenced total seedling emergence or seedling emergence rate (time to 50% emergence). Under 30% shading, seedlings from DCPTA-treated seeds were taller and had more shoot dry weight than seedlings from surfactant- or water-treated-seeds; however, DCPTA did not influence seedling height or shoot weight under 63% or 84% shading.

732

Agricultural Applications of Ethephon

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Physiological effects on plant growth caused by the plant hormone ethylene have been noted for many years. More than 100 years ago, workers noted that illuminating gas or broken gas mains had deleterious effects on surrounding trees or plants. It was not until the 1960s that scientists documented that plant growth may be manipulated by applying ethylene. Some of the biological effects since noted include premature defoliation, fruit maturation ripening, induction of flowering, stimulation of sprouting or germination, and shortening of plant height. These effects are noted on a wide variety of agricultural crops, including vegetables, field crops, tree crops, and ornamentals. Ethylene is a gas and dissipates rapidly, and, thus, does not lend itself to field application. In the 1960s, the product ethephon [(2-chloroethyl)phosphonic acid] was developed. When taken up by the plant, ethephon is converted to ethylene in the cells and becomes available for physiological interactions. Because ethephon precipitates a wide variety of biological reactions, application technology becomes extremely important. Factors such as plant growth stage, plant stress status, plant foliage spray coverage, ethephon rates, and environmental conditions determine the responses obtained. An example is provided by processing tomatoes, where the desired response is to maximize fruit maturity enhancement and minimize premature defoliation—both ethylene responses. We have selected five agricultural applications of ethephon as examples of how plant growth may be altered. These are: increased boll opening in cotton; enhanced pistillate flower induction in hybrid squash seed; accelerated fruit maturity in processing tomatoes; enhanced hull splitting in walnuts; and reduced lodging in wheat. Each of these applications, and others, are common in California agriculture. Brevity necessitates providing only a summary of relevant applied research activities, which are not intended to be complete or thorough. Details on specific ethephon applications may be obtained from that particular researcher.

113 POSTER SESSION 15
Genetics/Floriculture, Fruits, Cross-Commodity

906

Genetic Variation and Mapping of the Carrot Nuclear and Chloroplast Genomes

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Studies of genetic variation at the DNA level in the genus *Dacus* have been very limited. Molecular markers based on restriction fragment length polymorphism (RFLP) have been highly useful and efficient gene markers in other plant species. We have evaluated the chloroplast genome of 19 *Dacus* species and inbreds cut with 10 restriction enzymes and probed with 14 petunia chloroplast clones. A phylogenetic tree generated to date shows three major groupings of these accessions as seen with data generated by an earlier study using nuclear RFLPs. However, *D. glochidiatus* and *D. guttatus* are in different groups. Details of the chloroplast study will be discussed. Also, a genetic linkage map of carrot will be constructed. The map will be used to determine the genomic regions conditioning traits such as pigmentation root and core diameter, and root length.

910

Cytological Evidence for the Sterility of an Interspecific *Alstroemeria* Hybrid

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Self-pollinations of a diploid (2n = 2x = 16) interspecific hybrid from the cross of *Alstroemeria aurea* x *A. caryophyllaea* resulted in no seed set. Pollen viability studies with the hybrid demonstrated that only 5% of the pollen grains were viable. Cytological observations with the hybrid pollen mother cell (PMC) revealed abnormal chromosome behaviors, such as no pairing in Prophase I and Metaphase I, and bridges in the Anaphase I and II. Although the development of microspores appeared normal in shape until the stage of tetrad release, some chromosomes did not remain in the nucleus after completing meiosis, formed isolated groups of 1 to 4, and remained in the cytoplasm. This genetic imbalance of the microspores could be one of the causes for the abortion of the pollen grains in the late stage of development. Additional meiotic cytological studies with colchicine-induced tetraploids (2n = 4x = 32) derived from the hybrid plants showed that chromosome pairings were normal in most cases. However, self-pollination with the tetraploid plants failed to set seeds. These studies with the tetraploids further demonstrate that the sterility of the hybrid is due not only to chromosomal differences, but also to complex genic interactions.

914

Molecular Markers for the Scab Resistance (V_f) Region in Apple

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Apple scab, *Venturia inaequalis* (Cke.) Wint., is one of the most damaging diseases of apples. Although fungicide sprays have been used to control the disease, genetic resistance in existing commercially important varieties would be desirable. Identification of molecular marker(s) would be helpful in devising biotechnological approaches to control the disease. We used bulk segregant analysis to identify RAPD markers that cosegregate or display a tight linkage with V_f gene in Prima x Spartan cross. Using this approach, we are saturating the region around the scab resistance gene for the purpose of bracketing the locus. We have identified several markers associated with the V_f locus. The closest markers have been isolated and sequenced to be used as SCARs. The relationship and distances of the markers with the V_f locus and other previously reported markers will be discussed.

918

Identification of Simple-sequence Repeats in *Malus* (Apple)

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Simple-sequence repeats (SSRs) are efficient and informative DNA markers with great potential for germplasm characterization. When used to characterize large arrays of accessions, such as the core subset of the USDA/ARS *Malus* collection, SSRs may be more effective than other approaches, such as restriction fragment length polymorphism (RFLP) and random amplified polymorphic DNA (RAPD). For example, SSRs can be PCR-amplified and fluorescence-based detected; they also appear to be abundantly disbursed throughout plant genomes and yield abundant polymorphisms in most taxa studied. We are conducting an extensive screening of a size-fractionated library of *Malus* x *domestica* cv. Golden Delicious to identify and characterize selected SSR loci. We are applying genetic information revealed by SSR loci in combination with passport and horticultural data to better comprehend genetic identity and relatedness in *Malus* germplasm collections and help develop the *Malus* core subset. Ultimately, application of molecular marker data will permit improved conservation and use of genetic resources.

922

Chloroplast DNA Polymorphisms in Sweet, Sour, and Ground Cherry

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Sour cherry (*Prunus cerasus*) is an allotetraploid with sweet cherry (*P. avium*) and ground cherry (*P. fruticosa*) as the proposed progenitor species. Three cpDNA markers from eight sweet, four ground, and 26 sour cherry selections were analyzed to investigate the relatedness of their cp genomes. To date, two RFLP polymorphisms have been identified with both the P2 and P4 fragments of tomato cpDNA, while four length polymorphisms of an intergenic spacer have been identified by PCR amplification. Sweet and ground cherry have different cp polymorphisms, while sour cherry individuals have been identified that have the sweet and ground cherry polymorphisms plus a unique polymorphism. Additional individuals chosen to represent the diversity within each species will be screened to provide a more complete assessment of cp diversity. In addition, progeny from a sour cherry cross where the parents have different cp polymorphisms are being evaluated to determine if the chloroplasts are exclusively maternally inherited.

926

The Use of RAPD Markers to Determine Parentage in *Mangifera indica* L.

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To investigate the usefulness of RAPDs for determining parentage in mango, progeny arising from caged trees of the cultivars Keitt (FS_1) and Kent (FS_2) were analyzed. In the FS_1, 110 bands were generated, of which 78 (70.2%) were repeatable. Of these 78 loci, 23 were variable and segregated 3:1 as expected. In the FS_2, 142 bands were generated, of which 57 (40%) were not repeatable, 6 (4.2%) were present in the progeny but not in the parent, and 79 (56%) were repeatable. Thirty-nine of these loci were variable; however, only 21 segregated as expected. Apparently, the progeny arising from the caging of 'Keitt' are the result of self-pollination, while those arising from caged 'Kent' are not. The six bands found in the FS_2 but not in 'Kent' are reproducible and, along with the 46% anomalous segregation, indicate that cross-pollination did occur. The implications for mango breeding efforts are discussed.

930

Comparison of Four Pistachio Rootstocks in California

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Currently, the California pistachio industry relies on four rootstocks: two species and two interspecific hybrids—*P. atlantica*, *P. integerrima*, *P. integerrima* x *P. atlantica*, and *P. atlantica* x *P. integerrima*. The first three are open-pollinated, the last is the result of a closed pollination. The objective of these long-term trials is to compare rootstock behavior in the three major pistachio-producing regions of California. Three trials of 100 replications consisting of one of each of the four rootstocks were established in the three major growing regions of California in 1988. All the rootstocks in all three locations were budded with buds from the

same female and male trees. Thus, all differences in performance are the result of rootstock or local climate. Results thus far demonstrate that rootstocks with *P. atlantica* as the maternal parent are more cold tolerant; more efficient in boron, zinc, and copper uptake; less vigorous; less precocious; and more susceptible to *V. dahliae* than rootstocks with *P. integerrima* as the maternal parent. The results also demonstrate that pistachios in California's southern San Joaquin Valley will bear 1 year ahead of pistachios in the central San Joaquin Valley or the northern Sacramento Valley. Trees on rootstocks with *P. integerrima* parentage also bear earlier than trees on *P. atlantica* and have higher yield efficiencies. All are colonized by vesicular–arbuscular mycorrhizae.

934

A Comparison of Chloroplast vs. Nuclear Genome Analysis for the Development of a Phylogeny of the Genus *Juglans*

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Chloroplast DNA polymorphisms were obtained using a combination of RFLP analysis of total cpDNA and a combination of PCR amplification restriction of a 3.2-kb region of cpDNA described previously. Nuclear genome analysis was conducted using 21 RFLP probes that revealed 192 alleles. Parsimony analysis of nuclear DNA places *J. cinerea* between *J. regia* and other Asian species, while Wagner-Distance analysis places all North American species between them. cpDNA parsimony also placed the North American species between *J. regia* and remaining Asian species, but did not resolve the placement of *J. cinerea*, because all North American species were monomorphic. Both analyses support an ancient origin for *J. regia* and multiple migration events between North America and Asia.

942

Evaluation of SCAR Markers to Identify Raspberry Cultivars

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Random amplified polymorphic DNA (RAPD) markers are used in Quebec's certification program to verify the identity of raspberry cultivars. However, sequence characterized amplified region (SCAR) markers, less sensitive to modifications in reaction conditions, could be derived from RAPD markers. Our objective was to evaluate the potential of SCAR markers to replace the RAPD ones. Five RAPD markers obtained with primer OPG06 (length of 520, 700, 825, 1450, and 2000 bp) were cloned in pTZ/PC or pCRII vectors. Extremities of the cloned markers were sequenced by the nonradioactive silver sequence method using pUC/M13 forward and reverse primers. Sequence information was used to make SCAR primers, similar in length to standard PCR primers. Some SCAR primers were elongated RAPD primers, whereas others were from internal regions. Ability of primer pairs and combination of primer pairs to discriminate cultivars of our certification program was compared with their RAPD counterparts as well as with the technical feasibility of both methods.

938

Optimization of the Colchicine Dropper Technique for Use in Vitro with *Fragaria vesca*

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Previous research has optimized the colchicine dropper technique for chromosome doubling under greenhouse conditions. In recent years, in vitro germination of cut strawberry achenes has greatly increased germination rates. Combining the two techniques would be especially useful when chromosome doubling is desired for interspecific hybridization. *Fragaria vesca* was chosen for initial study. Treatments included colchicine levels of 0%, 1%, 2%, 3%, 4%, or 5% (w/v); exposure time to colchicine was from 6 to 16 to 26 hours; application was at the cotyledon stage or after the first true leaf formed; presence or absence of 3 g activated charcoal/liter; and presence or absence of DMSO. Media consisted of MS salts and vitamins, 30 g sucrose/liter, and 2.5 g phytogel/liter. Charcoal enhanced upward growth of seedlings, thus allowing better placement of colchicine droplets. Reduced exposure time and application at the first true-leaf stage allowed higher levels of colchicine to be used without greatly reducing the vigor of treated seedlings.

946

Interspecific Crossability of *Fragaria vesca* as a Female Parent

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Fragaria vesca has been introgressed into *F.* x*ananassa* in the form of decaploids and synthetic octoploids. As *F. vesca* is self-incompatible and crosses with most diploid *Fragaria* species when used as a female parent, it could serve as a bridge for introgression of additional genetic material. A primary goal of this study was to screen selections of *F. vesca* for interspecific crossability among diploid species. The *F. vesca* collection included 10 cultivars of the alpine strawberry, *F. vesca* var. *semperflorens*, as well as 30 wild runnering types gathered from around the world. The following diploid species were represented by one to three genotypes each: *F. viridis*, *F. nubicola*, *F. nipponica*, *F. nilgerens*, *F. iinumae*, *F. daltoniana*, *F. gracilis*, as well as two unnamed species from China. *Fragaria vesca* was used as the female parent and the other species provided the pollen. Crossing took place in the greenhouse, with one pollination occurring during the "popcorn" or "balloon" stage. Germination was performed in vitro using cut achenes shortly after fruit ripening. The alpine strawberry cultivars were easier to cross than wild selections of *F. vesca*. Their continuous blooming habit combined with higher positioning of flowers allowed for easier and perhaps less-damaging emasculation. Crossability, as measured by seed set and germination, was more variable in wild-type *F. vesca* and generally lower than alpine strawberry cultivars.

950

A Comparison of Fatty Acids of Cultivated *Opuntia* Species

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Seeds and cladodes (stems) of cultivated *Opuntia* species were analyzed for fatty acids using gas chromatography. The major fatty acids found in the cladode tissues were myristic (14:0), palmitic (16:0), stearic (18:0), arachidic (20:0), and behenic (22:0). The seeds contained predominantly palmitic, stearic, and behenic acids. Significant differences, both in content and composition of fatty acids, exist among the species so that fatty acid profiles may be useful as taxonomic markers for the differentiation of cultivated *Opuntia* species.

954

Genetic Relationships among Weedy Purple Loosestrife (*Lythrum salicaria* L.) Populations and Cultivars

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Starch gel electrophoresis of plant proteins was used to genetically identify purple loosestrife (*Lythrum* spp.) cultivars and weedy populations. Preliminary determinations were made as to what degree weedy loosestrife populations were related (or genetically similar) to populations of *L. alatum*, *L. virgatum*, and horticultural cultivars. Cluster analysis of the data indicated that native *L. alatum* was genetically different from all populations of purple loosestrife and cultivars examined. The *L. salicaria* and *L. virgatum* cultivars, as groups, were not genetically distinguishable from the weedy populations analyzed. Seven cultivars of *L. salicaria* origin analyzed as a group were not distinguishable from the eight cultivars of *L. virgatum* origin, indicating that separation by cultivar origin may not be feasible. While the two "groups" were not distinguishable, most individual cultivars could be distinguished from one another by isozyme phenotype. Genetic variation was high within populations of weedy purple loosestrife but low among populations, which is characteristic of polyploid, perennial plant species that are widely distributed. Geographic location did not consistently correlate with genetic similarity.

958

Isozyme Polymorphism and Inheritance in *Rhipsalidopsis* and *Schlumbergera* (Cactaceae)

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Cultivars and seedlings of *Rhipsalidopsis* and *Schlumbergera* were subjected to isozyme analysis using seven enzyme systems [aspartate aminotransferase (AAT), aminopeptidase (AMP), glucose-6-phosphate isomerase (GPI), malate dehydrogenase (MDH), phosphoglucomutase (PGM), shikimate dehydrogenase (SKD), and triose phosphate isomerase (TPI)]. Isozymes were extracted from phyl-

loclades and roots, and were separated by polyacrylamide gel electrophoresis (PAGE) using single percentage (5% to 10%) gels. Six enzymes exhibited polymorphism in *Rhipsalidopsis*, whereas all seven enzymes were polymorphic in *Schlumbergera*. Inheritance studies were performed on AAT, GPI, MDH, PGM, and TPI for *Rhipsalidopsis* and on AMP, PGM, and SKD for *Schlumbergera*. Significant segregation distortion was observed in some families. Polymorphic isozymes are potentially useful markers for cultivar identification and for genetic and breeding studies.

962

Linkage and Correlation Analysis of Some Traits in Peach

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Segregating F_2 peach populations in the Univ. of Florida breeding program were analyzed to determine linkage relationships among five qualitative traits: flower type, Sh/sh, flesh type, M/m; flesh color, Y/y; leaf gland type, E/e; and pubescence, G/g. Independent segregation was confirmed between flesh color and leaf gland type, between pubescence and flesh color, and between flower type and pubescence. Previously undocumented independent segregation was found between leaf gland type and flesh type and between pubescence and leaf gland type in our populations. The relationship between these latter characteristics should be investigated in other breeding populations. No correlation was found between fruit development period and flesh type. Also, no correlation was found between chilling requirement and flesh type.

121 POSTER SESSION 16
Nutrition & Photosynthesis/Floriculture & Ornamentals

483

Controlled Release Urea Fertilizers Affect the Growth and Quality of Selected Foliage Plants

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Three formulations of an encapsulated urea product and one sulfur-coated urea were evaluated at 0 to 4 times the recommended rate on *Chomaedorea elegans*, *Chomaedorea seifrizii*, *Chrysalidocarpus lutescens*, *Spathiphyllum* 'Tasson', and *Rhapis excelsa* against a standard controlled-release fertilizer at equal N rates. Each plant species responded differently to the fertilizer sources. *Chomaedorea seifrizii* and *Spathiphyllum* 'Tasson' did not exhibit preferences for fertilizer source from top-growth measurements. *Chomaedorea elegans*, *Chrysalidocarpus lutescens,* and *Rhapis excelsa* growth measurements indicate that fertilizer source affected growth and quality of the plants. The general recommendation for foliage plant production is an equal ratio of ammoniacal to nitrate nitrogen sources. Economically, this ratio makes the fertilizer more expensive than other traditional fertilizers. The use of a controlled-release urea fertilizer has the benefit of being a cheaper source of N and would lower the cost of production, but results on the selected foliage plants indicate that the fertilizer composition is important in plant production.

487

Whole-plant Response of Six Poinsettia Cultivars to Three Fertilizer and Two Irrigation Regimes

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Six cultivars of poinsettia (*Euphorbia pulcherrima* Willd. 'Angelika White', 'Celebrate 2', 'Freedom Red', 'Lilo Red', 'Red Sails', and 'Subjibi Red') were grown for 9 weeks under three fertilizer treatments (80, 160, or 240 mg N/liter constant feed) and were either well-watered or water deficient between irrigations. Plant height decreased with decreasing fertilizer and with low vs. high irrigation treatments. Dry weight of all shoot components were reduced by deficit irrigation. For well-watered plants, leaf area and leaf dry weight increased from low to medium and decreased from medium to high fertilizer treatment. For plants under deficit irrigation, these variables were similar for low and medium fertilizer and increased at the 240 mg N/liter. Stomatal conductance and transpiration decreased with increasing fertilization level and deficit irrigation. Leaf chlorophyll content at week 5 was 40% and 49% higher for plants fertigated with 160 or 240 mg N/liter compared to 80 mg N/liter, while 2 weeks later these differences decreased to 20% and 26%. Irrigation had little influence on leaf chlorophyll content.

491

Nitrite Accumulation and Nitrogen Immobilization in Potting Media Containing Compost

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Growth inhibition has been observed with plants grown in potting media containing compost. The objective of this study was to determine if NO_2^- toxicity or N immobilization might be involved. Two potting media were blended from aged pinebark, vermiculite, sphagnum peat, and compost, along with a control medium without compost, and cropped with *Dendranthema* x*grandiflorum* 'Bravo'. Pots were fertilized weekly with a 15N–1.1P–12.5K soluble fertilizer at 24 mM N. Plants were harvested and media samples were collected at intervals. Saturated media extracts (SME) were prepared immediately. Separate samples were incubated at 25C for 4 days following addition of 2.5 mmol urea-N/cm^3. In SME of one compost-containing medium, NO_2^- was present at 0.25 ± 0.03 mM 2 weeks after transplant, and at progressively lower concentrations thereafter. In incubated samples of the same medium, accumulation of NO_2^- was observed after 3 weeks of cropping, with peak accumulation of 0.7 ± 0.32 µmol NO_2^-/cm^3 after 9 weeks of cropping. Nitrite was scarcely detectable in other media. Some indication of N immobilization was obtained, as NH_4^+ levels decreased during incubation without any increase in NO_3^- and NO_3^- present at the beginning of incubation disappeared during incubation. In this study, significant effects of media on plant growth were not related to differences in NO_2^- accumulation or N immobilization. However, subsequent studies appear to have established such a relationship.

495

Nutrient Uptake and Growth of Roses in Recirculating and Non-recirculating Systems

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This study compared the growth and nutritional status of three rose cultivars ('Jacaranda', 'Osiana', 'Kardinal') in recycled and non-recycled nutrient systems. The recycled treatment was maintained at an electrical conductivity of 1.8 mS·cm^{-1} throughout the three crop cycle experiment, whereas the non-recycled treatment allowed the 1.8 mS·cm^{-1} solution to drain off the troughs. All plants were grown using hydrokorn substrate in 12-liter pots at a temperature of 18C night and 22C day under 24 h supplemental lighting. The first crop cycle showed very little difference in plant growth parameters and foliar nutrient content between the two nutrient delivery methods. By the end of the second crop cycle, foliar N and P were lower in the recycled treatment. Foliar macronutrient concentration was lower in the recycled treatment. By the end of the third crop cycle, plants were visually less vigorous in the recycled treatments. Chloride accumulated in the recycled solution and reached 17 mg·liter^{-1} by the third crop cycle. Flower yields were lower for 'Jacaranda' and 'Osiana' in the recycled treatment. Vase life and water uptake of the cut flowers did not differ between the two treatments.

499

Use of Poultry Byproducts in a Production System for Greenhouse-grown Crops

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In 1993, the Arkansas poultry industry produced 1.048 billion broilers with a total live weight of 2.54 million metric tons. Depending on the type of processing used, from 30% to 50% of live weight can end up in the waste stream. Three primary waste-stream products are generated by the poultry industry: feather meal, poultry meal, and bone meal. Feather meal contains ≈14% N, poultry meal 11% N, and bone meal 8% N. Byproduct additions were made to tomato, marigold, and impatiens transplants at the rate of 6, 12, 24 and 48 g/10-cm pot. The two highest rates killed plants outright, while the lower rates resulted in some growth reduction when compared to the control. Studies are under way to further evaluate the use of these byproducts in an organic production system for tomatoes and bedding plants.

503

Response of Poinsettia to Different Nitrogen Forms

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'Freedom' poinsettias (*Euphorbia pulcherrima* Willd. ex Kl.) were grown to flowering in solution culture for 11 weeks. Treatments consisted of five ammonium : nitrate nitrogen ratios: 1:0, 3:1, 1:1, 1:3, and 0:1 with a total N concentration of 150 mg N/liter. The balance of essential nutrients was supplied with a modified Hoagland's solution. Fresh weight, dry weight, and macro- and micronutrient content of bracts, leaves, petioles, stems, and roots were determined at the end of the study. Leaf and bract area also was measured. Maximum bract size was achieved with 100% nitrate (0:1) treatment. Leaves were largest with the 1:3 ratio. Plants receiving ammonium as the sole N source exhibited severe ammonium toxicity symptoms: stunted growth, foliar chlorosis and necrosis, premature leaf abscission, stunted and clubby roots, and delayed or nonexistent bract coloring. Dry weights for bracts, leaves, stems, and roots increased as the ratio of nitrate increased. Elemental uptake was monitored weekly. Nitrogen-form effect on the uptake, concentration, and partitioning of other nutrients also was evaluated.

507

An Indication for Suitability of Bark for Use in Potting Mixes

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Various barks, aged and composted to different degrees, are used in potting mixes. These differences have different effects on plant growth. It was observed that electrical conductivities (ECs) of the bark mixes that reduced plant growth were lower when compared to the ECs of the mixes that did not reduce growth, despite the same fertilization. This difference in EC diminished over time, differently for different barks. The decrease in EC was mainly due to a decrease in N. Apparently, nutrients were adsorbed or immobilized, which decreased their availability to the plants. This observation may be used to assess the suitability of a bark. The relative decrease in EC or N of similarly fertilized bark mix vs. no bark, peat mix (that does not reduce EC) may indicate the relative unsuitability of the bark, as related to nutrition. The amount of decrease in EC may also indicate the amount of additional fertilization to be provided to the bark mix during its use. The same method may also be applicable to other wood wastes, such as kenaf, sawdust, etc.

511

Timing is Crucial for Plug Seedling Soil Testing

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Soil and tissue standards and procedures have not been developed for plug seedlings. Turn-around time for foliar analysis is often adversely long for timely crop corrections. Visual assessment occurs after damage has occurred. Many plug growers have tried but abandoned soil testing due to erratic results. Of the three monitoring systems, soil testing offers the best potential, but can it be effectively refined for plugs? Petunias were grown in 288-plug trays under six fertilizer regimes. Fertilization or waterings were applied at 9:00 am, and 1 hour later, soil solutions were squeezed out and analyzed. Soil levels after fertilization and watering were too variable to inscribe a curve, while levels after fertilization formed a curve consistent with growth of the seedlings. Twice, soil samples were taken 1, 4, 8, and 24 hours after a fertilizer application. Some soil solution concentrations 1 and 4 hours after fertilization were 51 and 36 ppm for NH_4-N, 46 and 32 ppm for PO_4-P, and 147 and 84 ppm for NO_3-N, respectively. Soil testing can be used for plug production, but samples must be taken after a fertilizer application and at a specified length after the application.

515

Effect of Root-media pH on Impatiens Shoot Micronutrient Concentrations

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Impatiens were planted in media containing either hydrated or carbonate dolomitic lime and subirrigated for 17 weeks using four irrigation water qualities (IWQ) and three water-soluble fertilizers (WSF). Micronutrients (Fe, Mn, Zn, Cu, B, and Mo) were incorporated into all root media at planting with fritted trace elements (FTE 555) at 0.07 $kg \cdot m^{-3}$ and were added to all WSF treatments with a commercially available chelated material (Compound 111) at a constant 50 $mg \cdot liter^{-1}$. Root-medium pH obtained from the various IWQ/WSF solutions at 4, 8, 12, and 17 weeks after planting were used to determine relationships with shoot tissue micronutrient concentrations. Tissue Fe concentrations decreased linearly as root-media pH increased from 5.0 to 8.5. Below pH 5.0, the tissue Fe concentration increased at a rate indicating greater nutrient availability in the root medium. However, between pH 4.0 and 7.5, tissue Fe was within acceptable levels. A linear relationship also was found with tissue Zn and B, but without the rate increase below a pH of 5.0. Tissue Mn decreased to a minimum as the root-medium pH increased from 4.0 to 6.0 and increased again as the root medium pH increased from 6.0 to 8.5. Tissue Mo concentrations increased as root medium pH increased. Tissue Cu concentrations were unaffected by medium pH.

519

Effect of Water-soluble Fertilizer Nitrogen Form on Root-medium pH, NH_4-N, and Impatiens Tissue Nitrogen

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Impatiens were grown in media containing either hydrated or carbonate dolomitic lime and subirrigated for 17 weeks with four irrigation water qualities (IWQ) and three water-soluble fertilizers (WSF). The WSF concentration was 14N–0.6P–5K mol$\cdot m^{-3}$ but contained either 50%, 25 %, or 3 % NH_4-N. After 8 weeks, root-medium pH ranged from 4.5 to 8.0. In general, the higher the percent NH_4-N content of the WSF, the lower the root-medium pH, although there were significant interactions between IWQ and lime type with WSF on root-medium pH. With the same WSF, the concentration of NH_4-N measured in the root media depended on root-medium pH. For example, with WSF containing 50% NH_4-N, root-medium pH with the various IWQ ranged from 4.5 to 6.0, and media NH_4-N ranged from 5.0 to 0.1 mol N/m^3. Tissue N concentrations were higher with the higher NH_4 : NO_4 ratio WSF at all four sampling dates. The effect of IWQ on tissue N resulted from the root-medium pH effects produced by the various IWQ/WSF combinations. Shoot fresh and dry weights were unaffected by the NH_4 : NO_3 ratios in the WSF.

523

Response of *Calendula officinalis* L. Plants to Different Nitrogenous Fertilizers

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Calendula officinalis L. plants were fertilized with urea (46% N), ammonium nitrate (31% N), and ammonium sulfate (20% N) at 0, 25, 50, or 100 kg N/Feddan (4200 m^2). The plants also received calcium superphosphate (15.5% P_2O_5) and potassium sulfate (48% K_2O) at 100 and 50 kg/Feddan, respectively. The results showed that fertilizers enhanced vegetative growth and improved flowering aspects compared to control plants. Application of urea at 50 kg N/Feddan gave the highest flower number (119) and flower dry weight (183 g). Moreover, the applied fertilizers increased the content of photosynthetic pigments (chlorophyll a, chlorophyll b, and carotenoids) in leaves and flowers and the N percentage in shoots. Nevertheless, P and K percentages were decreased.

527

Preplant Superphosphate Amendment and Leaching Fraction on Growth of Potted Poinsettia

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Earlier study indicates that greenhouse crop production may be an overlooked point source of P pollution. A potential strategy to reduce P leaching may be to eliminate superphosphate amendment in soilless medium. Single-pinched 'Amy' poinsettias (*Euphorbia pulcherrima*) in 15-cm pots were grown in a soilless medium of 3 peat : 1 perlite : 1 vermiculite (by volume). A treatment combination of preplant, finely ground, single superphosphate (SSP) (0N–8.8P–0K) amendment at 0 or 172 mg/pot and leaching fractions (LFs) of 0 and 0.2 were evaluated in a completely randomized design during a 10.5-week study. Plants received constant liquid fertigation with 7.8 mg P/liter and 210 mg N/liter from modified Hoagland solution #1. The total P applied via fertigation ranged from ≈38 mg at 0 LF to ≈50 mg at 0.2 LF. The leachate P concentration ranged from 4 mg/liter to 38 mg/liter. There was no significant difference in yield due to SSP and LF. Across all treatments, mean fresh mass was 36 g, mean dry mass was 5.9 g, mean leaf area was 980 cm^2, and mean bract area was 1900 cm^2.

531

Nitrogen Nutrition of New Guinea Impatiens and *Spathiphyllum* in a Subirrigation System

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Greenhouse cultural methods must change rapidly to minimize runoff and to keep pace with environmental regulation aimed at protecting water resources. Two experiments were designed to investigate the effect of N fertilization rate on New Guinea impatiens (*Impatiens* x *hawkeri*) and peace lily (*Spathiphyllum* Schott) in an ebb-and-flow subirrigation system. Maximum growth response for impatiens was centered around 8-mM N levels as measured by root and shoot fresh and dry weight, height, leaf number, leaf area, and chlorophyll concentration. For peace lily, growth peaked around 10 mM N. Growing medium was divided into three equal layers: top, middle, and bottom. Root distribution favored the middle and bottom layers, and the relative distribution of roots was consistent as N level increased. Soluble salts remained low in middle and bottom layers at N concentrations below 10 mM, but increased significantly for all soil layers at levels above 10 mM. The top layer contained two to five times higher soluble salt levels than in the middle or bottom layers at all N levels. Increased nitrate concentration mimicked increases in soluble salts, while pH decreased as N concentration increased for both impatiens and peace lily.

535

Nitrogen Uptake and Growth Response to Short Periods of Low Nitrogen by Two Bedding Plants

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'First Lady' marigold (*Tagetes erecta* L.) and 'Selenia' New Guinea impatiens (NGI; *Impatiens* sp. hyb.) were grown in solution culture for 60 days. At 10-day intervals, plants received low N for 10 days (marigold) or 20 days (NGI). Low-N treatment was 5% and 10% of the control, respectively, for marigold and NGI. After each low-N period, FW of treated and control plants was measured and N uptake by the controls was determined by solution depletion. Nitrogen uptake by marigold reached a peak 40 days after planting, and then decreased somewhat during the final 20 days of the experiment. In contrast, N uptake by NGI increased gradually after planting, reaching its highest level at the end of the experiment (60 days). Low-N periods 10 to 20 and 20 to 30 days after planting reduced the FW of marigold about 35% vs. control. FW reductions resulting from earlier or later low-N periods were much smaller or did not occur. Reductions in NGI FW resulted from low-N periods 20 to 40, 30 to 50, and 50 to 60 days after planting. While short periods of low N reduced the growth of both species, these reductions were desirable and not excessive, and no foliar symptoms of N deficiency were apparent at any time. Results of these experiments have implications for efficient fertilizer use and growth suppression using short periods of low nutrition.

539

Effect of Selected Iron Sources on Chlorosis of Pin Oak

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One-year-old, nursery-grown pin oak seedlings were planted in 25 x 10-cm plastic containers filled with silica sand. Plants were placed under greenhouse environment and fed every 3 days with 10, 20, and 30 ppm elemental Fe from FeEDTA, FeDTPA, FeEDDHMA, and $FeSO_4$. Two other treatments were Hoagland solution at normal pH and at pH 8.5. The control consisted of Hoagland solution without Fe. The pH of the nutrient solutions was maintained at 8.5 throughout the experiment. At the end of the growing season, leaves were visually rated (VR) for Fe chlorosis and saved for foliar Fe, Ca, and Mg analysis. There was no correlation between leaf Fe content and degree of chlorosis. FeEDDHMA at 10, 20, and 30 ppm; $FeSO_4$ at 10 ppm; FeEDTA at 20 and 30 ppm; FeDTPA at 30 ppm; and Hoagland solution at pH 8.5 resulted in lower leaf chlorosis than the control. There was no difference in foliar VR among the Fe sources.

543

Nitrogen Fertilizer-use Efficiency in Two Woody Ornamentals

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High levels of N are often used to produce a vigorous plant that is also aesthetically pleasing to the purchaser. Environmental concerns with the overuse of N raise the need to find the minimum N requirements necessary to produce a salable plant. *Ilex opaca* and *Lagerstroemia indica* plants growing in 1.5-gal containers were irrigated with nutrient solutions containing N concentrations of: 15, 30, 60, 120, 210, and 300 mg N/liter. After 4 months, data indicate that using solutions >60 mg N/liter for both plant species results in leachates with N concentrations higher than those in the applied solutions. Nitrogen leaching losses increased with applied N, ranging from ≈15% to 50% for the low and high treatments, respectively. Chlorophyll readings of leaf tissue were not significantly different for plants of both species receiving N solutions higher than 60 $mg \cdot liter^{-1}$. These results indicate that N levels lower than those typically used for production of these woody ornamentals will still produce salable plants while increasing N fertilizer-use efficiency.

547

Container Size Affects *Ligustrum* Growth and Nitrogen Use

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Three-month-old rooted cuttings of *Ligustrum japonicum* Thunb. were planted in a 2 pine bark : 1 Canadian peat : 1 sand substrate (by volume) in either 0.75- or 2.2-liter containers and grown for 17 weeks in a greenhouse. One-half of the plants grown in 0.75-liter containers were transplanted to 2.2-liter containers after 11 weeks and grown for 6 weeks in 2.2-liter containers. Shoot dry weights were highest for plants grown 17 weeks in 2.2-liter containers and smallest for plants grown 17 weeks in 0.75-liter containers. Root dry weights were similar for plants grown 17 weeks in 0.75-liter containers. The percentage of applied N used by shoots and roots (44% and 8%, respectively) was highest for plants grown 17 weeks in 2.2-liter containers and smallest (30% and 5%, respectively) for plants grown 17 weeks in 0.75-liter containers.

551

The Effect of Nutrient Regime on Biomass Allocation and Nutrient Accumulation in Red Oak Seedlings

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In Spring 1993, red oaks (*Quercus rubra*) were propagated from seed. From June through October, plants were fertilized twice daily with 1.4 liters of 20N–10P–20K water-soluble fertilizer solution at concentrations of 0, 25, 50, 100, 200, or 400 ppm N. Destructive harvests were conducted six times at intervals from June through Dec. 1993 . Leaf area, stem height, root length, root area, and dry weights of roots, stem, and leaves of harvested plants were measured and tissue nutrient concentrations were analyzed. There was no relationship between whole-plant N concentration and total plant biomass ($r = 0$). However, there were some linear relationships between total plant N and total plant biomass for an individual fertilizer treatment. Biomass allocation between root, stems, and leaves was very consistent across all fertilizer levels at any one harvest. Percent total N in roots, stems, and leaves also was fairly consistent across fertilizer levels. This was true at each harvest, except the first two, in which a greater percentage of total N was partitioned to the leaves and a smaller percentage was partitioned to the roots in the high (100, 200, 400 ppm N) fertilizer treatments. Whole-plant K concentrations increased with increasing fertilizer level, but decreased over time. Whole-plant P concentrations increased linearly with whole-plant dry weight in the higher (100, 200, 400 ppm N) fertilizer treatments.

555

Response of Several Grass and Legume Species to Paper De-inking Sludge

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Paper recycling generates large quantities of de-inking sludge, which is disposed of mainly by landfilling. More ecological disposal alternatives include land application and use as a container nursery medium. In this study, raw de-inking sludge was evaluated as a medium component supplemented with applications of four N fertilization regimes for the growth of three grass species (*Festuca ovina duriuscula*, *Agropyron elongatum*, *Alopecurus pratensis*), and four regimes of P fertilization for the growth of three *Rhizobium*-inoculated legumes (*Medicago lupulina*, *Galega orientalis*, *Melilotus officinalis*). Fertilizer was applied on the basis of sludge rate to maintain a uniform C : N ratio across sludge treatments. In one experiment, sand was mixed with 0, 10%, 20%, and 30% sludge by volume and 20% perlite, while in a second experiment, mineral soil was mixed with 0, 27%, 53%, and 80 % sludge and 20% perlite. Results indicate that shoot dry

weight of all species increased with the amount of sludge in the mixture in tests with sand. In the soil mixture experiment, grasses showed the best response to treatments of 53% sludge mixture at the two highest N treatments. In general, shoot dry weight was more directly related to the total amount of N applied than to the C : N ratio of the substrate. The nutritional status (foliar N and P) also was investigated for one grass and one legume species.

559

Physiological Responses of *Intsia bijuga* Trees to Drought Stress

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Intsia bijuga is an important native tree on Guam, and is being promoted as an urban forestry tree. Container-grown *I. bijuga* trees were subjected to a drying cycle (50% of mean water loss replaced daily) to determine physiological responses to drought. Early to mid-morning gas exchange began to decline compared to well-watered plants on day 12, and quickly declined thereafter. Net CO_2 assimilation (A) was close to zero by day 29 and became negative by day 36. Chlorophyll fluorescence of drought-stressed trees was not different from that of well-watered trees on numerous days of measurement throughout the drying cycle. Unlike leaflets of well-watered trees, leaflets of the stressed trees exhibited heliotropic movement to avoid direct exposure to the sun. The stressed trees did not respond with any change in osmotic potential of leaflets following rehydration. Carbon dioxide-use efficiency of stressed trees was reduced to 66% of well-watered trees. The most profound response following rewatering (day 37) was leaf shedding. All trees shed some leaves, and 33% of the trees shed the entire canopy. On the trees that retained some leaves, A returned to that of the control trees by day 13 of recovery.

563

Growth and Phyllode Gas Exchange of Three Acacia Species as Influenced by Developmental Light Level

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Acacia auriculiformis, *A. mangium*, and *A. koa* trees were grown in 5.4-liter containers under conditions of 100%, 44%, or 19% sunlight transmission to determine biomass accumulation and partitioning and phyllode gas-exchange responses to developmental light level. Following ≈100 days of growth, all three species exhibited a linear decrease in relative growth rate and biomass accumulation in response to developmental light level. The influence of reduced developmental light level on growth was similar for the three species, with biomass accumulation under 19% transmission averaging ≈20% of that under full sunlight. In a second study, the diurnal pattern of gas exchange of mature phyllodes was determined. Gas exchange of phyllodes under 19% or 44% transmission depended on photosynthetic photon flux throughout the day. In contrast, gas exchange of phyllodes in 100% transmission was highest in early to midmorning on sunny days. Phyllode gas exchange slowly declined thereafter for *A. mangium* and *A. koa,* but rapidly declined then slightly recovered in late afternoon for *A. auriculiformis*.

567

Gas Exchange and Mycorrhizal Development of Neem Trees in Response to Phosphorus Nutrition

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Cuttings of neem trees (*Azadirachta indica*) were grown for 65 days at four P levels: 0, 15, 30, and 60 mg P/kg soil. Half of the plants were inoculated with the vesicular–arbuscular mycorrhizal fungi (VAM) *Glomus intraradices.* VAM increased growth and net photosynthesis (*A*) at the lowest two soil P levels. Increased A was attributed to increased stomatal conductance (*g*) and greater leaf P concentration. Nonstomatal inhibition of *A* due to P deficiency also was observed in non-VAM plants at lower soil P levels. At higher soil P, VAM and non-VAM plants had comparable growth, *A*, *g*, and tissue concentration of P and other elements. VAM plants at 0 mg P/kg soil had similar growth and leaf P concentration when compared to non-VAM plants at 15 mg P/kg soil, yet had a 11% higher *A*, indicating a direct effect of VAM on gas exchange. As soil P increased, total VAM colonization and vesicle formation decreased, while the amount of extraradical hyphae increased. Arbuscule formation was highest at 0 and 15 mg P/kg soil. Apparently, arbuscules and extraradical hyphae play an important role in the enhanced growth and gas exchange of VAM plants at lower soil P levels.

122 POSTER SESSION 17
Growth & Development/Floriculture, Ornamentals, & Cross-Commodity

629

Cornus florida Floral Development

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Cornus florida L. floral development was monitored using standard paraffin histological techniques and light microscopy. Terminal buds (putative floral buds) were collected over 6 weeks from mature landscape trees located on The Univ. of Tennessee Agricultural Campus, Knoxville. Examination of samples taken at 3- to 7-day intervals revealed variations in development representing 1- to 2-week differences between florets in a single inflorescence, florets on the same tree and florets from different trees. Floral initiation occurred before July l9th in the 2 years of this study. Floral development followed typical angiosperm stages. Florets, although small, appeared morphologically mature by early September in both years.

703

Karyotypic Relationships among Some *Rosa* Species

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Mitotic chromosome numbers and measurements were determined from enzymatically digested shoot tips for 14 species of *Rosa*, subgenus *Hulthemia*, *Platyrhodon*, and *Rosa* (the latter represented by sections *Pimpinellifoliae*, *Cinnamoneae*, *Synstylae*, *Banksianae*, *Laevigatae*, and *Bracteatae*). All were 2n = 14 or 2n = 28, as expected from previously published chromosome counts in *Rosa*. Arm lengths of chromosome pairs measured from digitized images were analyzed for similarity using a least-squares algorithm. On this basis, tetraploid species were compared to their diploid relatives. This study demonstrates the value of karyotypic data in combination with morphological and ecological information for examining the evolution of *Rosa*.

707

Is the DIF Technique Suitable for the Italian Climate

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In Northern Italy, two trials have been performed on *Lilium* and poinsettia cultivars to control plant height by day–night temperature regimes. Two identical glasshouse compartments have been used for the experiments: one maintained at standard conditions (the same minimum and ventilation temperatures during day and night), the other with minimum day temperature lower than night. Cultivations of lilies and poinsettias started in Winter and Summer 1993, respectively, with different climate conditions (cold in winter and hot in summer). Results on *Lilium* indicated that a good control of greenhouse temperature can be achieved in Italy's winter climate, even on sunny days; the best height reduction (30%) was obtained on *Lilium longiflorum* cv. 'White American', compared to other *Lilium* species. Test on poinsettia have been based mainly on controlling ventilation of the glasshouse to raise temperature in the first part of the night and to lower it during the first daytime hours.

711

The Effect of Cold–Warm (5 to 20C) Stratification and Light on Germination and Cotyledon Emergence in *Trillium grandiflorum* (Michx.) Salisb.

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In nature, *Trillium* seeds are reported to take 2 years to germinate, the radicle emerging the first year and the cotyledon the second year. The accepted stratifi-

cation treatment has been a sequence of cold–warm–cold–warm. Our objective was to determine the temperature sequence and length of cold needed for optimum germination and the effect of light on cotyledon emergence. In the initial experiment, the seeds were subjected to either a warm–cold–warm–cold or a cold–warm–cold–warm regimen in a moist environment. Germination occurred after the first cold period and cotyledons emerged 7 weeks later. In a second experiment, seeds were subjected to various lengths of cold and the presence or absence of light during the following warm period. An 83-day cold period resulted in 79% germination and a 76-day cold period resulted in 53% germination. Light had little or no effect on cotyledon emergence.

715

Determining the Critical Photoperiod for Flowering of Several Herbaceous Perennial Species

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Twenty-four herbaceous perennial species were treated at 5C for 0 or 15 weeks. Critical photoperiods for flower initiation and development with and without a cold treatment were determined. Photoperiods were 10, 12, 14, 16, and 24 h of continuous light and 9 h plus a 4-h night interruption. Continuous photoperiodic treatments consisted of 9-h natural days extended with light from incandescent lamps. Response to cold and photoperiod varied by species; *Scabiosa caucasica* 'Butterfly Blue' flowered without a cold treatment under all photoperiods after 8 to 10 weeks of forcing, but plant height increased from 14 to 62 cm as daylength increased. *Rudbeckia fulgida* 'Goldsturm' flowered without cold after 13 to 15 weeks of forcing, but only under 16 hours of continuous light and night interruption treatments. *Heuchera sanguinea* 'Bressingham Hybrids' did not flower without cold under any photoperiod but did flower under all photoperiods with cold. The only *Lavendula angustifolia* 'Munstead Dwarf' plants that flowered without cold were those under 24-h continuous light; ≈60% flowered. After cold, some lavender plants flowered under all photoperiods, and the flowering percentage increased with increasing daylength.

723

Effect of Temperature on Time to Flower of *Coreopsis grandiflora*, *Chrysanthemum superbum*, *Gaillardia grandiflora*, and *Rudbeckia fulgida*

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Scheduling crops to flower for specific dates requires a knowledge of the relationship between temperature and time to flower. Our objective was to determine the relationship between temperature and time to flower of four herbaceous perennials. Field-grown, bare-root *Coreopsis grandiflora* 'Sunray', *Gaillardia grandiflora* 'Goblin', *Rudbeckia fulgida* 'Goldsturm', and tissue culture-propagated *Chrysanthemum superbum* 'Snow Cap' were exposed to 5C for 10 weeks. They were grown at 15, 18, 21, 24 or 27C under 4-h night interruption lighting. Time to visible bud (VB) and first flower (FLW) were recorded. Days to VB, days to FLW, and days from VB to FLW decreased as temperature increased. Time to flower at 15C was 70, 64, 96, and 54 days and 24, 39, 48, and 36 days at 27C for *Coreopsis, Gaillardia, Rudbeckia,* and *Chrysanthemum,* respectively. The 27C temperature apparently caused devernalization on *Coreopsis* because only 40% of the plants flowered. The effects of temperature on flower size, flower bud number, and plant height also are presented.

727

Light Quality Initiating or Ending the Day Affects Internode Length in Petunia

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'Ultra Rose Star' petunia plants were germinated and grown at 21C. The study was initiated 26 days after seeding and the photoperiod was 15 h of light and 9 h of darkness. During the initial or ending 90 min of the light period, the plants were exposed to a light quality of a higher (≈2.0) or lower (≈0.8) red (R, 660 nm) to far red (FR, 730 nm) ratio than daylight (R : FR, ≈1.1). Flowering occurred within 65 days from seeding for plants in all treatments. Plants receiving a low R : FR during the initial 90 min of the day had similar internode lengths as those plants receiving a high R : FR at the end of the day. The average internode length of the main stem at flowering was 0.6 ± 0.08 cm for plants receiving a low R : FR in the morning or a high R : FR at the end of the day. In addition, the internodes of those plants exposed to a low R : FR in the morning were longer than on plants receiving a low R : FR at night or a high R : FR in the morning. The average internode length at flowering was 0.4 ± 0.08 cm for plants with an ending low R : FR or a beginning high R : FR light quality of the day.

731

The Shoot Apex (Vegetative or Generative) of *Heliconia bihai* and *H. latispatha* in Relation to Growth

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The shoot apex from plants of *Heliconia bihai* (L.) L. and *H. latispatha* Benth. growing under natural inductive conditions, and two shade-loving (60% and 0%) at different growth stages (one to six or eight expanded leaves) was studied. Observations were made using a light microscope, in 15-µm-thick sections. The analysis included changes in 1) size and shape of the meristem, 2) shape, ubication of new leaves, spathes, and flowers in the apex, and 3) relation between these characteristics, the condition of the apex (vegetative, transitional, and generative), and the plant growth stages. The anatomical structures of the shoot apex (meristem, leaves, and flowers primordias) are illustrated by photomicrographs. The meristem change in size and shape with grow up expanded leaf number. The condition of the apex was related to the total leaf number. The total leaf number was five or six in *H. bihai* under 60% and 0 % shade levels and 8 in *H. latispatha* at both shade levels. The apex reaches the generative stage when the plant has a minimum expanded leaf number of four (at 60 % shade) and five (0 %) in *H. bihai* and five in both shade conditions in *H. latispatha.* After this, the inflorescence started progressively to raise above the rest of rhizome.

733

Growth and Development in Irrigated *Alpinia purpurata*

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The time frames for shoot emergence (SE) to inflorescence emergence (IE) and harvest (H) were determined for three *Alpinia purpurata* cultivars irrigated at 0.33, 0.67, 1.0, and 1.67 times the pan factor evaporation rate of the preceding week. Leaf area per shoot, rate of increase in clump area, and yield and quality measurements were also were determined. Cultivar differences were more important than irrigation regimes for the SE–IE and SE–H time frames; however seasonal effects were important for both temporal and quantitative variables. As the amount of irrigation water was increased from pan factor 0.33 to 1.67, yields increased by ≈10 inflorescences per plant (over the 18 months of the experiment), and the proportion of high-quality (fancy) inflorescences harvested increased by 10%.

739

Influence of Daylength Delivery on Flowering in Several Herbaceous Perennial Species

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To determine the most effective lighting strategies for flower induction of long-day (LD) plants, 10 species of herbaceous perennials were chilled at 5C for 0 or 12 weeks and then forced at 20C under the following photoperiods: short day, 4-h night interruption (4-h NI), 7-h night interruption (7-h NI), 7-h day extension, 7-h predawn (7-h PD), and 24-h continuous light (24-h). All treatments consisted of a 9-h photoperiod of sunlight supplemented with 90 $\mu mol \cdot m^{-2}$ from HPS lamps. LD treatments were delivered by incandescent lights and induced flowering in obligate LD plants. Rate of flowering, height, and bud number at first flower varied among species and LD treatments. Although flowering was accelerated under 24-h and 7-h NI for most species, it was delayed under 24 h for *Coreopsis verticillata* 'Moonbeam' and *Campanula carpatica.* For unchilled plants of most species, flowering was delayed under 7-h PD compared to other LD treatments. Chilling decreased time to flower and reduced differences between LD treatments. *Coreopsis* 'Moonbeam' and *C. lanceolata* 'Early Sunrise' were shorter when grown under 4-h NI.

743

Quantifying the Effects of Temperature and Plantlet Size on the Reproductivity and Vegetative Axillary Development of the African Violet (*Saintpaulia ionantha* Wendl.)

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Axillary buds of African violet develop vegetative shoots or reproductive inflorescences. Vegetative axillary development results in a multiple-shoot plant and reduces plant quality. We determined the effect of temperature and plantlet size on axillary bud development. Plantlets were removed from leaf cuttings, graded according to stem diameter, directly stuck into pots 10 cm in diameter, and placed in greenhouses at 18, 22, or 26C. Vegetative development was related to temperature, plantlet size, and nodal position. The number of vegetative axillary shoots per plant decreased from 3.7 to 1.3; that of leaves per vegetative axillary shoot decreased from 10.3 to 4.8 as temperature increased from 18 to 26C. The eight to 10 basipetal nodes developed vegetative shoots or were devoid of axillary development. The percentage of leaf axils in which inflorescences developed increased from 14 on node eight to 100 on nodes 12 and higher. The larger plantlets at the time of transplant had 20% fewer vegetative axillary shoots, whereas reproductive inflorescence development was not affected by plantlet size.

747

Influence of Day and Night Temperature on Development of Sweet Pepper Seedlings

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Sweet pepper (*Capsicum annuum* 'Resistant Giant #4') seedlings were grown in 128-cell plug trays under 16 day/night temperature (DT/NT) regimes from 14 to 26C. In this temperature range, plant stem height, leaf unfolding rate, plant volume, internode length, stem diameter, leaf area, and shoot dry weight were primarily functions of average daily temperature (ADT). Internode length increased as ADT or the difference between day and night temperature (DIF) increased. The root-to-shoot ratio decreased linearly as DT increased and was not significantly affected by NT. Leaves were darker green under positive DIF than negative DIF temperature regimes. Increasing NT from 14 to 26C reduced the node at which the first flower appeared by an average of 1.2 nodes. Percent abortion of the first flower increased as DT increased. Plant quality, as defined by seedling index [(dry weight x stem diameter)/ internode length], increased as DIF became more negative.

751

Comparison of Nine Native Grasses Grown on Sludge Applied Soil

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The use of grasses native to New Mexico are preferred for revegetating Albuquerque's sewage sludge disposal site. A greenhouse study was conducted to determine the most appropriate grass species that could be used in revegetation. Nine grasses grown in soil collected at Albuquerque's sludge disposal site were compared based on germination measurements, including plant height and density. Final shoot and root weights also were taken for comparison. Plant tissue was analyzed for the accumulation of metals and salts. With 200 ml of water applied weekly, plant height was greatest in spike dropseed (*Sporobolus contractus* A. S. Hitchc.) at 33.86 cm; plant density was greatest in alkali sacaton (*Sporobolus airoides* Torr.). Results indicate the grasses that have the best potential for use in revegetation are blue grama [*Bouteloua gracilis* (H.B.K.) Lag. ex Griffiths], sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.], and alkali sacaton.

759

Branching Architecture of 3-year-old Plantation-grown Micropropagated Silver Maple

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Whole-tree branch architecture was quantified by counting and measuring the lengths of main stems, basal branches, and all primary (1°), secondary (2°), and tertiary (3°) branches. Trees were grown in replicated clonal plantations established in 1991 on a southern Illinois lowland and an upland site. Fifty-two clones in each of five complete blocks were measured from each plantation. Number of primary branches that formed in 1991, 1992, and 1993, and the number of nodes in the terminal meter of growth were highly significant for silver maple provenance and for clones (four clones for each of 13 provenances), except that clonal differences were nonsignificant for the number of 1° branches on 1991 wood. There were significant effects of provenance and clone on total number and the various sizes of 2° and 3° branches. Generally, a greater number and longer length of 2° and 3° branches formed on trees from the more rapidly growing southern provenances.

763

Phytochrome-A as a Strategy to Control Internode Elongation in Crops Grown in Crowded Conditions

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Increased plant density can reduce the per-plant cost of ornamental and vegetable crop production, but also reduces the quality of the crop produced. Plants grown under these conditions exhibit internode elongation and yellow leaves. This response generally is described as a shade-avoidance response. Genetically transformed tobacco that express oat Phytochrome-A (Phy-A) grew short in white light but grew as tall as the nontransformed control (10 cm) in red light. When a mixture of red and 5% far-red (700 to 750 nm) was used, transformed tobacco remained short (5 cm) and dark green, whereas nontransformed grew taller (27 cm). The concept of masking the shade avoidance response was tested in transformed lines of tomato (Boylan and Quail 1989) that express elevated oat Phy-A. Transformed plants remained short and dark-green in shade-light. Phy-A may be a useful strategy to mask the shade-avoidance response.

767

A Simple Method for Measuring Crop Canopy

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Crop canopy cover data is used to study canopy structure and crop growth analysis. This study was conducted to determine the easiest and most reliable method of calculating crop canopy cover. Using Decagon Sunfleck Ceptometer was compared with the traditional method (tape measure) of retrieving crop canopy cover data. Data was collected on silage corn (*Zea mays*) and soybeans (*Glycine max* L.). The method of collecting data using the ceptometer was simple and quick compared to the traditional method. The ceptometer, even with human variability, was found to be ≈99% accurate. The traditional method was found to have >10% variability. The ceptometer is a much quicker and more reliable tool to use. It appears to decrease the variability in the collection of crop canopy cover data.

771

Shade Levels, Wind Speed, and Wind Direction Influence Air Temperature in Mini-shadehouses

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The effect of four shade levels (47%, 63%, 80%, and 91%) on air temperature was evaluated using 24 arch-shaped, open-ended shadestructures oriented with their longitudinal axis in north–south direction. The mini-shadehouses were 80 x 185 x 80 cm (width x length x height). Six replicates per treatment (shade level) were randomly assigned within the experimental plot. Light levels were measured using Sunceram solar cells. Copper-Constantan thermocouples were installed 60 cm from ground level and 20 cm from the north entrance. The experiment was initiated in July 1994 and terminated in Oct. 1994. Data from 20 consecutive days in August were analyzed. Eighty percent shade had the highest air temperature; however, the average difference between 47%, 63%, and 91% shade was less than 1C. Wind direction and speed affected air temperature with north or south winds correlated with highest temperatures. Analysis of the data shows averaged air temperatures differed by ≤1C for all shade levels. Consequently, these structures may be used for replicated research studies involving plant growth.

775

Expression of Soluble and Wall-bound Acid Invertases in Different Tissue of *Lilium longiflorum* Flower Buds

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In mature *Lilium longiflorum* flower buds, anther and stigma had the highest soluble acid invertase activity [3.29 and 2.31 μmol of reducing sugars (RS)/min per gram of fresh weight (FW), respectively] compared to style, ovary, petal, and filament with activities of 1.52, 1.08, 0.99 and 0.98 μmol RS/min per gram of FW, respectively. DEAE-sephacel chromatography revealed that invertase activity in petal, ovary, style, and stigma was composed exclusively of invertase II and III isoforms. Anther invertase was mainly invertase I with small amounts of invertase II and III. Filament tissue mainly had invertase II and III isoforms with a small amount of invertase I. Wall-bound invertases were extracted with 1.0 M NaCl. Anthers had the highest wall-bound invertase activity (4.42 μmol RS/min per gram of FW) followed by stigma (0.42 μmol RS/min per gram of FW). Other tissues had low wall-bound invertase activity (<0.1 μmol RS/min per gram FW). For further purification, the binding of soluble invertases to nine different reactive dyes was investigated. Invertase I was bound to Reactive Green 5, Reactive Green 19, and Reactive Red 120 columns and was eluted with 0.5 M NaCl, resulting in increase in specific activity ≈10-fold with ≈70% recovery. Invertase II and III bound only to Reactive Red 120. Elution with 0.5 M NaCl resulted in an ≈6-fold increase in specific activity.

779

Graphical Tracking Leaf Count to Support Easter Lily Crop Timing Decisions

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Timing of Easter lily (*Lilium longiflorum* Thunb.) for sales is complex because the date of Easter and the number of leaves formed on plants before flower bud initiation vary from year to year. A process control chart was developed that uses a leaf unfolding rate model of Easter lily to control development rate towards flowering. The technique allows observed and target leaf count to be tracked on a graph and compared visually over time. The optimum leaf unfolding rate and average temperature can be read directly from the chart without the need for mathematical calculation. The approach provides an intuitive method for transferring quantitative models to growers and can be applied to other management problem areas.

783

Growth and Carbohydrate Metabolism of Wheat Plants Grown with Red-light Emitting Diodes

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Light-emitting diodes (LEDs) are a potential light source for growing plants in space flight systems because of their superior safety and reliability, small mass and volume, electrical efficiency, and longevity. To determine the influence of narrow-spectrum LEDs on plant growth and metabolism, wheat (*Triticum aestivum* L. 'Superdwarf') plants were grown under red LEDs (peak emission 660 nm) and compared to plants grown under daylight fluorescent, red LEDs + 1% blue fluorescent light (BL), and red LEDs + 10% BL. Plants were taller, had longer flag leaves, and delayed seed development when grown under red LEDs or red LEDs + 1% BL compared to those grown with 10% BL or under daylight fluorescent. Viable seeds (290% germination) were produced in all plants regardless of the light treatment. Total dry matter (DM), head DM, and seed DM were similar in the plants grown under the four light regimes, and there were no differences in the starch content of the seeds. Starch levels were 4-times greater and sucrose levels were 2.5-times greater in leaves of plants grown under the red LEDs compared to daylight fluorescent. Daylight fluorescent leaves showed a 1.8-fold increase in sucrose phosphate synthase (SPS) activity, a regulatory enzyme of sucrose synthesis. These results indicate that wheat can be grown successfully under red LEDs, but there are differences in carbohydrate concentration and metabolism in photosynthetic tissue.

125 POSTER SESSION 18
Nutrition & Photosynthesis/Vegetable Crops

941

Compositional Nutrient Diagnosis of the P Status in Potato Crops

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In Quebec, potato crops are largely grown on light acid soils altered by podzolization. In the plow layer, abundance of sesquioxides, low pH and low organic matter content produce high P-fixing capacity. Liming to pH not exceeding 5.6, organic matter additions and banding of P fertilizers are practices to improve the P status in the soil–plant system. Plant response to treatments could be diagnosed by yield evaluation and foliar analysis. Agricultural lime, dolomitic limestone and basalt were applied to an acid soil (pH 4.6). Ordinary superphosphate, biosuperphosphate, triple superphosphate, and diammonium phosphate impregnated with humic peat were banded at two rates. Highest tuber yield was 40 $t \cdot ha^{-1}$. There was no response to liming materials as pH did not exceed 4.9. There was a significant response to P fertilizers. Nutrient balance assessment of the foliage by Compositional Nutrient Diagnosis indicated a critical "d" value of 1.5 and a critical P index of 0.8.

945

Development of DRIS Nutrient Norms for Processing Tomato

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Nearly 100 commercial processing tomato fields in California were sampled during 1993–94 with the objective of developing DRIS (Diagnosis and Recommendation Integrated System) nutrient norms. More than 30 farming operations and a wide range of soil types and conditions were included in the survey. Whole, recently mature compound leaves (blade + petiole) were collected at three growth stages: first bloom, main fruit set, and 10% to 30% red fruit. Fields were classified by fruit yield as high (>90 MT/ha) or low yield (<78 MT/ha); mean yield for these groups was 58 and 103 MT/ha, respectively. DRIS nutrient norms and nutrient ratios were calculated, by growth stage, for N, P, K, Ca, Mg, and S. Tissue concentrations of Zn, Mn, and Fe were so highly variable that meaningful ratios could not be achieved. DRIS norms varied substantially among growth stages, with K concentration declining precipitously, N and P declining modestly, and Ca, Mg, and S remaining relatively stable over the season. Evaluation of DRIS indices showed that ≈25% of low-yield fields exhibited serious nutrient imbalance. K was implicated as the most-frequently limiting nutrient.

940

Use of Pre-sidedress Nitrate Test and SPAD Meter to Evaluate Nitrogen Needs of Peppers

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Hot cherry peppers were grown after incorporation of the following three winter cover crop regimes in Summer 1994—hairy vetch (*Vicia villosa*) plus winter rye (*Secale cereale*), hairy vetch alone, and no cover crop. For each main effect there were three N rates applied to peppers in three applications over the course of the season: 0, 85, and 170 $kg \cdot ha^{-1}$. The pepper yield was significantly higher with hairy vetch plus rye than rye alone or no cover crop. There was also no significant yield increase with the addition of N fertilizer to the peppers grown with hairy vetch. Soil nitrate–N levels taken just prior to N sidedress were significantly higher in plots that had hairy vetch plus rye compared to other treatments. There was also a significant linear relationship of the soil nitrate–N levels among the three N rates. Based on the results of this study, sidedressing peppers would be recommended when soil nitrate levels are above the 25 ppm that is the current threshold for other crops. SPAD readings were taken several times during the season. There was a high correlation of SPAD readings to pepper yield very early and very late in the season. The correlation of SPAD readings to pepper yield was poorest when taken at the time of N sidedress.

953

Soil Temperature Influences the Response of Lettuce to Phosphorus

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Lettuce is planted in the southwestern U.S. desert from September through December and harvested from November through April each year. During this period mean soil temperatures range from 7 to 30C. Lettuce produced on desert soils shows a large yield response to P. Soil solution P is replenished by desorption from the labile soil P fraction and this process is temperature sensitive. A field study was conducted over 6 years to evaluate the response of lettuce to soil solution P levels under different ambient soil temperature regimes. The soil temperatures under which lettuce was grown were varied each year by altering planting dates. Soil solution P levels were established and maintained each season using P sorption isotherm methodology. Lettuce responded to P in all experiments. Phosphorus levels required for maximum yield varied with each experiment. Soil P levels required for optimal yield were best correlated to mean soil temperatures during the last 20 days before harvest. Lettuce accumulates over 70% of its P during the heading stage of development and it is likely that during this period of rapid growth and nutrient uptake, solution P becomes limiting when soil temperatures are cool.

957

Nitrate Accumulation and Reduction in Lettuce as Influenced by Nitrogen Fertilization Rate and Genotype

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The objective of this study was to investigate the effect of solution NO_3^- concentration (Ns), in a recirculating hydroponic system, on the accumulation and partitioning of NO_3^- and reduced N, and its relationship to root and leaf nitrate reductase activity (NRA), in five lettuce (*Lactuca sativa* L.) cultivars differing in NO_3^- accumulation capacity. Significant interactions between Ns and genotype influenced NO_3^- accumulation, reduced N levels, and NRA in roots and leaves. In two cultivars, leaf NO_3^- concentrations increased with increasing Ns up to 5.0 mM, and then leveled off, while in three other cultivars, leaf NO_3^- levels increased linearly with increasing Ns rate up to 15.0 mM. NRA in leaves was generally highest at 5.0 mM Ns, and tended to decrease at 15.0 mM Ns. In roots, NRA increased with increasing Ns rate up to 1.0 mM, and remained relatively constant as Ns increased to 5.0 and 15.0 mM. In each cultivar, in situ NO_3^- reduction (estimated by the relative concentrations of tissue reduced N to total N) decreased in both roots and shoots as Ns increased. The results suggested that genotypic variation in NO_3^- accumulation in response to increasing Ns was not exclusively a result of cultivar differences in NO_3^- uptake and reduction capacity, but may also involve other factors in relation to NO_3^- accumulation.

961

Induced Iron Toxicity in Chinese Cabbage and Leaf Lettuce

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The influences of elevated nutrient solution Fe^{++} concentrations on tissue iron contents and toxicity symptom development in Chinese cabbage and leaf lettuce were investigated. Seedling plants established in peat-lite mix in l5-cm plastic pots were fertilized with nutrient solutions containing 0 to 10 mM Fe^{++} for 6 weeks. Both Chinese cabbage and leaf lettuce produced dark leaf spots on plants grown with 5 mM or higher Fe^{++} concentrations. Biomass yields were reduced when leaf tissue iron contents in Chinese cabbage and leaf lettuce, respectively, were 551 $mg \cdot kg^{-1}$ and 379 $mg \cdot kg^{-1}$ or higher on a dry matter basis. In both species, tissue iron contents increased as the nutrient Fe^{++} concentration increased. Tissue iron contents in both species may be greatly enhanced to a certain level without causing plant toxicity by micronutrient fertilization.

965

Fertility Studies on *Brassicas* Grown in Acid Soils

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In soils that can range in pH from the low 4's to 7, depending on the location and liming history, deficiency of Zn, B, and Mo coupled with the soil acidity complex of Mn toxicity had been previously identified as severe limiting factors in producing quality *Brassica* crops. Fertility studies on fall and spring planted *Brassicas* focused on the effect of including/not including micronutrients during various phases of growth when NPK preplant fertilizer was reduced. Differential responses to reduction in preplant NPK and applications of micronutrients was found to be dependent on planting time (fall or spring), species of *Brassica* planted and cultivar. Nutrient uptake in leaf blades and petioles was followed. In broccoli timing of micronutrient applications significantly affected the harvest period length. Broccoli final yields of the B, Zn and Mg treatments were found to contribute ≈75% to 80% of the final yield of a full range micronutrient solution.

969

Reduced Nitrogen Fertilization Requirements of Potatoes under Precision Irrigation

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Seven potato cultivars were grown on silt loam with six N fertilizer treatments in 1992, 1993, and 1994 to evaluate varietal response to N fertilizer rate and timing under precision sprinkler irrigation. Crop evapotranspiration was replaced when the soil water potential at 0.2-m depth reached –60 kPa. Maximum yield responses were obtained using 0 to 134 kg N/ha, depending on the year and experimental site. In 1993 and 1994, with wheat as the previous crop, 134 kg N/ha maximized yields, over all varieties. In 1992, with alfalfa as the previous crop, there was no positive yield or grade response to N, over all varieties. Each year, available soil N accounting showed large surpluses for all treatments. Nitrogen mineralization contributed from 80 to 280 kg N/ha per year to the soil supply.

973

Effect of Composts and Synthetic Nitrogen Fertilizer on Growth and Nematode Infestation in Lettuce and Basil

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Experiments were conducted to evaluate the effect of two different compost materials and several compost: synthetic N fertilizer ratios on the growth, yields, and nematode infestations in head and semi-head lettuce, and basil. Treatments were homemade compost at 25 MT/ha, Amend compost at 25 MT/ha, N alone at 150 $kg \cdot ha^{-1}$, and Amend compost at 25 MT/ha plus 0, 100, 200 or 300 kg N/ha. The basil trial followed the lettuce experiment on the same treatment beds to evaluate the long-term effects of compost applications. Compost plus 100 kg N/ha resulted in the greatest yields of 12 to 24 MT/ha for the semi-head and head lettuce trials, respectively. Basil was harvested for 6 months during a 10-month growth cycle. Highest basil yields of 64 MT/ha and canopy growth were obtained with a combination of compost plus synthetic N fertilizer, with 300 kg N/ha required for maximum yields during the 6-month harvesting period. By the last sampling date nematode counts were lowest for plots that received compost treatment alone and highest for the controls and for plants receiving synthetic N fertilizer alone.

977

In Situ Chlorophyll Fluorescence Determinations on Vegetable Crops in the Tropics

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Portable chlorophyll fluorometers have made it possible to evaluate the photosynthetic efficiency of photosystem 11 for vegetable crops under ambient conditions. A sampling protocol was first established to eliminate variability due to positioning of the fiber optics in relation to the leaf, leaf selection, and natural environmental variability. Fluorescence parameters of the quantum yield of noncyclic electron transport (DF/Fm') and electron transport rate (ETR) were taken from several economically important vegetables under ambient conditions between 11 and 14 h. The objective of the second part of the study was to conduct in situ chlorophyll fluorescence and biomass determinations as affected by salt stress and N deficiency. DF/Fm' and ETR were studied in rhizobium inoculated, noninoculated and inorganic N-fed soybean and differences in fluorescence were related to yield. The influence that salt stress, and several N rates have on fluorescence photochemical quenching (qP) and nonphotochemical quenching (qN), NPQ ([Fm-Fm']/Fm'), DF/Fm' and ETR for hydroponically grown lettuce will also be presented.

981

Photosynthesis in Leaves, Fruits, Stem, and Petioles of Tomato Plants Grown in Peat Bags with Different Fertigation Management

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Tomato plants were grown in peat bags in greenhouse to examine the effects of variation of the nutrient solution electrical conductivity (EC) and substrate water potential (Ψ_{sub}) on photosynthesis in leaves, fruits, stem, and petioles. EC of the nutrient solution delivered to peat bags varied between 1 to 4 $dS \cdot m^{-1}$ with Ψ_{sub} of either –5 kPa or –9 kPa as the setpoint for starting the irrigation. The EC variation was adjusted by a computer system according to potential evapotranspiration. Gross photosynthetic capacity (P_C) decreased as the leaf age developed. P_C in the 10th, 15th and 18th leaves from the top was only 76%, 37%, and 18% of P_C in the 5th leaf, respectively. However, low quantum use efficiency (QUE) was only observed in the 18th leaf and low dark respiration (R_D) was only in 15th and 18th leaves. Net photosynthesis (P_N) was only observed in young fruits (≈10 g FW) or young petioles and no P_N was observed in large fruits (50 g or more FW) and stems. Both P_C and R_D were lower in older fruits and petioles or in the lower part of the stem compared to the younger ones or upper parts. EC variation increased P_C, QUE, and R_D in most parts. Low Ψ_{sub} increased R_D in most parts and decreased P_C in fruits, stem, and petioles. It is suggested that EC variation increased plant physiological activity of tomato and low Ψ_{sub} increased carbon consumption, although it was not severe enough to depress leaf P_C.

985

Influence of Phosphorus on Gas Exchange and Plant Development and Nutrient Uptake of Chile Ancho and Bell Pepper Plants

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In two separate experiments, the influence of phosphorus nutrition on gas exchange, plant development, and nutrient uptake of *Capsicum annuum* chile ancho 'San Luis' and bell pepper 'Jupiter' plants were studied. Plants were fertilized weekly using 250 ml of a modified Long–Ashton solution (LANS) containing 0, 11, 22, 44, 66, or 88 µg P/ml. Phosphorus stress was evident with both pepper cultivars at 0 and 11 µg P/ml, with reduced plant growth and development: leaf number and area, fruit, leaf, stem, root, shoot, and total plant dry weight. The root : shoot ratio was greatest at 0 µg P/ml, reflecting greater dry matter partitioning to the root system. Greater phosphorus stress occurred at 0 µg P/ml in 'San Luis' compared to 'Jupiter' (88% vs. 58% reduction in total plant dry weight compared to optimum P response). 'San Luis' was also more sensitive to phosphorus stress at 11 µg P/ml than 'Jupiter' as indicated by the greater reduction in growth responses. With increasing P nutrition, leaf tissue P increased in both cultivars with maximum leaf tissue P at 88 µg P/ml. In 'San Luis', there were no differences in tissue P between 0 and 11 µg P/ml plants, whereas 0 µg P/ml 'Jupiter' plants had the lowest tissue P. Low P plants generally had the highest tissue N and lowest S, Fe, Mn, Zn B, Mo, and Al. With both cultivars, gas exchange was lowest at 0 µg P/ml, as indicated by low transpiration (E), stomatal conductance (g_s), and net photosynthesis (A). Internal CO_2 (C_i) and vapor pressure deficit were generally highest at 0 µg P/ml, indicating that C_i was accumulating with lower g_s, E, and A in these phosphorus-stressed plants. Generally, no P treatments exceeded the gas exchange levels obtained by 44 µg P/ml (full strength LANS) plants.

126 POSTER SESSION 19
Culture & Management/Floriculture

493

A Comparison of Alternative Weed Management Strategies for Field-grown Specialty Cut Flowers in Maine

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A 2-year field study was initiated in May 1994 to show the effects of alternative weed control methods on weed suppression and cut flower yield. Cultural and economic analyses evaluate the feasibility of various management decisions. *Gomphrena globosa* cv. Woodcreek Pink seedlings were transplanted at 12-inch spacings with the following treatments: 10 mm chopped straw mulch, 10 mm shredded paper mulch, 1.25 mm black plastic mulch, bare soil with postemergent herbicide (Glyphosate) and bare soil with hand weed control. First-year results of the study show weed control was statistically equal between plastic, herbicide, and hand control. These methods provided significantly better barriers to weed growth than shredded paper and oat straw. Economic analyses show variation in the cost efficiency of these methods, however. It is expected that the results of the first year will be corroborated in 1995 for the herbicide, hand control, and plastic treatments, but will reflect change in the chopped straw and shredded paper treatments due to improved focus on experimental design and material selection.

497

Shredded Tire Rubber as a Medium Amendment for Container-grown Greenhouse Plants

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Media blends containing 25%, 40%, and 50% shredded tire rubber were compared to two commercial media, Baccto Grower's Mix and Ball Peat-Lite Mix, to evaluate its potential as a container medium amendment for container-grown greenhouse plants. *Salvia splendens* 'Red Hot Sally' and *Vinca rosea* 'Cooler Peppermint' grown in 25% rubber were marketable with growth similar to or superior to those grown in the commercial media. *Exacum affine* 'Little Champ', *Vinca rosea* 'Cooler Grape', *Tagetes erecta* 'Discovery Yellow', and *Begonia semperflorens* 'Vodka' grown in 25% rubber were of marginally acceptable quality. Plants grown in 40% or more rubber were shorter and chlorotic compared to those in the commercial media. *Exacum affine* grown in 40% or more rubber contained high levels of zinc, which may have been linked to the chlorosis and growth reduction. Rubber reduced media water-holding capacity, while cation exchange capacity and pH were not affected.

501

Rose Response to Nutrient Recirculation and High-pressure Sodium (HPS) Radiation

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Four cut rose cultivars ('Royalty', 'Samantha', 'Sonia', and 'Gabriella') were exposed to supplemental radiation for 2 years of production at the W.D. Holley Plant Environmental Research Center (PERC) at Colorado State Univ. and 1 year at Jordan's Greenhouse (cultivars Royalty and Kardinal). At PERC the house was divided into two treatments: I) natural light, and 2) supplemental radiation at ≈100 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (750 fc) from 1000-W high-pressure sodium (HPS) lamps for 10 h each night. Jordan's had a third treatment of supplemental radiation at ≈50 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (400 fc). Nutrient solution recirculation was tested with one bench in each of the treatments. Each rose was counted and measured for stem length and fresh weight. At PERC, all the cultivars showed no significant differences in the weekly number of flowers produced or the total flower fresh weight when grown under nonrecirculation vs. recirculation of nutrient solution. From 1993 results, grade A production for 60 'Royalty' plants increased from 455 flowers under natural conditions to 522 flowers under lighted conditions over 7 months, a 97-flower increase (21%) due to lighting.

505

Zonal Geranium Growth and Flowering Response to Chemical Growth Retardants

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Chemical plant growth retardant (PGR) treatments ($mg \cdot liter^{-1}$) were applied as foliar sprays to three zonal geranium cultivars: chlormequat at 1500, applied two, three, and four times, a combination of chlormequat at 750 and daminozide at 1250, applied one and two times, and paclobutrazol applied once at 5, 10, 20, and 30; twice at 5, 10, and 15; and three times at 5, plus an untreated control. Two paclobutrazol drench treatments at 0.1 and 0.25 mg a.i. per pot were also applied. The results of the PGR applications were significant at the cultivar x treatment interaction for leaf canopy height and plant diameter. Paclobutrazol rates of 10 to 15 $mg \cdot liter^{-1}$ resulted in acceptable height control for 'Medallion Dark Red' and 'Aurora'. 'Pink Satisfaction' is a less vigorous cultivar and lower paclobutrazol rates of 5 to 10 $mg \cdot liter^{-1}$ were more suitable. When the total concentration of the

single and multiple applications were compared, no additional height control was realized with the multiple applications of paclobutrazol.

509

Source Variation in Chemical Characteristics of Coconut Coir Dust

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Chemical characteristics of saturated media extracts of coconut (*Cocos nuc* L.) coir dust were determined from material from different sources (producers and countries) and were found to be source-dependent. For all samples tested, the pH was between 5.5 and 6.6, and the electrical conductivity ranged from 0.2 to 2.4 cm^{-1}. Nitrate-N levels were between 0.3 and 8 ppm, and ammoniacal-N levels were 0.2 ppm or less. Calcium and Mg levels ranged from 1 to 24 and 1 to 3 ppm, respectively. Potassium and CI levels ranged widely from 16 to 686 and 24 to 600 ppm, respectively. Sodium levels were between 28 and 53 ppm. The levels of B, Cu, Fe, Mn, and Zn were <1 ppm. Although there were significant differences between producers within a country, sources originating from different countries were found to have the greatest differences in chemical characteristics.

513

Effect of Iron Concentration on Growth and Phylloclade Edge Yellowing of Holiday Cactus.

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Production of holiday cactus has been limited by the common occurrence of marginal chlorosis of the phylloclades, which can lead to losses in crop quality. This work was conducted to determine if poor growth and phylloclade yellowing could be correlated to applied Fe concentration. Rooted cuttings of *Schlumbergera truncata* 'White Christmas', 'Twilight Tangerine', 'Christmas Charm', and 'Lavender Doll' were transplanted into a modified Hoagland's solution, adjusted to a pH of 6.3, containing Fe-EDTA at either 0,10,20,30, or 40 mg·$liter^{-1}$ Fe. Plants were grown in a controlled environmental chamber under 16 h daylength for 16 weeks at 22/18C day/night temperature. Plants grown under 0 and 10 mg·$liter^{-1}$ Fe had significantly greater fresh weight, height, and root length than plants grown under higher Fe concentrations for all cultivars. Comparison of tissue analysis results revealed a direct correlation between poor growth and levels of Fe within the tissue. There was no correlation, however, between Fe concentration and phylloclade edge yellowing, as yellowing occurred sporadically in all treatments. Comparison studies in the greenhouse of plants grown in peat : perlite medium showed similar trends.

517

Comparison of Paclobutrazol Drench, Spray, and Spike Applications for Height Control of Foliage and Flowering Baskets

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Experiments were conducted to determine the effectiveness of paclobutrazol in solid spike form as compared to foliar spray or medium drench applications for height control of several foliage and flowering plants grown in 8-inch or 10-inch hanging baskets. Paclobutrazol was applied as either a 20 or 40 mg·$liter^{-1}$ foliar spray, 1 or 2 mg·$liter^{-1}$ medium drench, or 200 or 400 mg·$liter^{-1}$ spike insertion per basket. *Begonia* x *tuberhybrida* 'Nonstop Apricot' and *Begonia* x *hiemalis* 'Barbara' treated with paclobutrazol were significantly shorter than nontreated controls. Drench applications were more effective than either spray or spike treatments for both species, with *Hiemalis* begonia showing severe dwarfing at both the 1 and 2 mg·$liter^{-1}$ drench. Paclobutrazol treatments did not significantly affect flower number for either species. *Syngonium podophyllum* 'White Butterfly' and *Epipremnum aureum* showed similar trends as the begonias; however, relative reductions in height were not as great. Plants appeared to be slightly less stretched than nontreated plants.

520

ROSESIM Restructured To Accept Full Quadratic Polynomial Coefficients and Daily Step Input

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An interactive simulation model of plant growth must be flexible to accept specific crop equations from the user. ROSESIM functions as a dynamic plant growth model based on 'Royalty' rose (*Rosa hybrida* L) response to 15 unique treatment combinations of photosynthetic photon flux (PPF), day temperature (DT), and night temperature (NT) under constant growth chamber conditions. Environmental factors are assumed constant over an entire day. Coefficients are read from an external ASCII file, thus permitting coefficients from any linear, quadratic, or interaction terms to be input into ROSESIM up to a full quadratic model form. Nonsignificant terms are given a coefficient of zero. ROSESIM has been restructured into Borland C++ object oriented program (OOP) code to execute in the Microsoft Windows 3.1 operating environment. This enables ease of operation in the user friendly graphical user interface (GUI) provided with most IBM personal computers (PC). The user chooses a set of environmental conditions which can be altered after any selected number of days, allowing conditions to be changed and modeled daily for interactive comparison studies.

521

Alternative Means of Thrips Control in Greenhouse Crops

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Various cultural, biological, and low toxicity methods of pest control that can be used as part of an Integrated Pest Management program for greenhouse growers were tested. Experiments were conducted to analyze alternative methods to control western flower thrips (*Frankliniella occidentalis*) on greenhouse crops, including an insect growth regulator (IGR), aluminized mulches, medial surface treatments involving irrigation, and predaceous nematodes. Persistence of thrips was determined by immersing excised flowers in 70% ethanol solution and pouring the extract through filter paper; thrips on the filter paper were counted. Various experiments were conducted over a 4-month period to determine which means provided the best control. The repeated use of an IGR was effective in reducing thrips populations. Preliminary evaluations indicate nematodes may provide better control than soil treatments.

525

High-resolution Analysis of the Effect of DIF and Growth Regulators on Stem Elongation in Zinnia

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Instantaneous stem elongation rates (SER) in zinnia (*Zinnia elegans* cv. Pompon) treated with daminozide (B-Nine) or gibberellic acid (GA_3) were recorded in 3 DIF regimes (+5, –5, 0; daily average 18.7C). Two developmental stages were chosen for study: Stage 1 was vegetative growth before flower bud formation Stage 2 was the period before anthesis. At both stages, patterns of SER and total diurnal growth were influenced by DIF regime. The application of GA_3 increased SER in a more or less additive manner over all phases of the diurnal growth cycle and daminozide similarly reduced SER. Neither GA_3 or daminozide application transformed growth patterns to match those of positive or negative DIF plants, respectively. Instead. the growth regulators only enhanced or reduced total diurnal growth without modifying the effects of DIF. This suggests that DIF can influence stem elongation growth in a manner which is independent of the effects of gibberellin.

529

Growth Performance of Potted Poinsettia in Crab Waste Compost

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Maryland Chesapeake Bay crab industry generates ≈20 tons of crab waste annually. The crab waste compost (CWC) was a mixture of crab chum and saw dust that had an initial EC of ≈26 dS·m^{-1}. In Fall 1994, soft-pinched single stem 'Annette Hegg Red' poinsettias (*Euphorbia pulcherrima*) in l5-cm azalea pots were grown in media containing Sunshine mix, 1 CWC : S base mix (BM), 1 CWC : 2 BM, . 1 CWC : 1 BM, or 2 CWC : 1 BM. Base mix is a 1 peat : 1 perlite (v/v). Fertigation treatment with 266 mg·$liter^{-1}$ N from 30N–4.4P–8.8K was began on the 1st, 2nd, or 3rd week after potting. The total fertigations ranged from 8 to 10 for the 13-week study. With Sunshine mix, shoot height and canopy diameter were ≈15% greater than with 16% CWC mix and were ≈27% greater than with 67% CWC mix. There was a ≈10% decreased in the shoot height and canopy diameter with increasing %CWC in mix from 17% to 67%, but there was no difference in number of branches among the CWC mixes.

533

'Annette Hegg Dark Red' Rootstock Reduces the Incidence of Poinsettia Bract Edge Burn on 'Supjibi' Scions

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The poinsettia cultivar Annette Hegg Dark Red (AHDR) is resistant to bract edge burn (BEB), while 'Supjibi' readily develops BEB. In 1993, scions of both 'Supjibi' and AHDR were grafted onto either 'Supjibi' or AHDR rootstock (RS) prior to bract initiation. At anthesis, BEB symptoms were more prevalent on 'Supjibi'/'Supjibi' than on 'Supjibi'/AHDR. Four weeks postanthesis, 26.4% of the bracts on 'Supjibi'/'Supjibi' developed BEB, and 10% of the bracts had severe symptoms (based on number and size of necrotic spots), while only 13.8% of the bracts on 'Supjibi'/AHDR developed BEB, with 1.7% having severe symptoms. Calcium levels in 'Supjibi' bracts averaged 0.41% for scions on 'Supjibi' RS and 0.39% on AHDR RS. AHDR scions failed to develop BEB regardless of RS. In 1994, plants with a 'Supjibi' scion on a dual RS ('Supjibi' + 'Supjibi', or 'Supjibi' + AHDR) were formed using an approach graft technique and the following treatments were applied: one RS severed before bract initiation to produce plants with just a 'Supjibi' or AHDR RS, AHDR + 'Supjibi' RS intact until anthesis then either the 'Supjibi' or AHDR RS severed, or both RS remained intact until termination of the study. Scions with only AHDR RS during bract development or only AHDR RS after anthesis developed a lower incidence of BEB than bracts on 'Supjibi' scions that were on just 'Supjibi' RS during bract development, or just 'Supjibi' RS after anthesis, or on both RS during the entire study.

537

Evaluating Paper Sludge in Container Media Used for Mum Production

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Paper sludge is a fibrous material that may be suitable as a replacement for peat moss in potting media. The goal of this study was to compare the growth of potted 'Iridon' mums (*Dendranthema* x *grandiflora* Tzvelev.) grown in sludge-amended media against that of plants in two peat-based commercial mixes. Paper sludge from a newsprint mill was composted 6 weeks. Plants were grown in a European pot mum regime with three rooted cuttings planted in square 10-cm pots containing either a commercial mix or a sludge-amended medium [75% sludge : 15% perlite : 10% vermiculite; or 50% sludge : 33% peatmoss : 17% perlite (by volume)]. Plants were grown for 12 weeks and not disbudded before plant growth indices were determined. Mums grown in sludge-amended media appeared similar to those grown in the commercial mixes. Plants grown in either sludge-amended medium were slightly shorter (1.5 cm) and narrower (2.5 cm) than those grown in the commercial mixes. In addition, mums grown in sludge-amended media produced eight fewer flowers and 4 g less shoot dry weight (per pot) compared to plants in commercial mixes. Composted paper sludge appears to be suitable for production of 'Iridon' pot mums, even though plants grown in this material grew slightly less than those in commercial media.

541

Wildflower Seed Mixes for Alaska

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The germination, establishment, survival, and public preference of four wildflower seed mixes were evaluated in relation to irrigation and seasonal sowing date. The mixes included two commercial nonindigenous wildflower mixes, a commercial mix with indigenous and nonindigenous wildflowers, and an experimental mix composed exclusively of Alaska native wildflowers. The two latter mixes were sown with and without 'Tundra' glaucous bluegrass (*Poa glauca*).The two nonindigenous mixes exhibited the greatest seedling establishment during the first season. Fall sowing and irrigation during seed germination significantly increased species establishment for all mixes. In the second season, 11 nonindigenous species did not reappear, whereas all of the indigenous species reappeared. The experimental mix had the greatest species richness of the six mixes in the second season. The addition of grass to the mixes did not significantly affect wildflower species richness in either the first or second season. Survey respondents preferred the nonindigenous wildflower mixes to those containing Alaska native wildflowers because of a greater mix of colors that appeared earlier in the first season than the other mixes. Alaska native species recommended for wildflower mixes include *Polemonium acutiflorum*, *Lupinus arcticus*, *Hedysarum mackenzii*, *Arnica alpina*, and *Aster sibiricus*.

545

Characterization of Substrate Hydraulic and Physical Properties as Related to Irrigation, Plant Growth, and Water Transport

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The influence of substrate physical properties on water transport and plant growth must be known if irrigation water use efficiency is to be improved. Three fundamentally different substrates were examined: 1 peat moss : 1 vermiculite (v/v), 3 pine bark : 1 peat : 1 sand, and 1 mineral soil : 1 peat : 1 sand. Capacity analyses included total porosity, container capacity, air space, available water and unavailable water. Water transport was characterized by saturated and unsaturated flow analyses. A new method, Pore Fraction Analysis, was developed to characterize substrate pore structure into fractions based on function with the substrate. This method is based on soil moisture retention curves, pore size distributions, and average effective suction at container capacity (AES_{cc}) This method is offered to expand the traditional terms of macropore and micropore into new definitions: macropores, mesopores, micropore, and ultramicropore; each based on a range of pore sizes and functions. Computer simulation models of air and water profiles were run on several container sizes with the three test substrates. Pore fraction analysis indicated that under traditional production practices macropores indicate the volume of a substrate that be filled with air at container capacity, the mesopore fraction effectively fills and drains with daily irrigation, the micropore fraction functions as a measure of water reserve, while the ultramicropores contain water unavailable to the plant.

133 POSTER SESSION 20
Seed Establishment/Cross-Commodity

709

Shortening the Dormancy Period and Improving Germination in American Ginseng Seed

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American ginseng seed is important as the primary source of propagation. Little is known about ginseng seed stratification and germination. The green seeds are harvested in August/September and stratified in boxes outdoors for 12 to 14 months. Then the after-ripened seeds are field-seeded; they germinate in the spring. Ginseng seeds undergo long dormancy periods caused by embryo dormancy and impermeable seedcoats. The objectives of this research are to shorten the dormancy period, increase the percent germination, and study the changes that occur during stratification using growth regulator and temperature treatments. Seeds stored at 15C from harvest to January and treated with 1000 ppm gibberellic acid (GA_3) resulted in the most embryo growth, highest percent germination, and best growth after one growing season compared to 20C and no GA_3. Tissue culturing immature zygotic embryos showed a requirement for GA_3 (3–5 µM). Radicle growth may need an attached suspensor for development.

713

Maintaining Impatiens Seed Quality

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Impatiens (*Impatiens wallerana* Hook.f.) flower seeds are believed to be sensitive to storage temperature and humidity conditions. A study was conducted to evaluate seed quality changes occurring during a 1-year period of storage under various temperature and humidity combinations. Four seed lots of 'Super Elfin Red' and 'Super Elfin White' impatiens were studied. Constant humidity treatments were obtained using saturated salt solutions; 15% relative humidity (RH) with LiCl, 25% RH with KAc, 33% RH with $MgCl_2$, and 43% RH with K_2CO_3. Constant temperature treatments were 5, 15, and 22C. At 3-month intervals, replicate samples were sown in plug flats in the greenhouse. Seed quality was evaluated as the percentage of usable seedlings 21 days from sowing. Rapid deterioration of seed quality was seen under high temperature and high humidity storage conditions. Seeds became less sensitive to humidity at 5C. Conditions of 20% to 25% RH and 5C are recommended for impatiens seed storage.

717

Copper Hydroxide is an Effective Control of Root Outgrowth in Plug-grown Seedlings Subirrigated by Capillary Mats

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Capillary mat subirrigation provides uniform water in the growing medium to optimize seedling growth in plugs. It also offers a closed system that allows the grower to regulate the amount of water available to seedlings and to reduce water runoff. However, root outgrowth into the capillary mat can be a significant problem. Copper hydroxide (Spin Out) was painted on the bottom, outside surface of the plug container to control root outgrowth into the capillary mat. Three square and two octagonal plug sizes were treated with copper. Regardless of the plug size or shape, copper treatment was an effective treatment to control root outgrowth in marigold seedlings. Copper treatment reduced overall root outgrowth by 80% to 92%. Marigold and geranium seedlings in copper-treated square plug containers showed some reduced shoot and root development during plug production, but there were no differences in copper-treated plants compared to nontreated plants following transplanting to cell packs.

718

Container Volume and Height Affect Shoot and Root Development in Marigold Seedlings

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Marigold seedlings were grown in four containers that differed in both volume and shape. Seedlings grown in 1.5-gal containers showed the greatest potential for shoot and root development 20 days after sowing. These seedlings had greater leaf area, shoot and root dry weight, and total root number and length compared to seedlings grown in 406 plug trays, 72-cell packs, or 6-inch containers. There was a positive correlation (r^2 = 0.81) between cell volume and seedling growth as well as a positive correlation (r^2 = 0.89) between container height with seedling growth. An attempt was made to separate the impact of container volume vs. container height on seedling growth. Containers were designed using acrylics to vary the container height while keeping the volume constant at 1500 cm^3. There was a positive correlation (r^2 = 0.87) between shoot and root dry weight with container height. The data suggest that both container volume and height contribute to overall seedling growth in marigold, but when container volume is not limiting, container height has a large impact on seedling development.

721

Establishment of Four Annual Species for Roadside Planting

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Seeds of *Celosia argentea plumosa* L. 'Pampas Plumes', *Cosmos sulphureus* Cav., *Helianthus annuus* L. '7111', and *Zinnia elegans* Jacq. 'Gold Medal Mixture' were mixed with clean sand and hand-broadcast over 6.7-m^2 plots at rates of 122 or 244 g/100 m^2. Each plot was either left undisturbed after sowing or the seed was raked into the soil surface. Treatments were applied in a complete factorial design and replicated three times. Germination counts were taken 2.5 and 5 weeks after sowing. The dates of flowering, number of plants flowering, and number of weeds present were recorded at anthesis. The *Celosia* and *Zinnia* bloomed for 42 days, *Cosmos sulphureus* for 28 days, and *Helianthus* for 12 days. Seeding rate had little affect on the number of plants maturing to flower in all species except *Cosmos.* There were no significant differences in number of weeds between treatments for any of the species. Raking the seed into the soil significantly improved germination at both 2.5 and 5 weeks in *Celosia, Cosmos,* and *Helianthus*, but not *Zinnia.* In *Celosia,* raking the seed in more than doubled the number of plants maturing to flower, while in *Cosmos*, the number reaching anthesis was not significant.

725

Emergence of Matriconditioned Cowpea and Pigeonpea Seeds at Different Soil Moisture Levels

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Increasing seed moisture has been beneficial in improving seedling emergence of some crops. Seed moisture contents of three cowpea (*Vigna unguiculata*) genotypes (MN13, Pinkeye Purple Hull, and IT 82E-16) and two pigeonpea (*Cajanus cajan*) (ICPL 85024 and ICPL 8304) were modified by incubating a 10 seed : 4 celite : 13 water (by weight) mixture at 15C. Conditioned seeds had moisture contents ranging from 46% to 64%, while nontreated seeds ranged from 4% to 8%. Matriconditioned and nontreated seeds had <15% emergence at 28 days after planting (DAP) in dry field conditions, where precipitation was <41 mm. In greenhouse tests at 14 DAP, matriconditioning had a negative effect on seeds in flooded, moist, and dry soils. The percent emergence for these seeds was 40% when compared to 60% for nontreated ones. Conditioning did not affect percent emergence at 7 DAP, days to first emergence, and percentage of germinated, unemerged seeds at 14 DAP. In the dry soil, emergence was less and later, and more germinated, unemerged seeds were present at 14 DAP. Cowpeas averaged 56% germination and pigeonpeas were 27%.

729

Net Photosynthetic and Evapotranspiration Rates in Situ of Tomato and Lettuce Plug Sheets in the Greenhouse

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Net photosynthetic and evapotranspiration rates of tomato (LAI = 2.3) and lettuce (LAI = 6.6) plug sheets were estimated based on measurements of the weight of plug sheets and vertical profiles of CO_2 concentration above the plug sheets. The measurements were continued in situ for several days in a greenhouse when plugs were at transplant stage. The maximum net photosynthetic rates of tomato and lettuce plug sheets were 0.8 and 2.0 mg CO_2/m^2 per sec on a plug sheet area basis, respectively. The maximum evapotranspiration rates of those sheets were 100 $mg \cdot m^{-2} \cdot s^{-1}$. Net photosynthetic and evapotranspiration rates of tomato and lettuce plug sheets increased linearly with an increase in solar radiation flux, with a correlation coefficient of 0.9.

733

Using the Float System and Copper Hydroxide Tray Treatment for Tomato Transplant Production

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Conventionally grown tomato transplants were compared with those grown in a float system for growth and productivity. Tomato plants grown in a float system were larger than plants grown conventionally and produced higher early season yields of small, medium, and large fruit. Yields of extra-large fruit and total yield were not affected by production method. Mean fruit size from conventionally grown plants was larger early in the season. Transplant growth in plastic foam tray cells treated with 7% $Cu(OH)_2$ was compared with growth in nontreated cells. Transplants from trays treated with $Cu(OH)_2$ were larger and had fewer roots emerging from the bottom of the trays. $Cu(OH)_2$ treatment had no effect on plant height in the field, seasonal yield distribution, total yields, or mean fruit size.

737

Transplant Cell Size Affects Early and Total Yield of Muskmelon

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Muskmelon (*Cucumis melo* L. cvs. Superstar and Mission) transplants were grown in seedling flats with individual cells ranging in volume from 7 to 100 cm^3. The smallest cells were in a 338-cell polystyrene flat 33 cm wide x 66 cm long x 4.75 cm deep; the largest cells were in a 32-cell plastic flat 30.5 x 50.8 x 6.5 cm. The study was conducted in Florida and Indiana during the 1993 and 1994 growing seasons. Seedlings of uniform age were transplanted to the field and grown to maturity using standard cultural practices. Early yield of 'Superstar' muskmelon, measured as number of fruit per plot or percentage of total yield, increased as transplant cell volume increased. In one trial, plants from 7-cm^3 cells produced no early yield, while plants from 100-cm^3 cells produced 40% of the total yield in the first three harvests. In three of the four trials, total yield of 'Superstar' increased as cell volume increased. Marketable early yield of 'Mission' muskmelon, measured as number or weight per plot, increased as cell volume increased in three of four trials. In Florida, total yield of 'Mission' also increased as cell volume increased. Size of 'Superstar' fruit was not influenced by cell volume. In Florida, size of early 'Mission' fruit increased as cell volume increased.

741

The Effect of Liquid Nitrogen and Sulfuric Acid on Several *Rubus* Species

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Many *Rubus* species have a seedcoat imposed exogenous dormancy. Our objective was to contrast the effect of liquid nitrogen (LN_2), sulfuric acid (H_2SO_4), and an untreated control on seed germination of *R. multibracteatus* A. Leveille & Vaniot and *R. parviflorus* Nutt. and to determine if LN_2 could be used as a mechanical scarifying agent for these species. Three replicates of 100 seeds of each species were treated with either three 3-min dips in LN_2 with corresponding 10 min thaws or for 30 min with H_2SO_4 or were left untreated. The LN_2 pretreatment did not significantly reduce the viability of *R. multibracteatus* or *R. parviflorus* as compared to the control. A random sample of germinated *R. multibracteatus* from the LN_2 pretreatment showed normal seedling development upon planting. The H_2SO_4 pretreatment significantly increased germination percentages as compared to the control or LN_2 pretreatment as well as for *R. ursinus* Cham. & Schldl. and *R. eustephanus* Focke ex Diels. The LN_2 treatment did not significantly improve germination over the control group and therefore was not an effective scarifying agent as applied to *R. multibracteatus* or *R. parviflorus*. However, these two *Rubus* species were not damaged by repeated dips in LN_2. Alternative LN_2 pretreatments are being examined for their potential to improve *Rubus* germination further.

745

Effect of Some Chloride Salt Concentrations on Germination of Four Saudi Date Palm Cultivars

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Seeds of four Saudi date palm cultivars were germinated on a modified White's medium (liquid and solid) containing various concentrations of sodium, calcium, and magnesium chlorides. These salts were incorporated in the medium to simulate their concentrations in Saudi underground water commonly used for irrigation. Different germination responses were observed on the liquid and solid medium. Variations between the four test cultivars on the same medium also were noticed.

749

Quality Variability of Prairie and "Garden" Wildflower Seed Obtained from Commercial Sources

*Michael N. Dana** and *Ricky D. Kemery,* Purdue Univ., West Lafayette, IN 47907

Interest in direct-seeding establishment of wildflowers as a component of landscape planting has continued to increase. Seed may be very expensive. Information is needed on the quality of seed available to consumers and the landscape industry. The goal of this work was to assess the level and consistency of seed quality available from the wildflower seed production/marketing industry. Eleven species of native prairie forb wildflowers and eight species of "garden" wildflowers from seven companies were purchased in 1992 and 1993 and subjected to germination testing. Germination procedures were those of AOSA where available, or generalized from the literature when no guidelines existed. Results showed significant variation among wildflower species, among companies supplying the same species, and over the two seed years tested in the study. These data reinforce the need for seed quality testing and reporting as a part of the sales of wildflower seed.

753

A "New" Method of Installing Prairie Forb Transplants

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Fir seedling transplant containers were used as an alternative to conventional plug containers (72 per tray) in a system to grow seedlings of native prairie perennials and install them on a highway site in central Indiana. Plants grown in deep-tube fir-seedling containers exhibited greater fresh and dry weights than conventional plug transplants with no root circling. Results from survival data indicate that plants grown in fir seedling containers offer better chances of success on highway sites with low soil fertility and poor soil structure. A chronology of installation methods, tools, and mechanization possibilities is presented.

757

Effect of Hydration and Dehydration on Corn Seed Germination and Vigor

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Seed water content has been considered the most important factor controlling various physiological reactions in seeds. Hydration/dehydration affects many physiological reactions, including the "priming effect" and "accelerated aging," depending on time and level of hydration. Corn seeds (11% mc) were subjected to six cycles of hydration (2 h) and dryback or one hydration of 12 h and dryback. Following soaking, seeds were dried quickly by using a fan to remove moisture and then equilibrated to their initial mc. Seeds were evaluated for germination and vigor (root length and leachate conductivity). Percent germination of seeds treated with either continuous or intermittent hydration and dehydration was >90%. Vigor of seeds hydrated for successive 2-h cycles initially increased (priming effect); however, after the sixth cycle, vigor was equal to the nontreated control seeds. One cycle of hydration for 12 h then dryback had no effect on germination but did increase vigor. We are now extending the number of 2-h hydration periods to 10 to determine when damage occurs from these cycles. Our objective is to better understand the relationship between seed hydration and physiological changes associated with seed priming, accelerated aging, and imbibition damage.

761

Effects of Salinity, Temperature, and pH on Germination of *Echinacea angustifolia* Seeds

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The influences of NaCl concentration, incubation temperature, and pH on the germination of *Echinacea angustifolia* seeds were investigated. Dehulled, surface-disinfected seeds were germinated in petri dishes containing 0, 0.5, 1, 1.5, 2.0, 2.5, 3.0, 3.5, or 4.0 $g \cdot liter^{-1}$ NaCl at 12, 17, 22, or 27C for 10 days. Percent seed germination was the highest at 0 ppm NaCl and was progressively reduced as NaCl concentrations increased to 4 $g \cdot liter^{-1}$ at all temperatures. The NaCl suppression of germination was most severe when seeds were incubated at 27C. No germination occurred at 12C. When seeds were germinated over a pH range from 4 to 11, the highest percent germination occurred at pHs between 6 and 8 at 25C.

765

Timing of Transplanting Affects Survival of Prairie Perennial Forb Seedlings

*Ricky D. Kemery** and *Michael N. Dana*, Dept. of Horticulture, Purdue Univ., West Lafayette, IN 47907

Seedlings of six species of native prairie perennial forbs were installed monthly from Oct. 1993 to Nov. 1994 on two highway sites near West Lafayette, Ind. Survival varied significantly among species. Overall, 85% of *Aster novae-angliae* seedlings survived compared to 15% survival of *Liatris pycnostachya* seedlings. Survival also varied significantly with time of installation. Three species (*Aster novae-angliae*, *Ratibida pinnata*, and *Veronicastrum virginicum*) exhibited 95% survival when planted in mid-October, compared to 50% survival when planted in March. Fifty-seven percent survival of *Echinacea pallida* seedlings was observed with April plantings, compared to 9% survival of September plantings. Results of this study indicate that transplant survival rates of particular prairie species may be enhanced by precise timing of planting in late fall or early spring.

769

Establishment of Hawthorn Seedlings as Affected by Site of Antidessicant Application

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A film-forming antidesiccant (Moisturin-4; Burke's Protective Coatings, Washougal, Wash.), 1:1 (v/v) with water, was applied to dormant, bare-root, 2-year seedlings of Washington hawthorn (*Crataegus phaenopyrum*), a difficult-to-establish species. Antidesiccant applications were made to nonstressed controls or to stressed plants (13 h air-drying at 19C and 20% RH) either before or after drying. Antidesiccant was applied to stems only (SO), roots and stems (RS), or not at all (stressed controls). Three subgroups of treated plants were measured to assess changes in fresh weight (FW), xylem water potential (XWP), or specific conductivity (k_s) of stems before stress, after stress, or 2 to 3 weeks following

planting in the greenhouse. Applications of antidesiccant to SO allowed stressed plants to recover prestress levels of FW after 2 to 3 weeks, whereas stressed plants receiving the RS treatment did not fully recover prestress levels of FW. XWP of stressed SO plants tended to increase following outplanting. k_s was highly variable, but tended to be higher in nonstressed plants. Nonstressed and SO seedlings had higher percentages of budbreak.

773

The Influence of Root-zone Temperature and Fertilization Regime on Early Growth and Development of Pawpaw (*Asimina triloba* Dunal) Seedlings

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A two-factor factorial, randomized block design was used to study the influence of root-zone temperature (RZT) and fertilization regime (Fert) on early growth and development of pawpaw seedlings in the greenhouse. Stratified seeds were sown in 45-inch^3 Rootrainer cells in Promix BX potting medium. Plants were watered/fertilized twice weekly to runoff. RZT was at two levels—ambient (75F–Amb) or bottom-heated (90F–Heat), and it commenced at sowing date. Fert was at four levels—125, 250, 500, or 1000 ppm Peter's 20N–20P–20K plus soluble trace elements, and it commenced at emergence date. Bench position in the greenhouse was used as the blocking variable (three blocks). The 20 most uniform seedlings were selected from each treatment/block for weekly growth measurements. At the termination of the experiment (equivalent to time for transplanting to a larger container), 10 plants per treatment/block were harvested destructively. RZT significantly influenced time to seedling emergence where Heat seedlings emerged 10 days earlier than Amb seedlings. Heat plants were significantly taller, had greater trunk diameter, leaf number, and leaf area than Amb plants. Fert at 125 to 250 ppm resulted in the most robust seedlings, with 1000 ppm Fert often inducing early terminal bud set. Impact of RZT and Fert on seedling development over time will be discussed.

777

Respiratory Byproduct—Ethanol: An Indicator of Lettuce and Sweet Corn Seed Quality

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The production of ethanol under anaerobic and aerobic conditions is suggested as a sensitive indicator of seed aging. Seeds of sweet corn (*Zea mays* L. 'Jubilee') and lettuce (*Lactuca sativa* L. 'Salinas') were aged at 75% relative humidity and 45C to obtain five aged seed lots and compared to a nonaged control sample. The percent germination decreased while percent abnormal seedlings initially increased with seed aging. Anaerobic treatments were induced either by immersing seeds in distilled water for sweet corn or in a solution of 50 mM glucose and 5 mM KPO_4 buffer adjusted to pH 5.6 for lettuce. Aerobic treatments were performed by placing seeds in a plastic chamber filled with a known amount of glass beads sufficiently moistened to allow imbibition. Ethanol was measured after 12 and 24 hours from lettuce and sweet corn, respectively. Aqueous extracts were analyzed by immobilized enzyme technology and verified by gas chromatography. Anaerobiosis induced large amounts of ethanol production compared to aerobic treatments. The amount of ethanol decreased with seed aging duration under anaerobic conditions while these trends were generally reversed under aerobic conditions. The ratio of ethanol produced under anaerobic compared to aerobic conditions was best able to separate differences in seed quality due to aging.

781

Seed Vigor and Sugar Leakage for Isolines of Sweet Corn with Traditional vs. shrunken-2 Endosperm

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Supersweet corn has problems establishing a stand, a problem that is related to a damaged pericarp that allows leakage from seeds during imbibition. This study compared seed vigor and sugar leakage of sweet corn isolines with different endosperms. Isoline pairs (C68, IaS125, Ia453, Il442a, and Oh43) of sweet corn (*Zea mays* L. var. *rugosa*) with two endosperms (*sul* or *sh2*) were used. Seeds were germinated at 10, 15, or 20C. Seeds also were planted in Urbana, Ill., where seedling growth was measured. Seeds also were soaked in water for 24 h, and then leachate was analyzed for sugars (anthrone method) and for sucrose, fructose, and glucose (HPLC). No seeds germinated at 10C. At 15 and 20C, more *sul* seeds germinated than *sh2* seeds in most cases. In fields, *sul* plants were more vigorous than *sh2* plants based on emergence, plant height, leaf number, weight, and leaf area. More sugars leaked from *sh2* than *sul* seeds. More sucrose leaked from *sh2* than *sul* seeds in all but two isolines, where none leaked. More fructose leaked from *sh2* than *sul* seeds in all but two isolines, where no differences occurred. More glucose leaked from *sh2* than *sul* seeds only in Oh43.

139 POSTER SESSION 21
Cell & Tissue Culture/Cross-Commodity

701

Adventitious Regeneration Studies in Hibiscus Species

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An adventitious regeneration protocol developed for *Hibiscus cannabinus* L. (kenaf) was attempted on various ornamental hibiscus species. *Hibiscus syriacus* (Althea, Rose of Sharon) has been successfully regenerated using the kenaf protocol. Leaf tissue from two cultivars ('Double Pink' and 'Diana'—a triploid) was placed on kenaf regeneration media. Adventitious shoots emerged from both cultivars within 8 to 10 weeks. Shoots were then excised and placed on a medium for rooting. Additional hibiscus species have been evaluated for regeneration ability. Previous studies with kenaf determined the adventitious regeneration protocol could induce mutations (somaclonal variation) in the regenerants. Variations in kenaf stem color and flower shape were noted. Since many ornamental hibiscus are asexually propagated, once a desired mutant is identified, it could be maintained and propagated without loss of the unique trait(s).

948

Effect of Different Levels of Blue-green Algal Extract on Somatic Embryo Elongation, Shoot Proliferation, and Root Formation of Five Pecan Cultivars

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Attempts to improve somatic embryogenesis of five pecan (*Carya illinoinensis* L.) cultivars using different levels of blue-green algal extract added to the media proved effective. WPM_4-pecan media, containing 1.0 g malic hydrozide/liter and 30 g sucrose/liter, for embryo enlargement showed that the higher the extract concentration the longer the embryo harvested after 7 to 8 weeks of incubation at 22 to 25C. 'Desirable' responded the best to the algal extract, where the percent elongation recorded was 129.1, 177.3, 174.2, and 200.6 for 0%, 1%, 2%, and 4%, respectively. Dessicating the embryos at 5C for 5 days enhanced the conversion on WPM_4 conversion media containing silver nitrate and GA_3. The number of normal shoots and roots was higher at 1% extract in cultivars Muhan, Elliot, and S-17, while the 4% algal extract was more effective for 'Desirable' and 'Shawnee'. Algal extract had no effect on media pH. Survival of converted embryos in the greenhouse was promising.

952

Scanning Electron Microscope Studies of the Development from Germination to Mature Plant of Some Hardy Terrestrial Orchids

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Cultures of several orchid species [*Barlia robertiana* (Loisel.), *Dactylorhiza fúchsii* Soó, *D. incarnata* (L.) Soó, *D. maculata* (L.) Soó, *D. majalis* (Rchb.), *D. saccifera* (Brong) Soó, *D. sambucina* (L.) Soó, *Gymnadenia conopsea* (L.) R.Br., *Himantoglossurn hircinum* (L.) Spreng., *Ophris sphegodes* Mill., *Orchis coriophora* ssp. *fragrans* L., *Orchis laxiflora* ssp. *palustris* Lam., *Orchis mascula* L., *Orchis morio* L., *Platanthera bifolia* (L.) Rich., *Spiranthes aestivalis* (Poir.) Rich.] were initiated with fresh ripe seeds from desiccated fruit and 4-month-old in vitro seedlings. The medium used for both germination and seedling culture was a modified FAST medium. Samples for the scanning electron microscope

(SEM) surveys were taken from the in vitro cultures and some plant materials were collected from their native habit. Samples were observed with a Tesla BS 300 SEM. Seeds ranged from 300 to 450 µm in length and were flask-shaped. The first germination step is opening of the seedcoat, when the first few white cells will be visible. After a few weeks, the apical meristem appears. The young protocorm is covered with numerous translucent rhizoids. In the last stage of germination, the first root and the first true leaf start to develop. After 2 years, they are suitable for transfer ex vitro. Structure of the mature organs and tissues can be examined at this stage.

956

Nitrogen Assimilation of Micropropagated Strawberry Plantlets during the Transition from Heterotrophy to Photoautotrophy

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A study was conducted to determine the implication of nitrate reductase (NR) and glutamine synthetase (GS) during the transition of micropropagated plantlets from heterotrophy to photoautotrophy to document how nitrogen metabolism interfaces with photosynthetic and anaplerotic CO_2 fixation. The activity of the two enzymes was determined in different tissues at different organogenic stages during the development of plantlets transferred onto rooting media containing varying quantities of sucrose. Under 3% sucrose, NR activity was much higher in leaves than in crown tissues. When roots are initiating, there is a shift in the proportion of nitrate reduction from leaves to crown. As roots mature, the proportion of nitrate reduction increases in roots. Similar trends were observed under 5% sucrose. In contrast, under 1% sucrose, a higher proportion of the nitrate is reduced in the leaf tissues throughout the culture period. This suggests that nitrate is reduced mainly in leaves in photoautotrophic plantlets, while it is reduced in crowns and root tissues for mixotrophic plantlets. In general, the GS activity follows the pattern of NR, but is always in excess, to enable rapid assimilation of ammonium derived from metabolism and medium absorption.

960

Factors Affecting the In Vitro Storage of Strawberry

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Fragaria germplasm, stored at 4C as cold-hardened in vitro plantlets, was rated for condition on a 0–5 scale at 9, 12, and 19 months. Plants with ratings ≥2 were healthy enough to remain in storage. Benzyladenine (BA) at 0, 1, 2.5, and 5 µM and storage in darkness or with a 12-h photoperiod were examined for a group of four genotypes. Means of plant condition ratings over all treatments and genotypes were best (3.4) at 9 and 12 months and declined to 2.2 at 19 months. Increasing concentrations of BA were correlated with higher condition ratings compared to those without BA, and plants stored with a 12-h photoperiod had higher ratings than those stored in the dark. At 9 and 12 months, plants grown with BA and a 12-h photoperiod had the highest ratings. Five different *Fragaria* genotypes were used to study the effect of photoperiod and cold-hardening on condition ratings of stored plantlets. Cold-hardened plants had higher condition ratings (2.1) than those stored without cold-hardening (1.8). Plants stored with a 12-h photoperiod had higher mean condition ratings (2.2) than those stored in the dark (1.7). Storage with cold-hardening and a 12-h photoperiod resulted in improved plant condition. The extent of improvements was genotype-dependent.

963

In Vitro Regeneration of Trichosanthes from Shoot Tips

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The morphogenetic potential of parval or pointed gourd (*Trichosanthes dioica* Roxb.) shoot-tip explants was investigated to establish this species as a model tissue culture system. An effective multiple-shoot propagation method is described. Ten-millimeter shoot tips from young branches of greehouse-grown plants served as explants. They were initiated on a MS basal medium. Multiple shoots were encouraged by transferring established explants to a proliferation medium consisting of MSB + 1 mg BAP/liter, because lower concentrations of BAP (0.1 to 0.5 mg·liter^{-1}) inhibited multiple shoot formation; however, the same concentrations promoted rooting in explants. Medium supplemented with 1 mg BAP/liter and 100 mg PVP/liter caused the best proliferation of shoot tips. Upon transferring to fresh medium of the same composition, these shoot tips elongated 24 cm with three to five nodes in 4 weeks of culturing. Shoot multiplication cultures were maintained by transferring segments of multiple-shoot clusters to medium containing 1 mg BAP/liter and 0.5 mg GA_3/liter. Medium supplemented with TDZ inhibited the number of regenerating explants but enhanced the number of shoot buds. Eighty percent of these plantlets were successfully rooted on MS medium supplemented with 1 mg NAA/liter. Plantlets survived in potting soil and exhibited normal growth under mist in the greenhouse.

966

Micropropagation of *Helleborus orientalis* Lam. and *Aconitum uncinatum* Linn. (Ranunulaceae)

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The objectives of this study were to develop systems for mass proliferation, rooting, and reestablishment of microcuttings of *Helleborus orientalis* and *Aconitum uncinatum*. Basal medium for *H. orientalis* contained 1/2 MS with 0.4 mg thiamine·HCl/liter, 0.5 mg pyridoxine·HCl/liter, 0.5 mg nicotinic acid/liter, 100 mg *i*-inositol/liter, 5 mg BA/liter, 2% sucrose, and 0.7% Phytagar. There was no effect of GA (1 mg·liter^{-1}) or TDZ (0.1, 1 mg·liter^{-1}) on axillary shoot proliferation. *Helleborus orientalis* rooted in vermiculite, Redi-Earth, or 4 perlite : 1 peat with 50% to 56% survival. A field plot containing 18 clonal *H. orientalis* has been established. Basal medium for *A. uncinatum* contained WPM with 2% sucrose, 2.5 mg BA/liter, 150 ppm ascorbic acid, 150 ppm citric acid, and 0.7% Phytagar. There was no effect of photoperiod (8, 12, 14 h, 52.5 µmol·m^{-2}·s^{-1} photosynthetic active radiation) or banana extract on axillary shoot proliferation. Significantly more axillary shoots were generated in the presence of BA (10 mg·liter^{-1}) + kinetin (10 mg·liter^{-1}). Medium containing 500 ppm of PVPP resolved blackening of microcutting bases. More than 500 in vitro-rooted microcuttings (1 mg IBA/liter) survived and grew when transplanted into MetroMix 510 and placed under humidity domes for 6 weeks in the mist.

968

Variation of Chromosome Numbers in Easter Lily Regenerated from Ovary Tissues

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Easter lily (*Lilium longiflorum* L.) cultivars Ace and Nellie White were regenerated through the culture of immature ovary tissues. Shoot initiation and proliferation were most efficient when a modified Murashige and Skoog (MS) medium containing 5% sucrose, 1 mg 2,4-D/liter, and 2 mg benzylamino purine (BAP)/liter was used. The shoots, when divided and subcultured on the same medium, formed roots within 4 weeks. The rooted plants were transferred to soil in a greenhouse. Root-tip smears made from the regenerated plants showed a range of variation in chromosome numbers from 10 to 25 per cell, in contrast to the bulb-grown plants, which had 2x = 24 chromosomes per cell. The mixoploid condition existed in many regenerants exhibiting chromosome number variation in different root cells of the same plant.

971

Variation in Micropropagated Trees of 'Redspur Delicious' Apple

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Small actively growing micropropagated trees of 'Redspur Delicious' apple (*Malus* x *domestica* Borkh.) were planted in an orchard at the end of May 1982. By Spring 1986, a lack of uniformity in tree size, appearance, and flowering was obvious. Only four of the 18 trees had a typical spur-type growth habit. These four trees had significantly more spurs per unit of shoot length, flowered sooner, had higher early fruit yields, and remained significantly smaller after 13 years in the orchard, but had significantly less cumulative yield than the nonspur types. Shoots from the spur-type trees were recultured in 1988 and the resulting trees planted in an orchard in 1990. These latter trees were uniform in appearance and all had typical spur-type growth with ≈30% more spurs per meter of shoot growth than the original trees from which they were propagated.

974

Improved Plant Regeneration from *Rosa* x*hybrida* L. Leaf Explants

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Attempts to regenerate plants from leaf explants of *Rosa* x*hybrida* L. on Murashige and Skoog medium have met with limited success. We report improved regeneration of somatic embryos and adventitious shoots from leaves of 'Golden Emblem' on N6 medium. Leaf explants were obtained from microshoots that had been in culture for 4 years. Leaves were placed on N6 medium containing various combinations of 0, 0.4, or 1.0 μM 2,4-D and kinetin for 20 days with an initial dark treatment of 12 days, then transferred to a medium without plant growth regulator. Adventitious shoots and somatic embryos were observed 3 weeks after transferring to medium without plant growth regulators. Leaf explants placed on media without 2,4-D failed to form embryos or shoots. The best combinations of 2,4-D and kinetin (0.4 and 0.4 μM, 0.4 and 1.0 μM, or 1.0 and 1.0 μM) induced regeneration percentages ranging from 21% to 39%. N6 appears to improve regeneration of somatic embryos and adventitious shoots from 'Golden Emblem' leaf explants, but the interaction between media formulation and duration of exposure to 2,4-D and kinetin needs to be examined.

976

Development of a Base Collection of *Malus* Germplasm with Cryopreserved Dormant Buds

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The USDA/ARS collection of *Malus* is held by the Plant Genetic Resources Unit in Geneva, N.Y. The collection comprises ≈2500 accessions, most of which must be maintained as clones in the field to provide propagating material for distribution to the user community. Field maintenance of replicated accessions places the collection at risk from weather extremes, pests, diseases, etc. and is extremely costly. Cryopreservation of dormant buds in a base, or backup, collection could reduce risks and decrease maintenance costs. Since 1988, we have developed and implemented protocols to cryopreserve dormant apple buds at the National Seed Storage Laboratory, Fort Collins, Colo. More than 500 accessions have been placed in cryogenic storage. Buds have been successfully recovered by grafting from >70% of the first 250 accessions cryopreserved. These results, and those from ongoing recovery tests, indicate cryopreservation may be a safe, cost-effective approach to back up collections of tree fruit germplasm. It also may be used to enhance management of the active collections of *Malus*, *Vitis*, and *Prunus* at Geneva.

979

Modified Medium to Improve Somatic Tissue to be Used in Callogenesis

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Somaclonal variation has been one way to create variants that could be used in the breeding programs. However, initial explants may not be useful if they show small leaves or nondeveloped stems. The aim of this work was to find a tissue culture medium so that potato shoots cultured in vitro could regenerate somatic material for use in trials aimed at somaclonal variation. Shoots of 'Baronesa' and 'Monte Bonito' were inoculated in media with or without activated charcoal (3.0 g·liter^{-1}), BAP (1.0 g·liter^{-1}), and different MS salt concentrations (50%, 75%, and 100%). After 30 days in controlled conditions (25C, 16-h photoperiod, and 2000 lux), BAP with activated charcoal improved the percentage of dry matter, and at higher MS salt concentrations, a better response was achieved for 'Monte Bonito'. However, the presence of activated charcoal improved leaf development and stimulated higher shoot and bud formation, especially for 'Monte Bonito'. This somatic material can be used to initiate callogenesis trials successfully.

982

The Mass Production and Acclimatization of Somatic Embryos in *Oenanthe stolonifera* DC.

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Immature florets were inoculated on MS basal salt media (3% sucrose + 0.8% agar) + 1.0 mg 2,4-D/liter to induce embryogenic callus. Induced embryogenic callus was sieved through serial metal mesh screens (40 and 60 mesh) and placed on the embryo induction media at different concentrations of cytokinins and osmotica. BAP (0.1 mg·liter^{-1}) or TDZ (0.001, 0.01, 0.1, and 1.0 mg·liter^{-1}) were treated on 1/2 MS (3% sucrose) according to the following schedules: 1) first 2 weeks of treatments, followed by 3 weeks of 1/2 MS (3% sucrose) (FT); 2) first 3 weeks of 1/2 MS (3% sucrose), followed by 2 weeks of treatment (LT); and 3) 5 weeks of treatments. PEG, mannitol (0, 2.5%, 5.0%, 7.5%, and 10.0%), and sucrose (0%, 3%, 6%, 9%, and 15%) also were used as osmotica with ABA (0.05 mg·liter^{-1}), respectively. The treatment schedules were FT and LT. Several good quality embryos were produced at 0.001 mg TDZ/liter, 0.1 mg BAP/liter, or 7.5% and 10.0% PEG (only FT). Abnormal embryos were significantly reduced at 7.5% and 10.0% PEG. Leaves of the plants obtained through somatic embryos were compared with those of seed-propagated plants before and after acclimatization using SEM. Epidermal and conductive tissues developed little in the plants before acclimatization; however, they developed gradually after acclimatization and were similar to those of seed-propagated plants.

984

A Comparative Study on Plant Regeneration from Protoplasts of Two Genotypes of *Asparagus officinalis* L.

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The effects of culture media, culture modes, and carbon sources on plating efficiencies of protoplasts of two genotypes of *Asparagus officinalis* L. were investigated. Protoplasts grew best in a semisolid culture system containing half-strength MS medium with 1 mg NAA/liter, 0.5 mg zeatin/liter, 0.6 M glucose, and 0.1% Gelrite. The plating efficiencies were 12.5% and 8.1% for genotypes G 203 and G 171, respectively. Embryogenic calli were produced from protoplast-derived microcalli after culturing on MS medium with 1 mg 2,4-D, 3% sucrose, and 0.2% Gelrite. The somatic embryos were initiated, matured, and then germinated to plantlets in MS medium containing 0.1 mg NAA/liter, 0.3 mg 2-iP/liter (EMM), and different levels of carbohydrates. Transfer of somatic embryos from EMM with 10% glucose to EMM containing 2% sucrose produced the highest number of bipolar embryos and plantlets. The plantlets regenerated shoots and roots in MS medium with 3% sucrose, 0.1 mg NAA/liter, 0.1 mg kinetin/liter, and 1.28 mg ancymidol/liter. Cytological analysis of these plants revealed 2n = 20 chromosomes.

987

Development of Two Screening Methods for Tomato Seedlings Containing the NPT II Selectable Marker Gene

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Two simple, cost-effective methods to screen fresh-market tomato seedlings containing the kanamycin resistance gene construct, in which the nopaline synthase promoter from pMON128 is driving the NPT II gene, have been developed. The assays can reliably distinguish kanamycin-resistant from sensitive progeny for a variety of tomato genotypes. One method is an in vitro germination assay. Two selective agents, geneticin (G418) and kanamycin sulfate, were evaluated for their efficacy, and titrations were performed to determine the optimal concentration of the appropriate agent. The second method is a whole-plant spray test of seedlings to identify kanamycin-resistant progeny. A protocol was developed that could distinguish positives from negatives in 5 weeks. Currently, these assays are being used to screen R_1 progeny rapidly to identify positives and obtain segregation ratios. They also are being used to screen R_2 progeny to identify quickly those lines that are "true-breeding" or homozygous for field trial evaluation.

990

High Efficient Procedure of *Agrobacterium*-mediated Transformation of Cultivated Tomato (*Lycopersicon esculentum*)

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Tomato is one of the most important crop species where the introduction of foreign genes is expected to have a major impact on agriculture. Several transformation methods exist that rely on the cocultivation of various tissue or organ explants. However, tomato is still considered more difficult to transform than species such as *Petunia hybrida* and *Nicotiana tabacum* and can show widely varying success rates. Using cotyledonous explants, we propose a highly efficient procedure of *Agrobacterium*-mediated transformation and regeneration of

an agricultural cultivated tomato (*L. esculentum* cv. Summerset). Results showed that up to 90% of the cotyledons generated callus within 3 weeks (1 to 5 calli/cotyledon) and 50% of them regenerated shoots in another 3 weeks. Finally, it resulted in 50 to 100 independent transgenic plants per 100 inoculated explants within 10 weeks. These results are at least 40% more efficient than those of already published protocols. Moreover, up to 95% of the regenerated plants that form vigorous de novo roots under the antibiotic selection tested positive for the GUS assay. Screening by PCR for the presence of the T-DNA genes gave the predicted DNA fragment bands. This high efficiency procedure was mainly achieved by 1) an adequate optimization of the hormone composition and concentration of the successive culture media; 2) the fresh explant wounding before the *Agrobacterium* infection (important for optimal cell transformations); 3) the explant position, inside down for callus induction and coculture period, and upside down for the selection and organogenesis period (important for antibiotic selection).

992

Influence of Boron and Salt Concentration on Calcium-45 Uptake by Micropropagated Potato Plantlets

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Calcium^{45} uptake by in vitro-grown 'Bintje' potato plantlets increased linearly as the salt concentration of the nutrient medium was decreased from 2 to 0.5 MS. The increase in Ca^{45} absorption was significant for shoot tips and stems ($P \leq 0.05$), but not for foliage. In shoot tips and stems, Ca^{45} uptake increased linearly as medium Ca increased, independent of boron (B) medium concentrations. However, in leaves, this increase was linear at low B concentrations (0.05 mM) and parabolic at relatively higher B concentrations (0.1 and 0.2 mM). When medium Ca was 9 mM, Ca^{45} absorption was reduced significantly ($P \leq 0.01$) by increasing B concentration in the medium.

995

Microtuberization of Potato (*Solanum tuberosum*) under Saline Stress

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In vitro bioassays for screening and selection of salinity (NaCl)-tolerant potato have primarily focused on nodal cuttings. However, the relative tolerance of the microtuberization stage to salinized medium may be more relevant. A two-step microtuberization protocol was used in which in vitro layering was followed by microtuber induction in salinized media. 'Norland', 'Russet Burbank', and 'Superior' shoots were layered in liquid Murashige and Skoog (1962) basal salt medium with 20 g sucrose/liter and incubated for 4 weeks at 25C with 50 $\mu mol \cdot m^{-2} \cdot s^{-1}$ photosynthetic photon flux density and 16-h day/8-h night period. Medium was replaced with liquid medium containing 80 g sucrose/liter and NaCl at 0, 80, or 160 mM. Cultures were incubated for 4 weeks at 15C with 50 $\mu mol \cdot m^{-2} \cdot s^{-1}$ photosynthetic photon flux density and 8-h day/16-h night period. Relative salinity tolerance of cultivars differed during the microtuberization stage. Low salinity (80 mM) stimulated, but high salinity (160 mM) depressed, microtuber yields compared with controls.

998

Shoot Differentiation and Proliferation in *Echinacea purpurea* through Leaf Tissue Cultures

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Leaf sections of *Echinacea purpurea* obtained from greenhouse-grown plants were cultured on Murashige and Skoog (MS) medium supplemented with 0.5 to 4.0 µM benzyladenine (BA) and 0.1 to 10.0 µM naphthaleneacetic acid (NAA). The efficiency of adventitious shoot formation from leaf explants varied depending on growth regulator concentrations. About 90% of leaf tissues cultured with 20 µM BA and 0.1 µM NAA produced shoot differentiation. Initially, the adventitious shoot buds were purplish-red in color; they turned to green shoots as young leaves began to unfold. The individual shoots, when excised and subcultured on the MS basal medium containing 10 µM gibberellic acid (GA_3), produced 15 to 20 new shoots per culture within 4 weeks.

1000

In Vitro Responses of Tissues from Rhododendron Plants With and Without Tissue Proliferation

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Rhododendron 'Montego' shoot cultures initiated from plants with and without tissue proliferation (TP and NTP) served as explant sources for all studies (Note: in vitro TP shoot cultures produce primarily dwarf shoots, some long shoots, and stem tumors). Calli induced from TP leaves and tumors and NTP leaves were cultured on woody plant (WP) medium containing NAA and 2-iP. During the first 4 weeks of culture, calli from NTP leaves had higher relative growth rates than calli from TP leaves or tumors. However, calli from TP leaves and tumors grew faster than calli from NTP leaves for all subculture periods that followed. Shoot tips (5 mm) were excised from TP dwarf shoots, TP long shoots, and NTP shoots and were cultured on WP medium with or without 15 µM 2-iP. Shoot tips from TP dwarf and long shoots multiplied on medium without 2-iP, averaging 18.4 and 1.7 shoots per shoot tip in 12 weeks, respectively. Shoot tips from NTP shoots only multiplied when maintained on 2-iP-containing medium. When placed on 2-iP-containing medium, both types of TP shoot tips produced clusters of callus-like nodules that gave rise to highly tumorized, short shoots or leafy meristems.

1003

Gelling Agents Affect Adventitious Shoot Organogenesis in White Ash

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Dissected white ash seeds were placed on an agar-solidified MS medium with 10 µM TDZ and 1 µM 2,4-D (shoot initiation medium). After 4 weeks, explants were transferred to shoot elongation medium (3 µM TDZ, 1 µM BA, and 1 µM IBA) solidified with 0.7% Sigma agar, 0.525% agar + 0.05% gelrite, 0.35% agar + 0.1% gelrite, 0.175% agar + 0.15% gelrite, 0.2% gelrite, or no gelling agent (liquid medium). After 12 weeks in vitro, shoot growth and number were suppressed in cultures containing 0.2% gelrite (9.3 mm and 0.7 shoots) and in cultures containing no gelling agent (6.9 mm and 0.7 shoots). There were no differences in shoot growth and number in cultures containing 0.7% Sigma agar (2.2 mm and 16.5 shoots), 0.525% agar + 0.05% gelrite (2.6 mm and 18.7 shoots), 0.35% agar + 0.1% gelrite (1.6 mm and 17.4 shoots), and 0.175% agar + 0.15% gelrite (2.0 mm and 20.4 shoots). The most vitrification occurred in cultures on medium with the lowest amount of agar, gelrite only, and liquid medium.

1006

The Effect of Culture Physical Conditions and Explant Type and Source on the Growth and Multiplication of *Ficus benjamina* in Vitro

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Shoot cultures of *Ficus benjamina* cv. Cleo showed a variable response to light intensity in the range of 8 to 50 $\mu mol \cdot m^{-2} \cdot s^{-1}$. The highest leaf area occurred at 15 $\mu mol \cdot m^{-2} \cdot s^{-1}$ and shoot length and chlorophyll contents increased with the decrease of light intensity. Incubating explants for 8 weeks at 25 and 35C showed that shoot length increased at 35C; however, shoot multiplication, leaf number, root number, and callus weight were higher at 25C. Shoot-tip explants were superior to axillary buds when cultured or subcultured for shoot elongation, whereas axillary buds were better for shoot multiplication. Shoot tips with two or three small leaves appeared to be the best explants for fast growth and healthy cultures of *F. benjamina*.

1008

Long-term in Vitro Regeneration of *Hamelia patens*

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This report describes an efficient in vitro regeneration protocol for *H. patens* (firebush), a heat-tolerant ornamental shrub native to tropical and subtropical America. Shoot cultures were initially established using shoot tips placed on MS-revised medium containing 2.3 µM 2,4-D, 2.3 µM kinetin, and 0.25% polyvinylpyrrolidone. Other types of explants (nodal and internodal segments, leaf pieces, floral buds) did not regenerate shoots when placed on this medium. Two-month-old plantlets derived from the shoot tips were subcultured on

MS medium supplemented with 0.5 μM thidiazuron (TDZ), and within 3 to 4 weeks, some callus was produced at the root–shoot junction. When this callus, with a small portion of the root and shoots, was placed on MS medium with 0.05 μM TDZ and 0.01 μM ABA, prolific shoot formation occurred within 3 to 4 weeks followed by root formation. By regular subculturing every 5 to 6 weeks, hundreds of plantlets have been obtained over the past 3 years with no apparent decline in regeneration potential. Addition of activated charcoal (0.5%) to the culture medium has greatly improved growth of the plantlets.

1011

Forcing Large-diameter Stems of Adult White Ash in a Greenhouse to Obtain Softwood Shoot Explants

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Branches were collected from trees in July. Lengths with a 2.5-cm caliper were cut to 30 cm and placed horizontally into flats of perlite with half of the diameter of each stem above the perlite surface. Flats were watered daily with tap water and stems were kept moist. Buds swelled quickly, and after 6 days, small epicormic shoots were visible. These softwood shoots continued to elongate and retain good turgor for 2 weeks, when they were excised and placed in vitro. Shoot-tip and nodal explants were placed onto MS medium with 1 μM BA; 1 M IBA; and 0, 3, or 10 μM TDZ where shoots slowly elongated. Forcing large stems in the greenhouse has been superior to forcing smaller stem tips in the laboratory because of lower contamination (40% on shoots from large stems vs. up to 90% on shoots from small stems), longer life of the softwood shoots (less wilting from the larger stems), a longer time during the year for forcing, and the possibility of forcing shoots from more juvenile wood than stem tips.

1014

Response of Adult Black Walnut (*Juglans nigra* L.) Nodal Explants on DKW and LP Media

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Branch tips (30 to 40 cm long) of adult black walnut were forced in a half-strength solution of Long and Preece medium (LP) salts (minus iron) plus 1 mM 8-hydroxyquinoline citrate (8-HQC). The resulting softwood shoots were surface-disinfested and cut into 1.5-cm-long nodal segments. Explants were placed on two media: Driver and Kuniyuki Walnut medium (DKW) or LP with four plant growth regulator combinations: 5 μM BA with 0.05 μM IBA, 10 μM BA, 1 nM TDZ, or 10 nM TDZ in a factorial arrangement. Gelrite was used as the gelling agent. Explants were transferred to fresh medium on days 1, 3, 5, and 7 after initiation, then weekly. Data recorded 60 days after culture initiation showed more and longer shoots and leaves, greater explant diameter, more green (living) tissue, and less exudation per explant on LP than on DKW. Greatest explant and shoot length were observed when the medium contained 10 nM TDZ. BA (10 μM) and LP were best for long-term maintenance of cultures

1016

Improved Adventitious Shoot Production in White Ash

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To increase adventitious shoot formation, we investigated the effects of the number of weeks on medium with high levels of plant growth regulators and seedcoat removal. Dissected white ash seeds were placed on a solidified MS medium containing 10 μM TDZ and 1 μM 2,4-D (shoot initiation medium). After 2, 3, or 4 weeks in vitro, explants were transferred to shoot elongation medium (3 μM TDZ, 1 μM BA, and 1 μM IBA). After 12 weeks, the greatest number (1.8) and longest shoots (18.7 mm) were in cultures incubated on the shoot formation medium for 3 weeks. In a separate experiment, dissected seeds were placed on shoot formation medium. Seedcoats were removed after 10 days in vitro. Explants were transferred to shoot elongation medium after 4 weeks in vitro. There were more shoots (2.5) on 12-week-old explants without seedcoats than on explants with seedcoats (0.9). This result may be related to inhibitors in the testa.

1019

The Effect of Glass-cracking during Cooling in Liquid Nitrogen on Viability of Mint Shoot Tips

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Cryopreservation using vitrification has been reported for several plant species. Shoot tips and vitrification solution were placed in semen straws and immersed in liquid nitrogen (LN). Cracking of the external glass occurred, but may be avoided by annealing slightly below the glass transition temperature before immersion. A varying percentage still cracked with some vitrification solutions. Rapid warming also can cause cracking. There is concern that cracking may reduce viability. Shoot tips from *Mentha* species were used to examine this problem. Glass cracking during either cooling or warming did not produce visible damage to shoot tips. Viability of shoot tips from tubes that cracked during cooling was not different from those that did not crack; however, shoot formation was slightly reduced. Cracking upon warming did not reduce viability nor shoot formation. Very slow warming reduced viability, but warming in either water or air (room temperature) gave higher levels of survival.

1022

Visualization and Analysis of Air Currents in the Plant Tissue Culture Vessel

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Air currents, and consequent diffusion processes, in the plant tissue culture vessel are slow and limit photosynthesis, transpiration, and uptake of water and nutrients by in vitro plantlets. Air currents in Magenta-type and Mayonnaise bottle-type culture vessels were visualized using fine particles of feathery crystal of metaldehyde [$(CH_3CHO)_4$] as tracers. Pictures of visualized air currents were recorded by the video camera. Air current speeds in the culture vessel were determined by analyzing the changes in video pictures with time. Air current speed around the culture vessel was set at 0.1 and 1.0 $m \cdot s^{-1}$. Shortwave radiation flux density on the shelf was varied between 0 and 34 $W \cdot m^{-2}$. Shortwave absorptivity of the medium was 44% for agar medium and 97% for agar medium containing activated charcoal. Under a shortwave radiation flux density of 10–34 $W \cdot m^{-2}$, the upward air currents were observed at the central part of the culture vessel and downward air currents were observed near the inside walls of the culture vessel. The upward air current speed was affected by air current speed around the culture vessel, shortwave radiation flux density, and shortwave absorptivity of the medium. Under shortwave radiation flux density of 34 $W \cdot m^{-2}$, the upward air current speed in the culture vessel was ≈4 times greater with 1.0 $m \cdot s^{-1}$ air current speed around the culture vessel than with 0.1 $m \cdot s^{-1}$.

1024

Growth and Nutrient Uptake of Cell Suspensions of *Thlaspi caerulescens* and *Brassica napus* Treated with the Heavy Metal Zinc

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Thlaspi caerulescens (Brassicaceae), known as a Zn hyperaccumulator, is able to accumulate and tolerate Zn at high concentrations in its biomass. Cell suspension cultures of *Thlaspi caerulescens* J et C Presl and *B. napus* 'Westar' have been initiated to study the effect of high Zn concentrations on growth and nutrient uptake. Preliminary studies determined the optimal conditions for subculturing and maintaining cultures. Cell suspensions grew best on Murashige and Skoog medium supplemented with B5 vitamins and 1 mg 2,4-D/liter at 0.4 g/25 ml inoculation density, and with a 2-week subculture period. In an initial experiment, cell suspensions were cultured in media containing 1.96 ppm Zn (basal) or 49 ppm Zn (25x). Media and tissue samples were collected at days 0, 4, 7, 10, and 13, and their nutrient content was analyzed by ICP-AES. *Thlaspi* and *Brassica* cell suspensions grew equally well on both media. For both species, uptake patterns of Ca, K, Mg, Mn, and P were not significantly different between the two media; however, >97% of the P was taken up within 2 weeks. Zinc concentration was reduced during the first 4 days (lag phase) in the high-Zn medium, with 27% and 41% taken up by the *Thlaspi* and *Brassica* cultures, respectively. *Thlaspi* took up significantly less Zn than did *Brassica.* By day 13, *Thlaspi* and *Brassica* tissue collected from the high-Zn medium contained 10x and 32x, respectively, more Zn when compared to tissue grown on basal medium.

1027

Spontaneous and Induced Changeableness and Accumulation of Phenol Compounds in Cell Culture of *Alhagi kirghisorum*

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Our studies concerned the peculiarities of phenol compound (PhC) formation in cultivated in vitro cells of *Alhagi kirghisorum*. To isolate cell strains with a high level of PhC biosynthesis, cells were sown on a medium containing parafluorophenylalanine (PFPA). To increase the number of resistant cell lines, the cells were treated with *N*-nitrose-*N*-methylurea (NMU). Four groups of individual clones were obtained: spontaneous, induced NMU, and resistant to PFPA. These clones differed in their intensity of growth, color, consistence, quantity, and PhC composition, as well as in their biological activity. Maximum differences were found in the clones with induced resistivity. In this group, clones with PhC content were at the level of control cells (40%), with high (33%) and low level of biosynthesis (27%). The PhC content in two more productive lines was 3.3 and 4.2 times higher than in controls. The induced NMU clones and clones with spontaneous resistivity to PFPA had biosynthesis levels similar to the control or 3 to 4 times lower than the latter.The biological PhC activity of a clone was tested by its effect on the processes of protein biosynthesis in a system without cells from rabbit reticulocytes. Eleven clones were found, the total PhC fractions of which in 40% to 99% inhibited protein biosynthesis.

1030

The Effects of Some Antioxidants on the Growth of Excised Date Palm (*Phoenix dactylifera* L.) Roots Cultured in Vitro

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The objective of this investigation was to study the effects of some antioxidants on the growth and elongation of in vitro-cultured date palm roots. Several trials were conducted to determine the antioxidant and the concentration of antioxidants used in date palm tissue culture. Three types of antioxidants were tested—activated charcoal, polyvinylpyrrolidone (PVP), and sodium metabisulfite ($NA_2S_2O_5$)—in various concentrations, singly, or in combinations. The medium used for root culture consisted of MS salts mixture, 1/2 modified White's organics, 60% sucrose, 0.004% inositol, 240 mg adenine sulfate/liter, 1.0 mg 2,4-D/liter, and 2.0 mg kinetin/liter. pH was adjusted at 5.7 ±0.1. Concentrations of activated charcoal tested (in g·liter^{-1}) were: 0.0, 1, 2, 3, 4, 6, 8, 10, and those of PVP (in g·liter^{-1}) were: 0.0, 5, 10, 20, 40 (with or without 4 g activated charcoal/liter). $NA_2S_2O_5$ concentrations (in mM) tested were: 0.0, 0.2, 0.4, 0.8, 1.6 (with 4 g activated charcoal/liter). The addition of activated charcoal to the culture medium of date palm roots is of vital importance. Four grams per liter gave the best growth and elongation, and there was no significant difference between it and 10 g·liter^{-1}. No growth or elongation occurred in the control. PVP, however, significantly inhibited growth and elongation of cultured roots at all concentrations tested. $NA_2S_2O_5$, however, stimulated growth and elongation at 0.2 mM. Higher concentrations inhibited growth and elongation.

1031

The Influence of the Physical State of the Nutrient Media on the Growth of Excised Date Palm (*Phoenix dactylifera* L.) Roots

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The effects of the physical state of nutrient media on the growth and elongation of excised date palm roots were investigated. Roots were cultured in a nutrient medium containing MS salts mixture, 1/2 modified White's organics, and (in mg·liter^{-1}): $NaH_2PO_4·H_2O$, 170; sucrose, 60,000; inositol, 40; adenine sulfate, 240; activated charcoal, 4000; 2,4-D, 1; kinetin, 2. pH was adjusted at 5.7 ±0.1. Both agar and Gelrite were singly used as solidifying agents. Liquid media were either stationary or rotated on gyratory shakers at 70 to 80 rpm. The effects of incubation of cultured roots under light or dark conditions were also studied. Media pH and its effects on growth and elongation of cultured roots were tested at various ranges (3, 4, 5, 6, 7, 8, 9, 10). Trials were also made to determine the passage length for transfer and subculture of cultured roots to a newly prepared medium. Liquid media highly supported better growth and elongation of cultured roots compared to solidified media. There was no significant difference in growth or elongation between agar or Gelrite media. Shaking liquid medium resulted in significantly better growth and elongation compared to stationary medium. No difference was observed between dark- and light-incubated cultured roots. Cultured roots grew and elongated better at pH 7.0–8.0. No growth or elongation occurred at pH 9.0. Roots continued to grow and elongate even after 12 weeks in culture. Therefore, 10 to 12 weeks after culture was determined to be the optimum passage length for date palm root culture.

1032

Establishment of Excised Date Palm (*Phoenix dactylifera* L.) Roots in Vitro

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Several trials were conducted with the objective of obtaining an explant for the establishment of date palm root culture in vitro. These trials included disinfecting and germinating seeds of three cultivars on several autoclaved culture media, the influence of incubation temperature on different germination parameters, and the quality of roots before excision and after culture in nutrient media. Three culture media were used: distilled water only; minimal organics that consisted of MS salts, 3% sucrose, modified White's organics, 0.01% inositol, and 0.15% activated charcoal; and 1/2 MS salts mixture, 3% sucrose, and 1/2 modified White's organics. All three media were solidified with 0.7% agar. The seeds were incubated at 25 or 35C for germination. The study revealed the difficulty of seed disinfection. We immersed seeds in 20% to 40% Clorox, with two to four drops of Tween-20, for 30 to 60 minutes and then rinsed them four to five times in deionized distilled water before culturing. The minimal organics medium supported optimal growth of excised roots, and incubation at 35C significantly improved germination. The use of 10-mm-long root tips as explants for culture initiation gave the best growth and elongation. In addition, the growth and elongation of excised root tips increased significantly as the distance from it to the apex of the cotyledonary sheath increased.

140 POSTER SESSION 22
Biotechnology/Cross-Commodity

524

Examination of Factors Affecting Transformation of 'McIntosh' Apple by *Agrobacterium tumefaciens*

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The overall goal of our research is to develop an efficient transformation and regeneration system for 'McIntosh' apple. The first objective was to determine the optimum combination of Gelrite (G) and agar (A) to maximize regeneration and minimize vitrification. Treatments included the following combinations of agar (in g·liter^{-1}) and Gelrite (in g·liter^{-1}): 1) 7 and 0; 2) 5.25 and 0.625; 3) 3.5 and 1.875; 4) 1.75 and 1.875; and 5) 0 and 2.5. There were 10 replications, and a single petri plate containing six leaf pieces was the unit of replication. Both 5.25(A) and 0.62(G) and 3.5(A) and 1.25(G) provided high regeneration of healthy, nonvitrified shoots. Since modification of media affects the concentration of antibiotics used in selection due to precipitation of antibiotics, the second objective was to determine the optimal concentration of antibiotic for the selection and regeneration of transformed 'McIntosh' on gelrite–agar- based media. Kanamycin was tested at 0, 10, 25, 50, 75, and 100 μg·ml^{-1} and paromomycin was tested at 0, 50, 100, 150, 200, and 250 μg·ml^{-1}. Antibiotic selection will be discussed relative to optimum concentration and efficiency of selection.

528

Study on Genetic Relationship of Peach Rootstocks by RAPD Markers

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Cluster analyses of 20 peach rootstocks by 40 RAPD markers produced a dendrogram of genetic relationship in good agreement with their putative pedigrees. BY520-9, BY520-8, SL1089, and SL1090, which are selections derived from a common ancestor, clustered together, with the normalized average distance (NAD) ranging from 0.20 to 0.55. Similarly, the clustering of Lovell with

Halford and Boone County with Harrow Blood, whose respective NADs were 0.19 and 0.22, implied a high degree of genetic relatedness between each pair of genotypes. Okinawa and Yunnan, both introduced from eastern Asia, tied in a close group (NAD = 0.63) and share relatively similar phenotypes. The first major bifurcation in the dendrogram divided the 20 rootstocks into two groups. One group (Lovell, Halford, Montclar, Bailey, Harrow Blood, Boone County, Tennessee Natural, and GF 305) is susceptible to root-knot nematodes, whereas the second group (BY520-9, BY520-8, SL1089, SL1090, Higama, Nemaguard, Flordaguard, Yunnan, Okinawa, and Nemared), with the exception of Rubira and Siberian C, is tolerant or resistant.

532

Mutagenesis and Tissue Culture for Selecting *Phytopthora cactorum*-resistant Strawberry (*Fragaria* x*ananassa*) Plants

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The aim of this study was to isolate *Phytopthora cactorum*-resistant strawberry plants, regenerated from gamma-irradiated explants on a shoot regeneration medium. Three gamma doses (0, 5, 10, 15 krad) were used to irradiate strawberry axillary buds taken from in vitro-grown plants. After irradiation, axillary buds were cultured on a shoot regeneration medium containing 0.75 mg BA/liter and 0.4 mg IBA/liter. Shoot regeneration occurred mainly from axillary buds irradiated with 5 and 10 krad. The highest dose (15 krad) produced few shoots. The shoot regeneration rate was highest at the 50-krad dose. All the regenerated plants were transferred in the greenhouse. The crude extract of *P. cactorum*, isolated from the strawberry field, was prepared in sterile water; 1 ml of it was put directly in the center of the crown of each of 400 regenerated plants. After 2 weeks, leaves of most of the plants wilted. Only 20 plants survived the first round of selection; they grew slowly when compared with the control and also showed some tolerance to drought. Further investigations are in progress to reconfirm the resistance of selected putative disease-resistant strawberry plants.

536

Monitoring Prunus Necrotic Ringspot Virus Infection by Hybridization with a CRNA Probe following in Vitro Grafting

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In vitro micrografting was tested as a technique for inoculating peach [*Prunus persica* (L.) Batsch] with prunus necrotic ringspot virus (PNRSV). Cultured 'Suncrest' shoots derived from a naturally infected tree (as indicated by ELISA testing) maintained virus in vitro, with virus concentrations in growing tips and folded leaves being several times those of fully expanded leaves. The infected shoots served as graft bases and the source of virus. Grafted tips were derived from 'Suncrest' trees that had tested negative for the virus. Leaf samples were collected from the tips following grafting and analyzed for the presence of virus by slot-blot hybridization with a digoxigenin-labeled cRNA probed derived from PNRSV RNA 3. Rates of successful grafting were 55% and 73% in three trials and PNRSV was found in all tips analyzed. Virus concentrations approximated those found in the source shoots, suggesting that this method should be useful for screening transformed peach shoots for coat protein-mediated resistance to PNRSV.

540

An Evaluation of Antibiotics for the Elimination of *Agrobacterium tumefaciens* from Apple Leaf Explants in Vitro and for the Effect on Regeneration

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A range of antibiotics was evaluated for their effect on eliminating *Agrobacterium tumefaciens* supervirulent strain EHA101(pEHA101) from leaf explants of 'Royal Gala' apple (*Malus domestica* Borkh) and on regeneration. After long-term (38 days) exposure to 100-$\mu g \cdot ml^{-1}$ concentrations of either cefotaxime (cef), carbenicillin (carb), mefoxin (mef), or combinations of these antibiotics, only on carb or carb with mef was regeneration not inhibited. None of the above antibiotics or antibiotic combinations eliminated *A. tumefaciens* from leaf explants. Short-term (1-18 hours), vacuum infiltration with 500- to 1000-$\mu g \cdot ml^{-1}$ concentrations of either of the above antibiotics did not inhibit regeneration, but did not eliminate *A. tumefaciens* from leaf explants. After a 30-min vacuum infiltration with a 2000-$\mu g \cdot ml^{-1}$ concentration of either cef, carb, or mef, only cef reduced the number of leaf explants with *A. tumefaciens*.

544

Essential Oils of *Boronia megastigma*—Selection of Improved Genotypes

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Boronia megastigma is cultivated or picked from natural stands in Western Australia for the production of essential oil. Boronia absolute is extracted from the highly perfumed flowers. It is currently valued at between US$4000 and US$7000 per kilogram, and world consumption for perfumery is about 1 tonne. The variation in essential oil composition within and between populations has indicated considerable variation in oil components. Some individuals have high β-ionone and low levels of pinenes. Principle components analysis indicated that the content of β-ionone and dodecyl acetate were tightly linked, as were the monoterpenes, α-pinene, β-pinene, and, to a lesser extent, limonene. Separate linkages between the desirable oil components (β-ionone and dodecyl acetate) and the undesirable components (α-pinene, β-pinene, and limonene) will facilitate selection of plants to be used in oil production.

548

Effect of Irradiance Level and Iron Chelate Source on the Shoot-tip Culture of *Carica papaya* L.

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Interaction between irradiance levels (5–40 $mM \cdot m^{-2} \cdot s^{-1}$) and iron chelate sources ($FeNa_2EDTA$ and FeNaDTPA) on the establishment, growth, and proliferation of shoot tips of *Carica papaya* were tested. Reduced irradiance level (5 $mM \cdot m^{-2} \cdot s^{-1}$) enhanced the establishment of shoot tips regardless of the source of iron chelate tested. At higher irradiance levels (30 and 40 $mM \cdot m^{-2} \cdot s^{-1}$), presence of FeNaDTPA in the medium enhanced establishment of shoot tips. Continuous or alternating light/dark (16/8 h) photoperiods at high irradiance levels had no effect on the establishment or growth of the culture. At higher irradiance levels, the cultures produced smaller leaves as compared to lower irradiance levels. Low irradiance and $FeNa_2EDTA$ was preferred during the proliferation stage.

552

Transformation of Grape (*Vitis vinifera* L.)

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Transgenic grapevines were regenerated from somatic embryos produced from immature zygotic embryos of two seedless grape selections and from leaves of in vitro-grown plants of 'Thompson Seedless'. Somatic embryos were bombarded with gold microparticles using the Biolistic PDS-1000/He device (Bio-Rad Labs) and then exposed to engineered *A. tumefaciens* EHA101 (E. Hood, WSU). Alternately, somatic embryos were exposed to *A. tumefaciens* without bombardment. Following cocultivation, secondary embryos multiplied on Emershad and Ramming proliferation medium under kan selection. Transgenic embryos were identified after 3 to 5 months and developed into rooted plants on woody plant medium with 1 mM N6-benzyladenine, 1.5% sucrose, and 0.3% activated charcoal. Seedless selections were transformed with plasmids pGA482GG (J. Slightom, Upjohn) and pCGN7314 (Calgene), which carry GUS and NPTII genes. 'Thompson Seedless' was transformed with pGA482GG and pGA482GG/TomRSVcp-15 (D. Gonsalves, Cornell Univ.) containing the tomato ringspot virus coat protein gene. Integration of foreign genes into grapevines was verified by growth on kan, GUS, and PCR assays, and Southern analyses.

556

Somatic Embryogenesis in Muscadine Grape

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Low frequency of in vitro regeneration has hampered the adoption of genetic engineering technique for improving the quality of muscadine grape. This study is to develop a straightforward method for high-frequency regeneration of muscadine grapes in vitro. Leaves, petioles, and immature ovules of muscadine grapes were cultured on various media. Embryogenic callus, somatic embryos were formed after 9 weeks inoculated on embryo rescue (ER) medium. The somatic embryos were isolated and subcultured on fresh medium to promote enlargement and in-

crease the number of uniformly sized somatic embryos. Of the medium tested (MS, NN, and ER), the ER medium was the best for somatic embryo growth and multiplication. The somatic embryogenic lines were maintained by transferring the embryos to the fresh ER medium every 4 weeks. Germination was achieved by transferring these embryos to woody plant medium or NN medium. The frequency of somatic embryogenesis of embryo germination appeared to be genotype dependent. The establishment of the somatic embryogenesis system in this study should be a step forward in directly transferring a foreign gene into muscadine grape.

557

Genetic Diversity in Muscadine and Bunch Grapes Based on RAPD Analysis

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Two morphologically very distinct grapevines belonging to the subgenera *Euvitis* and *Muscadinia* of the genus *Vitis* are cultivated in the United States. The former is commonly called "bunch" grape, while the latter is usually called "muscadine." Genetic diversity among these grapes was investigated based on random amplified polymorphic DNAs (RAPDs). Sixteen grape cultivars, with their parentage including *V. rotundifolia, V. vinifera,* and several American *Vitis* species, were used for the RAPD analysis. More than 200 RAPDs were produced from 20 random primers. More than 90% of which were polymorphic between the muscadine and the bunch grapes, while polymorphism was considerably low within the muscadine and the bunch grapes. The relationships of grapes between these two subgenera were estimated based on bandsharing and cluster analysis. The result based on the DNA analysis agrees with the isozyme data obtained from a separate study, which demonstrated that the muscadine grape shares very low common alleles with the American bunch grapes and the European grapes.

560

Influence of the Genotype and TDZ on the in Vitro Regeneration of Hybrid Grapes

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It has been previously demonstrated that thidiazuron (TDZ) enhanced the regeneration and multiple shoot proliferation of *vinifera* grape cultivars. To determine the effect of TDZ on the multiplication of hybrid grapes, in vitro nodal segments from cultivars Chancellor, Leon Millot, and Valiant were cultured on MS medium supplemented with 0, 0.01, 0.05, 0.1, 0.5, and 1.0 mg TDZ/liter. After 1 month, the higher percentage of rooted shoots was obtained from the explants cultured in medium containing the lowest concentration of TDZ (0.01 mg·liter^{-1}) independent of the genotype. Multiple shoot proliferation was favored by high concentrations of TDZ (0.5 and 1.0 mg·liter^{-1}). An average of 0.39 and 0.39 shoots, respectively, was obtained from 'Chancellor' cultures, 0.56 and 0.59 from 'Leon Millot', and 1.93 and 2.38 from 'Valiant'. Vitrification and teratological structures were observed in all the cultures of the three genotypes, but less vitrification occurred in 'Valiant' plantlets.

564

Plant Growth Stage for Geranium Inoculation with Vesicular–Arbuscular Mycorrhizal (VAM) Fungi

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The most appropriate time for VAM inoculation has been assumed to be the early stages of plant growth, and this study aimed to investigate the impact of VAM inoculation at the seedling and at the 10-week geranium plant stage. Seeds were planted in propagation plug trays (200) filled with four different seed-germinating substrates: half were inoculated with *Glomus intraradices* while the other half were noninoculated controls. Two types of media received inoculum or not (control); they consisted of sphagnum peat with perlite in one case and vermiculite in the other. After 10 weeks growth, the root systems were checked for colonization, and height, weight, and leaf number were registered. The subsequent growth was carried out in 4-inch azalea pots with the appropriate medium. The pre-inoculated plants were transferred in Mycori-Mix, and the controls were transferred in Pro-Mix. All plants received mild liquid fertilization at each irrigation time (20N–2P–20K). The number of cuttings and flowers were monitored 6 weeks after beginning of pot growth. The pots were displayed in a complete factorial block with six replicates per treatment, and 10 plants were used for each experimental unit. Significant differences did occur between plants initiated in the different germinating substrates; when pre-inoculated, 12.5 cuttings and 7 flowers were recorded in comparison to 9.8 and 3.9, respectively, for controls. These results reflect the importance of introducing VAM at the earliest growth stage.

565

Pest and Disease Control for Vesicular–Arbuscular Mycorrhiza (VAM) Pot-grown Plants

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Increased use of VAM for pot-grown cultures has sustained certain inquiries as to the compatibility of pesticides and biocontrol agents with this novel practice. Asparagus, Boston fern, geranium, and poinsettia were cultivated in a peat-based medium (SB-Mix) with various fungicides, insecticides, and insect predators. Each plant consisted of an individual trial. All treatments were randomly set up in a complete block experimental design consisting of a noninoculated control and pre-inoculated with *Glomus intraradices*, in combination with the different pesticides used for a given plant species. Commonly used pesticides in greenhouses were chosen, and the concentration applied was as recommended by the manufacturer. A control, consisting of water, was included with the pesticides tested. The effect of a given pesticide varied from one plant species to another concerning root colonization by the VAM and plant growth. The poinsettia growth results were significantly superior with the water-treated plants than with those that received insecticidal soap, dienochlor, and dicofol on a regular basis. Colonization rates, however, were low with all treatments, but significantly lower with oxine benzoate. Growth parameters and colonization rates of geranium, Boston fern, and asparagus showed no significant differences between water and pesticide treatments, even those treated with benomyl, which has been reported in the past to reduce colonization rates. These results show that a good pesticide and insect predator integration control program will not alter the VAM colonization rates.

568

Optimizing RAPD Markers for Onion Genomic DNA Analysis

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Random amplified polymorphic DNA (RAPD) have potential as genetic markers that may facilitate selection in plant improvement. To obtain clear, reproducible, and repeatable RAPD bands, four DNA extraction protocols and two *Taq* polymerases were compared. DNA extraction followed modified Tai and Tanksley (PMBR), Dellaporta et al. (PMBR), and Guilllemant et al. (PMBR) protocols, and a plant tissue DNA isolation kit from Gentra Systems was used. The modified Guillemant protocol was selected because of ease of extraction and cost effectiveness. Genotypes studied were TG1015Y (*Allium cepa*). Polymerases compared were *Taq* and *Taq* Stoffel fragment. Results are based on separate amplifications and electrophoretic assays. PCR amplifications of Stoffel fragment produced more scorable and reproducible RAPD bands compared to bands produced using *Taq* polymerase.

572

Molecular Characterization of a cDNA that Encodes Glutamate-1-semialdehyde-2,1-aminomutase in Tomato

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Our recent research has focused on the control of genes and enzymes involved with the synthesis of chlorophyll, especially as it relates to tomato fruit development and ripening. Glutamate-1-semialdehyde-2,1-aminomutase (GSAAM) is one of the first committed enzymes in the chlorophyll biosynthetic pathway, and it is one of three enzymes that catalyze the conversion of glutamate into 5-aminolevulinic acid. We have isolated a full-length cDNA clone of GSAAM from a tomato fruit library. The tomato primary sequence shows extensive homology to GSAAM sequences found in other plant species. The primary structure also predicts a 46.7-kDa, 437-amino acid, mature protein and a transit peptide of 44 amino acids. Southern analysis indicated that GSAAM was present as a single copy. Northern blot analysis showed that GSAAM was expressed differentially in various tomato organs and that GSAAM transcripts decreased with increased fruit age. Immunoblot analysis also indicated that GSAAM protein decreased dramatically with increased fruit age. These results show that there is developmental regulation of the expression of GSAAM in tomato fruits.

576

Post-translational Regulation Using Anti-peptide Antibody of 22-Kilodalton Potato Proteinase Inhibitors

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The 22-kDa potato proteinase inhibitors (22-kDa PPI) are synthesized as a preprotein with a hydrophobic signal sequence of 40-residue amino acids. The amino-terminal amino acid sequence (10-mer amino acids : 18-Ala-Phe-Ala-Arg-Ser-Phe-Thr-Ser-Glu-Asn-27) of signal peptide of 22-kDa PPI was synthesized. The 22-kDa PPI signal peptide specific anti-peptide antibodies were raised in New Zealand white rabbits against the 22-kDa PPI synthetic signal peptide. Immunoblot and Northern blot analysis were performed by using 22-kDa PPI anti-peptide antibody and cDNA probe, p34021, which codes for the 22-kDa PPI, respectively. In this paper, we determined the process of the 22-kDa potato proteinase inhibitor in tuber and wounded leaves.

580

Establishment of Parameters for *Agrobacterium* Transformation of Asparagus Embryogenic Suspension Culture Cells

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Conditions for *Agrobacterium* transformation of asparagus embryogenic suspension cells were investigated using an intron-containing GUS gene in pCNL56 to detect transformation events. Embryogenic suspension cultures of Rutgers 22 were maintained on LS medium with 5 mg NAA/liter, subcultured weekly, and used 5 days thereafter. For initial experiments, cells were inoculated at 5 x 10^8 cfu/ml for 15 min and cocultivated for 4 days on LS medium with 10 g Phytagel/liter (EM1 medium). Subsequently, the cells were transferred to EM1 with 200 mg Timentin/liter and tested for GUS expression after a total of 6 days. The effect of acetosyringone (AS) on four *A. tumefaciens* strains was tested. With or without AS induction, EHA105 and C58C1(pMP90) produced a significantly greater number of GUS foci on embryogenic cells than C58C1(pGV2260) and LBA4404. Transient expression was very low from cells inoculated with C58C1(pGV2260) and nonexistent from LBA4404. AS induced significantly more GUS foci from EHA105 and C58C1(pMP90) than from the same noninduced bacteria; however, it had no effect on C58C1(pGV2260). Upon repeating the experiment using EHA105 and C58C1(pMP90) only, no differences in response were observed, although AS induced more GUS foci from both strains and EHA105 outperformed C58C1. Inoculum density was investigated using induced EHA105. 5 x 10^7 cfu/ml significantly increased the number of GUS foci than 10^8, 5 x 10^8, or 10^9, although it was not statistically different from 10^7, which produced slightly fewer foci.

584

PCR Amplification of the Mitochondrial DNA Sequence Specific to the Male-sterile and Normal Cytoplasm in Onion

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We compared the transcriptional properties of mitochondrial DNA (mtDNA) from a pair of male-sterile (S cytoplasm)/maintainer (N cytoplasm) lines together with the nuclear-restored plants. The transcriptional patterns of the mitochondrial genes, *cob* and *cox1*, were different between N and S cytoplasm. We cloned and sequenced the *cob* gene from both N and S onion. The *Scob* gene diverged from the *Ncob* gene 56 bp 5' to the initiation codon. This upstream region of the *Scob* gene was homologous to a part of ORF1708 of the tobacco chloroplast DNA. We designed primers to amplify the upstream regions of the *cob* by PCR. A 414-bp DNA fragment was amplified from the total DNA of '2935A' (S cytoplasm) and a 130-bp DNA fragment was amplified from that of '2935B' (N cytoplasm) using a pair of primers specific to S cytoplasm and nor cytoplasm, respectively.

588

Validation of Boxwood Cultivars by Biochemical Markers

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Leaf tissue from 10 *Buxus* spp. cultivars were collected and evaluated for differences in isozyme and random amplified polymorphic DNA (RAPD) markers. In addition, samples of named cultivars were collected from multiple locations to estimate the degree of cultivar fidelity across locations. In general, isozymes were highly polymorphic among cultivars. Aconitase, malate dehydrogenase, aminoaspartate transferase, and phosphoglucose isomerase were the most useful isozymes to distinguish among the selected clones. Good quality DNA was readily extracted from leaf tissue using a standard CTAB procedure. RAPDs were generated from polymerase chain reactions using a random set of primers. Of 200 primers that were screened, 20 gave reproducible and polymorphic patterns that could be used to distinguish among the boxwood cultivars. In general, cultivar fidelity among commercial nurseries was fair. Biochemical analyses could be used to resolve problems with cultivar identity once baseline information is collected.

592

RAPD Variation among Salt-selected and Nonselected Buffalograss [*Buchloë dactyloides* (Nutt.) Engelm.] Clones

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The use of random amplified polymorphic DNA (RAPD) markers has been shown to be a potentially useful technique for identifying buffalograss breeding lines. Analysis of RAPD markers has also revealed considerable variation within, as well as among, each of four natural buffalograss populations surveyed. Identification of genetic markers for quantitative traits, such as physiological components of tolerance to salt stress, can provide important information for plant improvement programs. The objectives of this study were to develop DNA fingerprints for buffalograss clones selected from an in vitro seedling screening program for survival at high NaCl (200–250 mM) levels, identify markers for future analysis, and assess the variability among the lines. DNA was extracted from leaves of 10 salt-selected and 15 non-selected buffalograss clones. Fifty-two 10-mer primers were screened for ability to produce bands with DNA from four clones as visualized on ethidium-stained agarose gels. Bands were most reproducible with a genomic template DNA concentration of 1 ng·μl^{-1} reaction volume. Primers selected for ability to produce a moderate number of clear bands were used to produce RAPD profiles of the 25 clones. Abundant polymorphism to distinguish among clones was found. Four primers produced a total of 45 polymorphic markers. The primer 5´-CGGAGAGCCC-3´ produced 11 readily scored markers, allowing identification in 94.67% of pair-wise comparisons. As a group, RAPD profiles of salt-selected clones are more variable than non-selected clones from the same population; however, no unique pattern of markers generated by primers screened to date differentiates all salt-selected clones from the non-selected group.

596

RAPD Marker for Sex Determination of Dioecious Plants

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Several horticulturally important species are dioecious (e.g., pistachio, date palm, poplar, and others). It would be advantageous if the gender of a seedling could be determined at the vegetative stage. In this report, we present results of our search for molecular markers for sex differentiation in dioecious species. The method used was bulked segregant analysis of random amplified polymorphic DNA (RAPD) for sex. A male-specific marker fragment OPB01-1470 was obtained in *Mercurialis annua*. The sex linkage and characterization of this marker will be discussed.

600

Transfer of *Lycopersicon chilense* Chitinase Gene to Cultivated Tomato (*L. esculentum*)

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We have isolated a drought-induced chitinase gene from *L. chilense*, a wild tomato species. Owing to our interests in genetic improvement of cultivated tomato, we have transferred the *L. chilense* chitinase gene to this species. The transformation plasmid constructed contained the coding sequence of *L. chilense* chitinase gene linked to CaMVS35 promoter as well as the NPT II gene linked to nopaline synthetase promoter. The leaf disk transformation regeneration technique was applied to one commercial tomato cultivar and four inbred lines. Shoots were produced on the selection medium through direct or indirect organogenesis. Plantlets that have been rooted on kanamycin-containing medium were transferred to soil where they grew to maturity and produced flowers and fruit. The transgenic nature of some of the analyzed plants was confirmed by polymerase chain reaction. Research is continuing to evaluate transgenic plants with regard to their level of tolerance to phytogenic fungi.

141 POSTER SESSION 23
Nutrition & Photosynthesis/Fruits (General)

726
Inoculation- and Fertilization-mediated Changes in Xylem Fluid Chemistry of Soybean and Subsequent Effects on Leafhopper Performance
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The xylophagous leafhopper, *Homalodisca coagulata* (Say), is an important vector of diseases caused by *Xylella fastidiosa* (e.g., Pierce's disease, phony peach disease, plum leaf scald, etc.). The nutritional status of xylem fluid has a profound influence on leafhopper distribution, feeding, and performance. Xylem fluid typically consists of 95% to 99% water and contains organic compounds (mainly amino acids and organic acids) in low concentration (i.e., 2 to 8 mM). Successful development of this highly polyphagous leafhopper depended on host-plant chemistry. The reasons for variable success on different host species include variable assimilation efficiency of organic compounds and variable feeding rates. An assessment of nutritional requirements for leafhoppers is an integral component for developing a "whole systems" approach for the biological control of xylem-limited diseases. Soybean (*Glycine max* L.) was used as a model system in a 2 x 2 factorial experiment, with *Rhizobium* (inoculation/noninoculation) and fertilization source (urea or nitrate) as the main factors, to assess the influence of specific dietary profiles of xylem fluid on leafhopper performance. These treatments resulted in a high survivorship throughout development (inoculated urea); low survivorship throughout development (noninoculated nitrate); high survivorship for nymphs, but decreasing with age (noninoculated urea); and low survivorship for nymphs, but increasing with age (inoculated nitrate). Consumption rates, maturation time, body weight, and body composition were also correlated to host-plant chemistry.

730
Effects of the Time of B Application on Almond Tissue B Concentration and Fruit Set
*Agnes M.S. Nyomora** and *P.H. Brown*, Dept. of Pomology, Univ. of California, Davis, CA 95616

Previous work in our laboratory demonstrated that B promotes flowering, fruit set, and yield in almond. A positive response of almond tissue B concentration, fruit set, and yield to B application was observed. Positive correlations between tissue B concentration with fruit set or yield were found when B was applied at 0–1.67 kg B/ha. An investigation was undertaken to test whether the time of B application had a significant effect on B concentration and yield in almond. Solubor (20.5% B) was applied at 0.8 and 1.67 kg B/ha during fall (September), winter (December), and spring (February) to 'Butte' (pollinizer) and 'Mono' (pistil donor). Results show that for most attributes, September application was more effective than spring and winter. 'Butte' was more responsive to B application than 'Mono'.

734
Heavy Metals in Fruit and Berries in Kaunas District (Central Lithuania)
Stanislovas Svagzdys, Lithuanian Inst. of Horticulture, Babtai 4335, Kaunas District, Lithuania

During the expeditions of 1989–92, samples of soil, fruit, and berries were picked up in Kaunas District (central Lithuania) and experimental orchards to determine the content of heavy metals (Cr, Pb, Ni, Zn). They were established by the atomic absorption meter AAS-30. Within in the limits of the industrial center (Kaunas), the content of heavy metals in soil exceeds the background: cadmium, 6 times; lead, 3, 6 times; zinc, 5 times. When fruit trees grow within the city limits, chromium and lead accumulates in the fruit skin and pith. There is probability that increased amounts of heavy metals can accumulate in the flesh. Fruit grown by roads with intensive traffic, as in town zones, accumulate chromium in the pith and lead in the skin. Fruit from trees grown at a distance of 50 to 100 m from the road contained high amounts of chromium and lead in the pith. In all investigated cases, nickel and zinc accumulated in the pith. When fruit trees grow by roads with intensive traffic or within city limits, fruit are contaminated more with chromium than with lead. Consumers should use only the flesh and remove the skin and pith of such fruit. In experimental orchards, different crops accumulated different amounts of diverse heavy metals. In an irrigated area, strawberries accumulated more heavy metals than currants. Heavy metals (Cr, Pb, Ni, Zn) were found in small quantities in the flesh of sour cherries and plums. Microfertilizers (0.1% boric acid applied after flowering) reduced the absorption of heavy metals (especially Cr and Pb) to the plant's reproductive organs.

738
Soil Acidification Potential of Four Commercial Nitrogen Solutions Used for Fertigation
*Rhoda L. Burrows** and *Frank J. Peryea*, Washington State Univ., 1100 N. Western Ave., Wenatchee, WA 98801

Nitrification-induced subsoil acidification is a major problem encountered with the use of ammonium- or urea-containing fertilizer solutions for drip fertigation of tree fruit crops. We conducted a laboratory experiment to evaluate the soil acidification potential of the four fertilizer N solutions most frequently used for fertigation within the Washington tree fruit industry. Treatments were five orchard soils x four commercial N solutions (calcium nitrate, calcium-ammonium nitrate, ammonium nitrate, urea-ammoniun nitrate) x four N rates (0, 100, 200, 500 mg N/kg). Air-dry subsamples of each soil were inoculated with fresh soil known to exhibit nitrifying behavior amended with treatment solutions. Subsamples were maintained at simulated field capacity of –15 kPa. Soil pH was measured after 5 weeks incubation. The treatment solutions were reapplied and pH measured after another 5 weeks. The soil were then leached with distilled water and further incubated to determine if pH would increase as has been observed in the field. The fertilizer solutions acidified the soils in direct relation to their ammonium plus urea content. The calcium nitrate solution was acidifying because it contains ammonium nitrate as an impurity. We will present the pH "rebound" data.

742
Cytological Modifications of Phytotoxicity Induced by Foliar-applied Urea-nitrogen in Citrus
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Foliar applications of urea-nitrogen are widely used to alleviate N deficiencies in citrus; however, improper applications can cause serious foliar burn and loss of active green leaf area. Light (LM), transmission (TEM), and scanning (SEM) electron microscopy were used to characterize anatomical and ultrastructural details of foliar burn in citrus. LM examination of the burned leaf area showed collapsed adaxial and abaxial epidermal cells and plasmolysis of mesophyll cells that created large intercellular spaces. SEM showed wrinkling of both the adaxial and abaxial epidermal cells. TEM revealed cytoplasmic vacuolation, disruption of cellular membrane, degradation of grana, and appearance of large plastoglobuli, implying loss of physiological activity. In contrast, control leaves had turgid adaxial and abaxial epidermal cells and compact mesophyll cells with few intercellular air spaces.

746
Foliar Spray at Spring Flush Enhances Zinc Status of Pistachio and Walnut Trees
Qinglong Zhang and *Patrick H. Brown*, Dept. of Pomology, Univ. of California, Davis, CA 95616

In this study, we investigated the effectiveness of several Zn formulations applied at various times of the year in increasing Zn status of pistachio and walnut leaves. Formulations included inorganic and organic forms of Zn. Fall sprays was ineffective at supplying Zn to developing leaves even when very high rates (5000 ppm) were used. Late dormant and budbreak sprays were effective at supplying Zn to developing leaves and nuts only when extremely high rates (5000 ppm) were applied. Spring flush sprays were the most effective, while late spring and summer sprays were ineffective. The majority of the Zn applied remained in the epidermis of the sprayed leaves, which resulted in high Zn content of leaves but poor correction of Zn deficiency and little or no translocation of Zn to other plant parts. Many of the Zn formulations sprayed at spring flush at a rate of 1000 ppm effectively increased leaf Zn values by at least 10 $\mu g \cdot g^{-1}$. Addition of an appropriate organic acid to the spray solution and adjustment of pH to $\approx$4.5 improves leaf uptake and translocation of Zn. Addition of specific surfactants into the spray solution is also recommended. Use of N- and P-containing Zn spray formulations is less effective than sulfur-based sprays (i.e., $ZnSO_4$). Significantly, there is little residual effect of foliar sprays (even at spring flush), indicating that

consecutive sprays for several years are needed to maintain productivity in Zn-deficient regions.

750

Effect of Urea, Some Micronutrients, and Growth Regulator Foliar Sprays on the Yield, Fruit Quality, and Some Vegetative Characters of Washington Navel Orange Trees: Fruit Physical and Chemical Properties

Ahmed M. Akl, Abdel-Fattah M. Eid*, and *Mohamed Y. Hegab*, Dept. of Horticulture, Faculty of Agriculture, Minia Univ., Minia, Egypt

This part of the investigation studied the effect of foliar spraying with urea (0.5%); a mixture of Zn (0.4%), Mn (0.3%), Fe (0.5%), and Cu (0.3%) in sulphates (from 23% Zn, 28% Mn, 19% Fe, and 30% Cu, respectively); and two growth regulators (GA_3 at 25 ppm and α-NAA at 10 ppm); as well as number and date of sprays on fruit volume, percentage of pulp, juice acidity, TSS, reducing and total sugars, TSS : acid ratio, and vitamin C content. The results showed that Washington Navel orange trees receiving urea, micronutrients, or both gave fruit with significantly larger volume compared with the control, but the treatment including both resulted in the highest values for fruit volume in 1991–92 and 1992–93 seasons. GA_3 sprays gave the highest fruit volume, followed by NAA, while the water spray (control) gave the lowest values for this trait. Two sprays of urea, micronutrients, and GA_3 resulted in the highest fruit volume in 1991–92 and 1992–93 seasons. The effect of different treatments on pulp percentage were slight and mostly insignificant in the two experimental seasons. Spraying urea, micronutrients, or both slightly reduced juice acidity and increased TSS, sugars, and vitamin C contents, as well as TSS : acid ratio; however, both of them together was more effective in this respect. Conversely, either GA_3 or NAA caused an appreciable increase in acid content in the juice, but decreased the other determined constituents, except vitamin C, which increased.

754

Effect of Urea, Some Micronutrients, and Growth Regulator Foliar Sprays on the Yield, Fruit Quality, and Some Vegetative Characters of Washington Navel Orange Trees: Fruit Pedicel Pectin Content, Flowering Aspects, and Fruit Set, and Dropping Percentages

Ahmed M. Akl, Abdel-Fattah M. Eid*, and *Mohamed Y. Hegab*, Dept. of Horticulture, Faculty of Agriculture, Minia Univ., Minia, Egypt

This part of the investigation studied the effect of foliar spraying with urea (0.5%); a mixture of Zn (0.4%), Mn (0.3%), Fe (0.5%), and Cu (0.3%) in sulphates (from 23% Zn, 28% Mn, 19% Fe, and 30% Cu, respectively); and two growth regulators (GA_3 at 25 ppm and α-NAA at 10 ppm); as well as number and date of sprays on fruit pedicel pectin content, some flowering aspects, and fruit set and drop percentages. Applying urea, micronutrients, or both significantly increased pectin content in the pedicels of the attached and dropped fruit. The treatment including urea plus micronutrients resulted in the highest values for pectin in fruit stem. Either GA_3 or NAA significantly raised pectin content over that of the water-sprayed control. However, NAA was more effective in increasing pectin content in fruit pedicel. The overall treatment including urea and micronutrients with GA_3 or NAA was the most effective in producing the highest percentage of leafy inflorescence in 1991–92 and 1992–93 seasons. Any nutrition treatment was significantly effective in increasing fruit set and reducing fruit drop compared with the water-sprayed control; however, the treatment including all sprayed nutrients was the most effective. Application of GA_3 or NAA significantly increased fruit set percentage and reduced June and preharvest fruit drop; however, NAA was more effective in reducing fruit drop than GA_3.

758

Analysis of the Major Elements in Orange Leaves Using NIR Spectroscopy

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Fertilizers are an essential input for sustained high yields and quality of orange fruit. Monitoring leaf nutrient levels is desirable and procedures for using leaf analysis to make fertilizer recommendations are well established. Wider adoption of leaf analysis would result if more-convenient sampling and analytical techniques were available. Analysis using near-infrared reflectance spectroscopy (NIR) offers many advantages, including accuracy, low cost, and short turnaround time, which should appeal to citrus producers. NIR analysis is currently being used to decide the appropriate fertilizer applications for local cereal producers. Samples were collected from a cross-section (7%) of the orange-producing farms in the Murrumbidgee Irrigation Area (MIA) of New South Wales (lat.35, long.146). This semi-arid, winter-dominant rainfall region is a major citrus-producing area in Australia. Samples comprised the 2nd and 3rd fully expanded leaves from non-fruiting 4-month-old flush shoots of sweet orange trees 'Late Valencia' on *P. trifoliata* rootstock. The microwave-dried and ground samples were analyzed by the traditional techniques, and the samples were then used to develop and verify calibrations for N, P, and K. These calibrations determine nutrients in leaves with error (SEP) values that are close to the errors associated with traditional methods.

762

High Zinc Concentrations Contribute to Chlorosis in Blueberry

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To determine if high Zn concentrations contribute to chlorosis in blueberry, plants of rabbiteye 'Climax' and southern highbush 'Bladen' were fertilized in sand culture with 30, 60, 90, and 120 ppm Zn solutions at 4, 4.5, 5, 5.5, 6, and 6.5 pH. Only Zn levels significantly affected the degree of chlorosis in plant leaves. No interaction among cultivars, pH, or Zn concentration was significant. The linear response to Zn levels was significant ($P = 0.0001$), but quadratic and cubic responses were not significant. Cultivars and Zn fertilization levels affected Zn and Mn accumulation; however, no difference in chlorosis rating was observed between cultivars. An inverse relationship existed between Zn fertilization levels and leaf Mn content so that the total concentration of the two minerals was about the same for each fertilization level, suggesting that Mn toxicity would not be expected at high levels of Zn fertilization. We concluded that high levels of Zn may induce chlorosis in rabbiteye and southern highbush blueberry.

766

The Fertilization of Day-neutral Strawberries in Quebec

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During 1993 and 1994, the day-neutral strawberry cultivar Tribute was subjected to two rates of N (50 and 100 kg·ha^{-1}), four rates of K (0, 60,120, and 180 kg·ha^{-1}), and three rates of Mg fertilization (0, 25, and 50 kg·ha^{-1}) from June to September through trickle irrigation. The objective of this experiment was to determine the best N, K, and Mg fertilization rates in the production of day-neutral 'Tribute' strawberry. The N treatments had no significant influence on yield and fruit size for the two years. We observed the same situation for K as for N. For Mg treatments, fruit size was increased by adding 25 kg·ha^{-1} during the first picking in 1993, and they had no effect in the second year. For both years, the Mg had no effect on the yield.

770

Preparation and Analysis of Grape Leaf and Petiole Samples by NIR Spectroscopy

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NIR-based tissue analysis has proven useful in Australia for making fertilizer recommendations for rice and wheat growers. Viticulturists have for some time made fertilizer recommendations based on tissue analysis, although there is some debate in the literature as to whether younger or older leaves or petioles provide the best indicator of vine nutrient status for diagnostic purposes. The aim of our research has been to develop NIR-based nutrient analysis for grape producers. Aspects of sample collection, including leaf lamina vs. leaf petiole; leaf opposite the basal cluster vs. youngest leaf; aspects of drying (microwave vs. convection oven), have been reexamined from the viewpoint of convenience, cost, accuracy, and turnaround time with respect to NIR analysis. We have refined procedures for collecting and microwave-drying samples. The samples of leaves and petioles were collected from vines in most wine-growing regions of Australia and included all the major wine grape and some dried fruit cultivars on their own and, in some cases, on rootstocks. At this stage, we have developed preliminary NIR calibrations for the major nutrient elements in both leaf lamina and petioles.

774

Effect of Boron and Calcium on Lowbush Blueberry Fruit Set, Fruit Characteristics, and Yield

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Foliar sprays of B (400 ppm), Ca (4000 ppm), B (400 ppm) + Ca (4000 ppm), or water (control) were applied in Sept. 1993 to treatment plots of 12 lowbush blueberry (*Vaccinium angustifolium*) clones having low leaf B concentrations (<20 ppm). Boron concentration was raised in stem and bud tissue 3 months after application, but Ca concentration was unaffected. Twenty randomly selected stems with four flower buds were tagged in each treatment plot in Apr. 1994 to determine treatment effects on fruit set and fruit characteristics. Blossoms on tagged stems were counted in late May and a count of initial fruit was taken in early July. Initial fruit set was reduced slightly by the Ca treatment, which also resulted in a lower number of flowers per bud. Tagged stems were cut before plot harvest and stored at –15C for final fruit set and fruit characteristic measurements (fruit number, diameter, weight, and firmness, and seed number and size). Treated plots were harvested and weighed in August. Boron and Ca treatments did not increase yields averaged across all clones, but some clones showed a positive response. Yield of Ca-treated plots was significantly lower than the plots without Ca treatment. Effect of treatments on final fruit set and fruit characteristics will be presented.

778

Fruit Tree Light Interception, Simulated Carbon Assimilation, and Carbon Partitioning

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Plant dry matter production is proportional to light interception, but fruit production does not always increase with increased light interception. Seasonal daily patterns of light interception by cling peach trees planted in four different planting density/training systems were obtained using a Decagon ceptometer. The High Density V system (1196 trees/ha) intercepted significantly more light than the KAC V and Cordon systems (918 trees/ha). The Vase system (299 trees/ha) intercepted significantly less light than the other systems. Response surfaces using a quadratic model with interactions for time of day and day of year explained 84% to 91% of the variance in the data sets for each training system. Crop yields per acre were greatest for the High Density V, followed by KAC V, Cordon, and Vase, corresponding to the light interception data. A carbon budget model, which incorporated canopy photosynthesis, respiration, and carbon partitioning based on organ growth potentials, was used to simulate seasonal patterns of carbon assimilation, crop dry weights, and individual fruit dry weights.

782

Net CO_2 Assimilation and Foliar Injury of Citrus Leaves Sprayed with Saline Solutions and Urea Nitrogen

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The penetration of foliar-applied urea and salt solutions into citrus leaves was investigated using 'Duncan' grapefruit and 'Valencia' orange seedlings in a greenhouse, and 8-year-old 'Ruby Red' grapefruit trees in field tests during the summer and fall. Net gas exchange rates, Cl, nitrogen, and chlorophyll concentrations of singles leaves were measured during or after the period of foliar applications. Foliar-applied salt treatments increased leaf Cl, and visible burn symptoms were observed when Cl levels reached ≈0.4% of leaf dry weight. After 11 weeks, green areas from salt-treated leaves had similar rates of net CO_2 assimilation as control plants. Leaf nitrogen and total chlorophyll increased with repeated sprays. Urea sprayed at 15% caused foliar burn symptoms after two to three applications and increased the amount of leaf abscission. Urea sprayed at 6% increased CO_2 assimilation rate ≈50% after three foliar applications in 3 weeks. Nitrogen content and net CO_2 assimilation of urea and urea + salt leaves were similar.

786

Gas Exchange Responses of Papaya Leaves to Light Variation as Influenced by Drought

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Container-grown papaya plants were subjected to a slow drying cycle by replenishing a portion of the mean daily water loss. When light-saturated net CO_2 assimilation (A) of stressed plants was ≈70% of well-watered plants, sun–cloud transitions were simulated by placing shadecloth between a lamp and the leaf cuvette. The cuvette was initially positioned to receive photosynthetic photon flux (PPF) of ≈1600 $\mu mol \cdot m^{-2} \cdot s^{-1}$. The shadecloth was placed over the cuvette for a 3-min period (250 $\mu mol \cdot m^{-2} \cdot s^{-1}$), then removed. Gas-exchange responses were recorded for another 3 min of high light. Within 20 sec of initiating low light on well-watered plants, A was <50% of the high-light value. Stomatal conductance (g_s) of these plants began to decline by 60 sec and slowly declined to <90% of the high-light value. Both A and g_s recovered to the original values by ≈2 min following return to the high-light conditions. For stressed plants, the decline of g_s under low light began earlier and was of greater magnitude, and g_s and A recovery following the return to high light was delayed. These results indicate that papaya has suntracking capabilities, and mild drought stress enhances the tracking response.

790

Net Carbon Dioxide Exchange Rates of Raspberries at Varying Irradiances, Carbon Dioxide Concentrations, and Air and Soil Temperatures

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The influence of irradiance, CO_2, and temperature on whole-plant net C exchange rate (NCER) of micropropagated raspberries (*Rubus idaeus* L. cv. 'Heritage') was examined in 1994. Irradiances >1000 $\mu mol \cdot m^{-2} \cdot s^{-1}$ PAR were required for light saturation, and net photosynthesis (Pn) greatly increased under CO_2 enrichment (up to 2000 $\mu l \cdot liter^{-1}$) and was optimum at 17C. Temperature effects were separated in another experiment using varying air and soil temperatures (15, 20, 25, 30, and 35C) under saturated light and ambient CO_2 levels (350 $\mu l \cdot liter^{-1}$). Both air and soil temperature influenced net Pn, with maximum rates occurring at an air/soil temperature of 17/25C and each contributing 71.2% and 26.7%, respectively, to the total variation explained by a polynomial model (R^2 = 0.96). Dark respiration and root respiration rates also increased significantly with elevated air and soil temperatures. Therefore, results from this study indicate that maximum net Pn occurred at an air/soil temperature of 17/25C and that irradiance, CO_2 levels, and shoot and root temperatures are all important factors in examining NCER in raspberries.

794

Effect of Defoliation on the Translocation and Use of Photosynthates in Grapevine

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On potted Carignane grapevines, the following three leaf removal treatments were used: 1) six basal leaves allowed; 2) all leaves left on the vine; and 3) all leaves left on the vine except shoot tip, darkened by covering the leaves with aluminum-coated paper bags. Translocation and use of photosynthates was studied using C_{14} in the season of application and in the following year. In the season of C_{14} application, the roots and trunk were the major sinks. Reserve photosynthates were used to support current-season growth following budbreak in all three treatments. Treatments 1 and 2 showed similar trends in use of reserves; in treatment 3, however, reserves continued to be used until harvest at full maturity. Defoliated vines used more stored reserves than nondefoliated vines. Defoliated vines used more reserve carbohydrates, leaving little C_{14} reserves in old roots compared to nondefoliated vines.

798

Development of an Inoculation Protocol for Ericoid Mycorrhizae

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Past experiments have proven that meristem tip-cultured blueberry plantlets are extremely difficult to inoculate using laboratory-grown cultures of existing known isolates of *Hymenoscyphus ericae*, *Scytalidium vaccinii*, and *Oidiodendron griseum*; fungi that have been previously established as ericoid mycorrhizal symbionts. An experiment using both seedling and meristem tip-cultured plantlets was conducted using these proven fungal symbionts from the Canadian Fungal Culture Collection (DAOM), as well as fungi isolated from local blueberry populations at Little Flat, Pa. Treatments included inoculation using soil from the Little Flat population, the same soil (autoclaved), autoclaved soil that was reinoculated with fungi, as well as axenic treatments using *H. ericae*, *S. vaccinii*, *O. griseum*, Little Flat *Hymenoscyphus* sp., Little Flat *Scytalidium* sp., and Little Flat

Oidiodendron sp. Sampling after 21 days revealed that only the nontreated soil plantlets were infected (≈4%). Results from later sampling dates will be presented, and the mechanism of infection discussed.

142 POSTER SESSION 24 Culture & Management/Vegetable Crops & Herbs

959

Early Growth Model of Muskmelon (*Cucumis melo* L. cv. Hiline) Using Accumulative Windspeed Frequency

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Experiments were conducted during summer seasons from 1991 to 1994 to find out the effect of winds on early growth of muskmelon. A randomized complete-block design with sheltered and exposed areas as treatments was used. Sensors for air temperature and relative humidity (model HMP35C or model XN217, Campbell Scientific) were placed at canopy height and 3-cup anemometers (model 12102, R.M. Young, Traverse City, Mich.) were 50 cm aboveground. All sensors were connected to CR10 automatic data loggers and recorded hourly average data. Using regression analysis, we found that the accumulative windspeed frequency below threshold (<4 $m \cdot s^{-1}$) can be used to predict both accumulative hourly heat units of air temperature (GDHT) with R2's more than 0.85 and total muskmelon fresh and dry weight and leaf area index at early growth. Predicted models using accumulative hourly windspeed frequency have R2's >0.80 in sheltered areas. Adding vapor pressure deficit to the model improves the prediction of muskmelon early growth, especially in exposed areas.

964

Nitrogen and Water Management for Drip-irrigated Tomato

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Tomatoes (*Lycopersicon esculentum* Mill.) were grown under plastic culture on a Bojac sandy loam soil in 1991, 1992, and 1994 to determine influence of nitrogen rate at planting and water application scheduling by pan evaporation (PAN) on crop yield and fruit size. Marketable yield and percentage of large fruit was significantly increased in 1991, 1992, and 1994 as irrigation application increased from 0.5 to 1.0 or 1.5 PAN (one application per day). Nitrogen applications exceeding 168 $kg \cdot ha^{-1}$ resulted in lower yield and reduced fruit size in 1992. In 1994 (late planting followed by hot, dry growing season), yield was increased with increasing N to 213 $kg \cdot ha^{-1}$ with 1.0 PAN, but not influenced by N at 1.5 PAN. Residual soil nitrate concentration was increased with reduced irrigation or increased nitrogen application. Nutrient management plans to address non-point source pollution concerns of EPA will need to reflect crop irrigation needs to maintain yield and fruit size while minimizing nitrate accumulation within the soil profile.

967

Comparison of Disease Forecasting for Early Blight Control on Stake Culture Versus Ground Culture Fresh-market Tomatoes in New Jersey

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The number of fungicide applications for tomato early blight control required by three disease forecasting systems—FAST, Pennsylvania State Univ., CUFAST, Cornell Univ., and TOMCAST, Ridgetown College, Ont.—was less than the number required following a weekly schedule. Foliar disease was significantly lower for all schedules compared to the untreated control. Cultural treatment had no significant effect on disease control, but disease incidence was significantly lower for stake culture than ground culture treatments. Total yield was not affected by cultural treatment, was significantly increased by a weekly fungicide application schedule, and was not appreciably different among the forecast fungicide application schedules. Marketable yield was significantly higher for stake culture than ground culture treatments and was significantly increased by all fungicide application schedules compared to the untreated control. Marketable yield was significantly lower for certain forecast schedules compared to the weekly schedule. Potential cost savings of $379 per acre and pesticide reductions of 33 lbs a.i. per acre for the season were calculated. Chemical name used: tetrachloroisophtalonitrile (chlorothalonil).

972

Plastic Mulch Enhances and Conserves $N0_3$-N in Bell Pepper

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$N0_3$-N is readily leached from mineral soils with rain or overhead irrigation. To determine the amount of $N0_3$-N conserved with plastic mulch, 'Northstar' bell pepper was grown with and without 2-mil black plastic mulch, with 0, 80, and 160 lbs/acre of preplant N. One treatment consisted of unplanted rows. At 1, 2, 3, and 5 months after planting on 26 May 1994, soil samples for $N0_3$-N analyses were taken at 0–6" and 6–12". Not only was $N0_3$-N conserved under the mulch, but it was also enhanced. $N0_3$-N levels increased up to 595 ppm in plots with mulch, no crop, and 160 lbs N/acre. The pepper crop utilized about one-third of the nitrogen under the mulch. After 5 months, nitrate levels averaged about 6 ppm in all plots without mulch, whereas, in plots with mulch, nitrate levels averaged about 97 ppm. For most of the season nitrate were higher at 0–6 inches than at 6–12 inches, but, nearer the end of the season, nitrates in plots without mulch were nearly the same or greater at 6–12 inches than at 0–6 inches. Yields were highest with mulch and 80 lbs N/acre.

975

Tillage and Cover-cropping Affect Weed Populations and Yield of Broccoli and Cauliflower

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Research was conducted to determine whether tillage in the fall rather than spring could be used to prepare fields for transplanting broccoli and cauliflower crops. Because fall-tilled soils are prone to erosion by winter rains, the effects of a fall-planted barley cover crop were also determined. Trifluralin was applied to the spring-tilled plots, according to grower practice. Herbicide treatments applied to fall-tilled plots were early and/or late applications of glyphosate and napropamide following early and late glyphosate applications. Weed emergence was generally increased by the barley cover crop, but the species depended on which herbicides were applied. Napropamide reduced the emergence of some weed species, whether or not a cover crop was grown. Yield of broccoli was reduced by the cover crop, and was highest in fall-tilled plots that received two glyphosate treatments. Yield of cauliflower was highest in spring-tilled plots that were cover-cropped. In fall-tilled plots, cauliflower response to the cover crop and herbicide treatments was inconsistent.

978

Growth and Yield of Greenhouse Tomato with Constant or Intermittent Heating of the Root and Shoot

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What is the effect of constant compared to intermittent heating of the shoot and root on growth, nutrient status, and yield of greenhouse tomato (*Lycopersicon esculentum* Mill)? Seedlings were transplanted on 4 Mar. or 25 Mar. 1994 into troughs heated to 21C by buried tubing, either constantly, or for 12 h during the day or the night, or they were not heated. The greenhouses had either 14/14C or 22/6C day/night minimum air temperatures. After 2 weeks, the 4 Mar. transplants had the greatest leaf weight with constant root heat and least with no heat. Root weight was greater for 14/14 than 22/6 air heat. With 14/14 air heat, only the no root heat reduced leaf weight, whereas with 22/6 air heat, root heat affected leaf weight; the ranking was constant > day > night ≈ no heat. After 2 weeks, the 25 Mar. transplants had least leaf weight with no heat, and other treatments did not differ. Most nutrient concentrations were less in the 25 Mar. compared to the 4 Mar. transplants. The number of fruit, and the number and weight of marketable fruit produced by I July from 4 Mar. transplants was affected by root heat; the ranking was constant heat > day > night > no heat. The 22/6 air heat increased marketable yield, because of fewer small, irregular, and blossom end rot fruit. Root heat had no effect on yield of 25 Mar. transplants. Research supported in part by grant 93-37100-9101 from NRI Competitive grants program/USDA.

980

Accelerated Test of Paper Mulch Degradation

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In 1994, field trials were undertaken to evaluate the agronomic performance of a range of paper mulches in vegetable production. During the course of the experiments, the majority of the paper mulches tested degraded part way through the growing season. Before the next growing season, a range of Kraft papers differing in densities and compositions were subjected to an accelerated degradation test to determine which mulches would be suitable for use under Quebec field conditions. A mixture of equal parts black soil, sand, and manure (two parts sheep manure and one part liquid cow manure) was placed into trays of 26 x 52 cm. Experimental papers were cut into strips measuring 2.5 x l.5 cm and put into the trays such that half of the strips were covered with the mixture. The trays were placed in a growth cabinet (30C with a relative humidity of 50%). Three replicates of each treatment were sampled 3, 5, 7, 11, and 14 days after placement to determined the amount of degradation that had taken place. It was found that the length of time taken for degradation in the accelerated system was 3.7 times less than that of the field.

983

Extent of Cross-pollination of One Sweet Corn Genotype onto Another in Adjacent Plantings

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Recommendations for culture of sweet corn (*Zea mays*) suggest separation of genotypes for color and/or sweetness by considerable distance since corn is generally wind-pollinated and unwanted pollination may result in undesired color or sweetness effects. Many small-scale producers lack adequate acreage to separate plantings by more than a short distance. To determine the extent of cross-pollination, 'Golden Queen' yellow sweet corn was seeded in a circular pattern of 16 rows in 1989 and eight rows in 1990. White 'Silver Queen' was then planted in 20 rows around the yellow genotype. The circular pattern enabled detection of pollen carried by wind in any direction. Yellow kernels on 'Silver Queen' were attributed to cross-pollination. Depending on wind speed and direction, cross-pollination ranged from 50% on adjacent rows to none as close as eight to 10 rows from the yellow type. Consumer acceptance of a white genotype with a few yellow kernels was not determined.

986

The Effects of Shiitake Mushroom [*Lentinula edodes* (Berk.) Pegler] Strains and Wood Species on the Yield of Shiitake Mushrooms

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White and red oak (*Quercus* spp.), Black Cherry [*Prunus serotina* (Ehrh.)], Sassafras [*Sassafras albidum* (Nutt.) Nees], and Eastern Sycamore (*Platanus occidentalis* (L.)] logs were inoculated, in 12-mm holes drilled 25 mm deep, with eight strains of shiitake mushrooms [*Lentinula edodes* (Berk.) Pegler]. Logs were then placed in 80% shade houses under natural environment. Harvested mushrooms were counted and weighed and biological efficiency computed. Interactions among strains and seasons of harvest and species and seasons of harvest were significant. The higher producing strains and species produced more mushrooms later in the life of the log than the least productive strains and wood species. White and red oaks produced significantly more than the other wood species. There was only one strain, CW25, that produced significantly less than the top four yielding strains.

989

Parthenocarpic Fruit Set in Summer Squash

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Low temperatures typical of early season production promote female sex expression and reduce male flower formation in summer squash. In addition, some summer squash cultivars do not produce sufficient male flowers for good fruit set early in the season in New York. Parthenocarpic fruit set could increase early season yield as well as at times when bee activity is restricted by wet weather or by row covers. More than 30 *Cucurbita pepo* cultivars and breeding lines were evaluated for their ability to produce parthenocarpic fruit over the past 3 years. Pistillate flowers were closed before anthesis to prevent pollination. In 1992, 66% of all the entries set parthenocarpic fruit where as 40% displayed the same pattern in 1993 and 81% in 1994. Varieties with the best parthenocarpic fruit set included Black Beauty, Black Magic, Black Jack, and Chefini Hybrid, all zucchini types. Most yellow-fruited cultivars had poor fruit set but the precocious yellow cultivar Gold Rush had good parthenocarpic fruit set in 1992 and 1993. In 1994, floating row covers placed over the plants 1 week after planting confirmed the results of the previous two seasons. This indicates that certain varieties of summer squash consistently set parthenocarpic fruit. These varieties may be most useful for early season production or for production under plastic tunnels or row covers where pollinator activity is restricted. In addition, our results indicate that it is possible to breed parthenocarpic squash of different fruit colors and types.

993

Influence of the Color of Mulch on Development and Productivity of Peppers

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The rational use of mulch associated with plasticulture involves the optimization of all bioclimatic parameters so as to minimize the considerable expenses engendered by use of this technology. The primary objective of this project is to study the influence of the transmission and the reflection of light involving different colored plastic film on the development and productivity of peppers. Spectroradiometric measurements between 400 and 1100 nm indicate that brown, red, and gray are the most opaque to light. Higher temperature were measured under clear, red, brown, and green plastic mulch. The greenhouse study shows that young plants subjected to white mulch and gray mulch grew into plants whose leaf surfaces were weaker than those subjected to other materials. Earliest yields were obtained from clear and red mulch. There was no significant differences noted in total yield.

994

Performance of Selected Carrot Cultivars in North Dakota

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The Red River valley and surrounding areas of North Dakota are ideal sites for growing high-quality carrots for fresh-market, processing, and dehydrated products. The results of cultivar trials performed for the past 3 years indicate that from 20 to 50 ton/acre of fresh carrots can be produced with or without irrigation in this region. The average sizes of individual carrots are big (260 to 310 g/root) due to high daytime temperatures and large diurnal temperature fluctuations during the growing season. In 1994, the highest yielding carrot cultivars were 'Toudo', 'Danvers 126', 'Delmar', 'Babbette', and 'Beta III' when evaluated near Absaraka, N.D. Cultivars with highest sugar contents were 'Sweetness', 'Apache', 'Presto', 'Comanche', and 'Navajo'. A summary of 2-year data on the yield and quality of carrots grown in North Dakota is presented.

997

Effects of Supplementary Lighting on Growth and Primary Nitrogen Metabolism of Greenhouse Lamb's Lettuce and Spinach.

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Two cultivars of lamb's lettuce (*Valerianella sp* L. cvs. Valgros et Vit) and one cultivar of spinach (*Spinacea oleracea* L. cv. Martine RZ FI) were subjected to supplemental lighting treatments provided by high-pressure sodium lamps (HPS, PL 90, P.L. Lighting Systems). The PAR level was 50 $\mu mol \cdot m^{-2} \cdot s^{-1}$. Seedlings were subjected to three photoperiods (natural, 12, and 16 h). The experiment was conducted from Jan. until Apr. 1994. The fresh weight of plants grown under supplemental light was higher than plants grown under natural light. Nitrate concentration was lower in the leaves of plants grown under supplemental light while nitrate reductase activity (NRA) was increased. The cultivar Valgros was more productive than Vit, but accumulated more nitrates. At harvest, the fresh weight of Valgros plants grown under 12- and 16-h photoperiods were 30% and 50% higher, respectively, than those grown under natural photoperiod. The fresh weight of Vit grown under 16 h of supplemental light was 30% higher than under natural photoperiod. The lowest nitrate concentrations in plants were obtained under a 16-h photoperiod and the highest NRA were obtained with the same treatment. Compared to that obtained under natural photoperiod, the fresh weight of spinach shoots was 40% higher when seedlings were lighted for 12 h and almost 100%

under 16 h. The lowest nitrate accumulation in spinach was found for plants grown under 16 h supplemental lighting.

1001

Response of Long- and Short-vine Tropical Pumpkins to Varying Cultural Practices

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Three field experiments were carried out in Lajas, Puerto Rico, to compare the effects of planting method (direct and transplant), plastic mulch (with and without), and planting density (1.8 x 1.8 m, 3.6 x 0.9 m, 1.8 x 0.9 m between and within rows) on production of short-and long-vined tropical pumpkins (*Cucurbita moschata*). The long-vine genotype produced greater yields and larger but fewer fruit than the short-vine genotype. However, most of the planting densities tested were probably not optimum for short-vine cultivars. Direct seeding of pumpkin was more efficient than transplanting and resulted in the same early and total yield as transplanting. Yields with plastic-covered banks were similar to yields without the use of plastic. However, use of plastic mulch increased the number of fruit and decreased the average fruit weight in the plots. The best planting distance depended on the type of genotype used. The long-vine genotype had the highest yields at 1.8 x 1.8 m, while the short-vine cultivar performed best with half that amount of space per plant (1.8 x 0.9 m). Production of short-vine cultivars might be improved by using even narrower planting distances.

1002

Performance of Bittermelon in Temperate Climate

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Bittermelon (*Momordica charantia* L.) is an annual vegetable crop commonly grown in the tropical regions of Asia. Because of a substantial Asian immigrant population, an ethnic niche market for the crop also exists in the United States. We conducted yield trials during 1993 and 1994 to find out whether bittermelon could be produced successfully In the southern United States to exploit this market. Seeds were planted in both years on 18 May. Plants started producing fruits ready for picking in about 60 days. Fruits were harvested three times/week for 11 weeks during both years. Yield/plant was significantly higher during 1993 than 1994. The lower yield during 1994 appeared to be associated with the excessive rainfall during the crop growing period. The total number of fruits produced/plant during 1993 and 1994 were 43 and 33, respectively. Respective fresh yield/plant for 1993 and 1994 were 8.2 and 4.7 kg. The data suggested that a bittermelon yield comparable to those reported in literature can be obtained in Georgia when summer is not excessively wet.

1005

Subirrigated Bell Pepper Production with Reduced Water Table Levels and Fertilizer Rates

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The effect of water table level and fertilizer rates on bell pepper production grown with the fully enclosed subirrigation (FES) system was studied over three fall growing seasons (1992–94). The FES system uses buried microirrigation tubing in the field to convey water for maintaining a water table level and has shown to achieve application savings of 30% to 40% compared to the conventional subirrigation method that maintains a high water table using lateral field ditches. Controlled water table levels of 45, 60, and 75 cm below soil surface and fertilizer rates of 1194, 1716, and 2239 kg·ha^{-1} (18–0–21 expressed as N–P–K) were used as treatments replicated in time over 3 growing seasons. The 45-cm water table level and 2239 kg·ha^{-1} fertilizer rate are considered the conventional commercial practices. Results showed that comparable seasonal production levels were achieved among fertilizer rates and water table levels with no significant interactions between treatments. These data indicate that using a lower target water table level allows lower rates of fertilizer to be used because the susceptibility of the fertilizer to leaching caused by excessive rainfall is lessened due to increased soil water storage capacity.

1009

NPK Fertilization of Cilantro and Dill

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Two experiments, one each with cilantro and dill, were conducted during 1994 to determine optimum rates of N, P, and K fertilizers. In these experiments, 'C1410' cilantro and 'Bouquet' dill were direct seeded in three-row plots with 0.3-m spacing between rows. A seeding rate of ≈40 seeds per meter of row length was used. Data were recorded, 45 days after planting, on moisture content, chemical composition of foliage (contents of essential oils, protein, and ash), and fresh yield following 25, 50, 75, and 100 kg·ha^{-1} application of each nutrient (4 x 4 x 4 factorial). Nitrogen rates significantly affected moisture, ash, and fresh yield of cilantro and dill. Phosphorus rates significantly affected moisture content and yield of dill but not cilantro. The effects of K applications were nonsignificant. The optimum N rate for both cilantro and dill was 25 kg/h. The optimum rate of P for dill was 25 kg/h. The data indicated that N and P requirements of cilantro and dill are modest. Further details of these results will be presented and discussed.

1010

Influence of Growing Media Amended with Compost and the Electrical Conductivity of Nutrient Solution on Three Medicinal Plants Grown in Multicompartment Trays

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Transplants of angelica (*Angelica archangelica* L.), horehound (*Marrubium vulgare* L.), and thyme (*Thymus vulgaris* L.) were grown in multicompartment trays with five proportions of compost (0%, 15%, 30%, 45%, 60%) mixed to peatmoss and perlite. Plants were fertilized with different electrical conductivity (EC) levels of the nutrient solution (0, 1, and 2 mmho/cm). Horehound and thyme plants were transplanted in the field to measure the residual effects of treatments on dry matter yields and level of active substances. The three medicinal plants showed increased shoot and root dry weights as well as leaf mineral content (some nutrients) when proportion of compost and EC of nutrient solution were higher. The optimal combinations of compost and fertilization treatments on plants growth varied between species. Residual effects of treatments applied in greenhouse on shoot dry matter weight of horehound and thyme plants were observed until the 9th and 12th week, respectively, after transplantation. Treatments also affected active substance levels in horehound plants in field. Organic fertilization management influenced growth, yield in the field and level of certain active substances of the harvested parts of medicinal plants.

1013

Use of Municipal Yard Waste Compost as a Component of Potting Media

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The objective of this study was to assess the feasibility of utilizing composted municipal yard waste as a component of potting media, which is predominantly composed of peatmoss, a nonrenewable and increasingly expensive medium. Green Comet broccoli (*Brassica oleracea* L. Italica group) was grown in five ratios (1:0, 1:2, 1:3, and 0:1) of composted yard waste : commercial soilless potting medium. Plant heights were recorded weekly. At the end of 6 weeks, measurements were taken on plant height, fresh weight, dry weight, and root : shoot ratios. Media leachate was tested for pH and soluble salt levels. Germination tests were run using the same potting mix ratios. Percent germination and seedling survivability were recorded. Results show that yard waste compost can be used as a component of potting media, although seed germination and seedling growth are inhibited at high compost levels.

1017

Manipulation of Plant Density to Enhance Rice Yield for a Bioregenerative Life-support System

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Rice (*Oryza sativa* L.) is a candidate crop for use in Controlled Ecological Life-support Systems (CELSS) proposed for a lunar or Mars outpost. 'Ai-Nan-Tsao' is a promising semi-dwarf cultivar because growth volume is limited and HI (percent edible biomass) is high. Yield efficiency rate (YER: g grain/m^3 per day [g nonedible biomass]-) combines edible yield rate (EYR: g grain/m^3 per day)

and HI to quantify edible yield in terms of penalties for growth volume, cropping time, and nonedible biomass production. Greenhouse studies indicate EYR increases with plant density from 70 to 282 plants/m^2. YER and shoot HI are stable across this density range because nonedible biomass accumulation keeps pace with edible. Tiller number and panicle size per plant decreased with increasing plant density, but total tiller and panicle number per unit area increased to compensate. Density trials in rigorously controlled environments will determine if higher plant densities will produce even greater YER. This research is supported by NASA grant NAGW-2329.

1018

Fish Culture Water and Sludge Applied Via Drip Irrigation Improves Yield of Pak Choi (*Brassica rapa* L. Chinensis)

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Using fish culture water and sludge may benefit vegetable production by reducing the need for high-quality irrigation water in areas where water is a limiting resource for agriculture. Fish water and sludge contains nutrients, thereby reducing the need for chemical fertilizers. A study was conducted to integrate fish (tilapia) culture with field production of Pak choi (*Brassica rapa* L. Chinensis). Water from tilapia culture tanks from which solids were removed (SR) and from tanks with no solid removal (NR) were applied to pak choi 2 to 3 times weekly through a drip system. These treatments were compared with sludge (FS) removed from culture tanks using three methods of irrigation. Conventional methods of fertigation (F) and band fertilizer (B) application were included as control treatments. The trial was conducted for 2 seasons. In the first season, pak choi applied with (FS) produced total yields ranging from 21 to 26 $t \cdot ha^{-1}$. Pak choi applied with fish water from tanks with (SR) and (NR) produced yields of 19 and 20 $t \cdot ha^{-1}$, respectively. Pak choi grown with (F) and (B) applications yielded 21 and 20 $t \cdot ha^{-1}$, respectively. There were no significant yield differences between the (FS) treated and (F) plots. Yield from (FS) treatment was significantly higher than all other treatments except (F). Similar results were obtained during the second season, but total yields from various treatments were 50% higher than the first season. Fish culture water and sludge are therefore good alternative sources of irrigation and fertilizer for pak choi.

1025

Grower Contributions to the Early Stages of Crop Nutrient Trials with Vegetables

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Trials to determine crop nutrients for four vegetable crops grown on the limestone soils of Dade County, Fla., have been conducted in growers' fields to duplicate commercial growing conditions. This has increased grower participation in the experimental process. The four vegetable crops are snap beans, Irish potatoes, sweet corn, and malanga (a.k.a. yautia or tannia, *Xanthosoma sagittifolium* Schott). The discussion will focus on grower participation in various critical decision-making activities: a) location of plots in a commercial field, b) placement of fertilizers, c) possible problems with Restricted Entry Intervals, d) harvest determinations, and e) grading criteria and quality assessment.

1029

Effects of Sowing Date on Yield and Quality of Broccoli Florets for Freezing

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In many countries, the frozen broccoli industry is based on the production of florets resulting from the separation of the inflorescence components. There is little information on the performance of presently used cultivars for this purpose. Three broccoli cultivars ('Arcadia', 'High Sierra', and 'Viking') were sown every 2 weeks in five dates, from midsummer to autumn, to measure effects on field and industry yields, and in quality of florets. All cultivars behaved similarly, showing a significant decrease in yields (from >20 to <10 $t \cdot ha^{-1}$), an increase in industry wastage (from <40% to >55%), and marked changes in quality of the florets (color, diameter, uniformity of flowers, etc.) with sowing dates associated with a slow degree-day summation.

1033

Potential Uses and Water Demand of Pigeonpeas in Mixed Intensive Horticultural Systems in Dry-subtropical Northwest Mexico

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A water demand model based on the plant–water–climate interactions is proposed to establish the effects of the photosynthetically active radiation (PAR) on the water demand processes of a crop. It is shown that a relationship exists between PAR, leaf temperature, and the transpiration of regional ecotypes of Northwest Mexico from Asia in the middle of the century. These ecotypes were found in the influence area of the Sierra de La Laguna, B.C.S., Biosphere Reserve. Estimated relationship was backed by measurements of leaf and ambient temperatures, and PAR, of which the transpiration is dependent. It is concluded that this procedure is useful to establish the expected level of transpiration of pigeonpeas and thus, their water requirements. The observed phenotype characteristics suggest the usefulness of pigeonpeas in intensive ecosystems; grain yield was near 6 $Mg \cdot ha^{-1}$. The results enable us to design appropriate horticultural systems in the villages of Sierra de La Laguna, which could include understorey horticultural species and pigeonpeas, a low-inputs crop.

148 POSTER SESSION 25
Growth & Development & Propagation/Fruits, Vegetables, & Herbs

549

Sensitivity of Broccoli Inflorescence Development to High Temperature

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Production of broccoli in areas where summer temperatures exceed 30C is difficult because the head may not form properly. The high temperature causes an unevenness in the head due to widely differing sizes of buds. The sensitive stage of development was determined for the early maturing variety 'Galaxy' by exposing it to 1-week at 36C at varying developmental stages, and subsequently analyzing the head structure. The injury is a cessation of bud enlargement during the high-temperature exposure. There is no corresponding cessation of bud initiation at the apex. The patter of injury is consistent with susceptibility over a relatively small range of bud development: even with a 1-week exposure, only about 1/3 of the buds will be affected. The plant's most developmental stage at this sensitive period still appears vegetative, but the youngest leaves are just beginning to reorient as a consequence of the reduced stem elongation rate. The meristem is less than 1 mm wide, and scanning electron micrographs show floral primordia just forming, still subtended by leaf primordia. The injury is fully expressed when the head is first exposed (≈10 mm wide), though it becomes more apparent as the head matures. The buds that were delayed in development by the high temperature developed into fertile flowers, albeit about a week late.

553

Root System Activity of Fruit Trees in Response to Shoot Pruning, High Temperature, and Excess Water

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Relationship between root system and shoot pruning was studied by three different pruning times (February, June, and August) and intensity (heavy, medium, and light) using satsuma mandarin trees (*Citrus unshiu* Marc.). Root weight, respiratory rate of fine root, and CO_2 concentration in root zone were measured on the 90th day after starting each pruning treatment. The weight of fine root was more severely influenced by pruning intensity than by pruning time. Fine root of heavy pruned trees showed lower respiratory rate than those of medium- and light-pruned trees. Heavy-pruned trees showed the highest CO_2 concentration level in root zone. Influence of high root temperature on root respiration was investigated using 'Kyoho' grape (*Vitis vinifera* L. x *V. labrusca* L.), kiwifruit (*Actinidia deliciosa*), and satsuma mandarin trees. Respiratory rate of grape root increased more rapidly than those of mandarin and kiwifruit under high root tem-

perature. Respiratory rate of mandarin root given immersion treatment in stagnated water began to decrease significantly at the 70th hour after starting the treatment. Photosynthesis of the trees decreased by 85% at the same time.

561

Cropping Efficiency of Young 'Fuji' Apple Trees

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Effects of crop load and time of thinning on productivity of young 'Fuji'/M.9 apple trees were tested by hand blossom (B) or fruit (F) thinning to two crop densities (fruit number/trunk cross-sectional area). Heavy (H) crop densities resulted in higher yields in both 2nd and 3rd leaf than light (L) crop densities. Time of thinning had no effect on yields in either year. In the 2nd leaf, fruit size was largest from trees B thinned to L crop densities, and smallest from trees F thinned to either crop density from mid-June through harvest. Both 1° and 2° vegetative growth were greatest in noncropped trees, intermediate in trees with L crops, and least in trees with H crops. Noncropped 2nd-1eaf trees had the highest flowering indices (flower clusters/100 total buds) the following spring and H cropped trees had the lowest. The flowering index was higher when trees were B thinned in the 2nd leaf than when F thinned. In the 3rd leaf, fruit size was largest when borne on weak upright shoots, intermediate on spurs, and smallest on 1-year-old terminal wood. Fruit on spurs had the highest incidence of sunscald (17%) and fruit on weak upright shoots the lowest (8%). Previous-season crop densities affected current-season's vegetative and fruit growth.

569

Development of Micropipette Method for Collecting Vacuolar Contents from Intact Tannin Cells in Persimmon (*Diospyros kaki*) Fruit and Preliminary Analysis of its Constituents

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In order to study the nature of tannins in vivo, we developed a method for collecting the vacuolar contents from intact tannin cells in persimmon fruit. We used a micropipette controlled with a MMS-77 micromanipulator system (Shimadzu Co., Kyoto, Japan) under an inverted microscope. Fruit flesh of mature persimmon fruit (cv. Miyazakimukaku) was cut into 300-μm-thick sections with a DSK-100 miaoslicer (Dosaka EM, Kyoto, Japan). The sections were then put on a glass slide, and a micropipette was inserted into a tannin cell to withdraw its contents. After determination of the sap volume collected, the sample was injected into a 25-μl drop of water on a glass slide. Then, the water-drop containing the tannin sample was transferred to a small microfuge tube and stored in a freezer until analysis. Based on calculations, we could collect approximately 7 to 12 nl of vacuolar contents per tannin cell. When tannin and sugar contents per tannin cell were determined, we found that tannin cells contain tannins at 10% to 15% as catechin equivalents (w/v) and 8% to 10% total sugars (w/v), while a whole fruit contains tannins at 1% to 1.5% as catechin equivalents and 10% to 13% total sugars on fresh weight basis. We are currently continuing more detailed analysis of tannin cell constituents.

571

The Advances in the Study on Mycorrhizas of Fruit Trees in China

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The study of mycorrhizas of fruit trees was carried out in the 1980s in China. More progress has been made in resources, taxonomy, anatomy and morphology, physiology, ecology, effects, and application of mycorrhizas in fruit trees. The present status and research trends in the study of fruit tree mycorrhizas in China were introduced, and the application prospects of mycorrhizas in fruit tree cultivation also were discussed.

575

Genetic Variations in Chlorophyll Fluorescence, Photosynthesis, and Carbon Partitioning into Sorbitol, Sucrose, and Starch in Apple Leaves

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Chlorophyll fluorescence measurements are providing insights into Photosystem II (PSII) quantum efficiency and hence are able to provide a good estimation of carbon assimilation under field conditions. A F_2 generation of sibcross seedlings from a cross of 'Goldspur' x 'Redspur' were selected to identify genetic variations and the relationships among fluorescence parameters, carbon assimilation, and carbon partitioning in apple leaves. Mature leaves from extension shoots were analyzed for chlorophyll fluorescence with a CF-1000 chlorophyll fluorescence measurement system, photosynthetic rate with a LI-6200 portable photosynthesis system, and carbohydrates with a Shimadzu HPLC. Significant variations in leaf chlorophyll fluorescence parameters and photosynthetic rates were found. The ratio of Fv : Fm, an estimation of photochemical efficiency of PSII, decreased from ≈0.90 in June to ≈0.75 in September while the photosynthetic rates decreased from ≈8.5 in June to ≈4.5 $\mu mol \cdot m^{-2} \cdot s^{-1}$ in September. The relationships between fluorescence parameters, photosynthesis, and carbohydrate partitioning were analyzed and the ratio of sorbitol to sucrose in relation to the efficiency of PSII and NADPH production will be discussed.

577

Peroxidase, Polyphenoloxidase, and Superoxide Dismutase Activities in Relation to Apple Fruit Development, Ripening, and Storage

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Peroxidase (POD), polyphenoloxidase (PPO), and superoxide dismutase (SOD) activities were measured during several phases of bud development, ripening, and storage of 'Oregon Spur Red Delicious' (*Malus domestica* Borkh) apple fruit. POD, PPO, and SOD activities were significantly altered as a result of bud development. At the early stages of fruit development, the activities of these enzymes were significantly higher, then declined as the fruit increased in size. The activities of these enzymes declined as the fruit reached full maturity. Fruits harvested 3 weeks before commercial maturity and stored for up to 6 months have higher enzyme activities than fruits harvested at or beyond commercial maturity. The activities of these enzymes in relation to fruit firmness, soluble solids, and ethylene will be determined and related to overall fruit quality.

579

Factors Affecting Anthocyanin Accumulation in *Solanum tuberosum*

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The color of red potatoes is due to an accumulation of anthocyanins in periderm tissues. The objective of this study was to examine the effect of several factors on tuber redness. Using the red tuber-producing *S. tuberosum* ssp. *tuberosum* cultivar Norland, we observed that chroma (intensity of redness) and anthocyanin content of greenhouse-grown tubers decreased as tuber weight increased. There was a slight or no increase in hue (tint). We used HPLC to determine that pelargonidin and peonidin are the major anthocyanidins (aglycones of anthocyanins) in tuber periderm. The ratio of pelargonidin to peonidin increased as tuber weight increased up to 25 g fresh weight. The decrease in chroma was not due to an increase in cell sap pH; we observed a decrease in cellular pH as tuber weight increased. Controlled-atmosphere storage had no effect on tuber chroma or anthocyanin content compared to air storage. Methyl jasmonate, sucrose, or light treatment did not increase anthocyanin accumulation. Tubers exposed to light had less anthocyanin than those kept in the dark. We are examining the developmental expression of anthocyanin biosynthetic genes, as well as the effect of maize transcription factors on anthocyanin synthesis, in tuber periderm.

581

The Effect of Various Pollen Grains on Growth and Development of *P. vera* Nuts

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The xenial and metaxenial effects of five different male sources on cross pollination of three pistachio cultivars, were studied in 1990 and 1991 in Rafsanjan/Iran. The pollen grains used were *P. atlantica* Desf., *P. mutica* F.& M., *P. vera* L. (Momtaz), *P. vera* L. (Soltani), and an open pollination. The female cultivars chosen were 'Owhadi', 'Kalleh-ghuchi', and 'Momtaz', which occupy the largest cultivation area. Experiment was done in two successive years in a completely randomized design. Results of this study agreed with previous studies regarding the retardance of pistachio nut development by wild pollen species rather than *P.*

vera L. The greatest change in various characteristics of nuts, e.g., kernel weight and shell splitting, occurred when *P. mutica* F.& M. pollen grains used followed by *P. atlantica* Desf. pollen grains. Thus, some manifestations of xenia and metaxenia could be inferred. In general, larger kernels and increased shell dehiscence resulted from the use of *P. vera* L. pollen grains. Greater kernel weight of 'Kalleh-ghuchi', higher shell splitting of 'Momtaz', and higher blank of 'Owhadi' produced by pollination with *P. vera* L. in some extent could also be cultivar characteristics.

583

The Effect of Pollens of Five Different Male-palm Trees on the Physical Characteristics of Jiroft Mazafati Date C.V.

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The type of pollens of the date palm trees could affect on the outward and physical characteristics of date fruits, so far to determine its qualitative and quantitative aspects (15). Therefore careful selection of proper pollen for pollination of the date palms is considered of high importance. This research work was conducted to select the best pollinizers and to study the effects of pollens of five varieties of male trees, from Shahdad area, on the outward and physical characteristics of 'Jiroft Mazafati'. For analyzing the results of this experiment, a completely randomized block statistical project was implemented for a period of 2 years from 1991 to 1993. The site of this experiment was in Jiroft area in Kerman Province. In this experiment, after pollination samples of fruit were collected during unripe (Kharak), ripe, and dry fruit stages and required information were recorded. Fruit length and diameter, seed length and diameter, weight of fruit, weight of seed, pulp weight, ration of fruit pulp to seed , ratio of fruit length to diameter, volume of fruit, weight of one full cluster of fruits, and finally the time of ripening were measured. Statistical calculations, analysis of compound variations and evaluation of treatments by Duncan's test indicate that different treatments of pollens will have no effect from statistical point of view on the ratio of fruit pulp to seed and the ratio of fruit length to diameter, and there are no significant differences. But there are significant effects on the other outward and physical characteristics of the fruit, and the differences from statistical point of view are considerable. The type of pollens are effective on the ripening time of the fruit and this difference ranges from 15 to 25 days for different treatments, which is important from early ripening point of view of the product.

585

Nondestructive Estimation of Pear Fruit Weight Using a Regression Model

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Nondestructive estimation of pear fruit weight is an important horticultural element for size prediction, particularly when repeated measurements of the same tree must be made without affecting growth. Our objective was to develop a method for determining pear fruit weight (W) using models correlating it with fruit maximum diameter (D), an easily measured dimension. A mature crop of *Pyrus communis* L. cv. Williams was studied at our Experimental Farm. Five trees were selected at random and fruits were sampled at weekly intervals, starting in September, 21 days after full bloom (DFB) and ending in January, 142 DFB, during three growing seasons (1991–92, 1992–93, and 1993–94). Regression equations were developed using SYSTAT procedure. Data for three years were amalgamated because analysis showed that their curves did not differ. W vs. D was best fitted to the model $W = 0{,}8236\ D^{2.778}$ $R^2 = 0{,}98$. Variability of W and D increased with fruit growth.

587

Fruit Growth and Development of Muskmelon (*Cucumis melo* var. *reticulatus* Naud.)

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As part of a program to develop a model for growth and development of muskmelon produced under various mulch and row cover combinations, all perfect flowers of five plants were tagged and measured on a daily basis. The polar and equatorial lengths of the inferior ovary were recorded from anthesis to fruit maturity. Mature fruits were harvested at full slip. The location of each flower on the plant was coded. Flowers and subsequent fruits were classified according to the following phenological stages: immature, close to mature, close to full bloom, full bloom, wilted, past full bloom, close to fruit, fruit. The netting was visually evaluated and rated on a scale of 0 to 5, the highest value representing maximum netting. At fruit maturity, the weight, polar and equatorial length of each fruit were measured and mature and immature seeds counted. The number of fruits that reached maturity was directly proportional to the total number of perfect flowers produced on a plant. Fruit weight during growth could be predicted from the polar and equatorial lengths.

589

Production Environment Influence on Pepper Pungency

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The objective of this study was to evaluate the possible causes for greater pungency in pepper (*Capsicum annuum*) pods of two chile selections when produced at eastern and western Oklahoma locations. Pungency tests over several years have demonstrated that peppers grown in western Oklahoma consistently produce pods with ≈25% greater pungency than peppers grown in eastern Oklahoma. Data from Oklahoma Mesonet stations located near each production location indicated the western Oklahoma location had higher temperatures and wind speed but lower relative humidity than the eastern Oklahoma location during pod development. Mature dry pods were dissected into cap and stem, seeds, and pod wall. Comparisons of pod component differences between the locations showed pods were similar in dry weight; however, western Oklahoma produced more cap and stem in both selections, and in one selection produced more pod wall but less seed. Pungency was 24% and 28% greater in the two selections when grown in western Oklahoma. More pod wall and less seed could account for some of the pungency increase in only one of the selections. The more stressful production environment in western Oklahoma appears to be the major factor in pungency differences between the locations.

591

Effects of Selected Fungicides on Pollen Germination, Tube Growth, and Distribution of the Cytoskeleton in *Tradescantia virginiana*

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Fungicides have been shown to negatively affect pollen germination, tube growth, and fruit set in important crops. However, little is known regarding possible modes of action in higher plant cells. To address this, the effects of propiconazole or benomyl on pollen germination and tube growth were evaluated in *Tradescantia virginiana* using light microscopy and immunocytochemistry. Concentrations were selected at levels that had inhibitory effects, but did not totally arrest germination and tube elongation, i.e., propiconazole and benomyl were added at 0, 102, 136, or 170 $\mu l \cdot liter^{-1}$, and 0, 480, 600, or 720 $mg \cdot liter^{-1}$, respectively. Both fungicides inhibited germination, cytoplasmic streaming, tube elongation, and induced abnormal tube morphology and cytoskeletal distribution. Propiconazole-treated tubes had weaker microfilament signals, with amorphous staining. Microtubule (Mt) distribution was severely affected. In benomyl-treated tubes, Mts were fewer in number, fragmented, sinuous, and increasingly disorganized. Possible mechanism(s) will be discussed.

593

Variations in Flowering, Vegetative Growth, and Dry Matter Partitioning Induced by Photoperiod and Temperature Treatments in *Papaver somniferum*

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Estimating yields of illicit narcotic crops requires knowledge of how climate, soil, and geography affect these crops. One method for estimating yields is to create databases from which to develop simulation models. This experiment is part of one of those databases, designed to determine if flowering time can be affected in young poppy seedlings by manipulating photoperiod (PP) and temperature. Plants were grown in chambers under a 12-, 13-, 14-, or 24-h PP and a 12-h thermoperiod of 25/20C. Plants at 10 or 20 days after emergence were transferred to separate chambers and treated for 48 h with either a) 10C and a 12-h PP or b) a 24-h PP and a 12-h thermoperiod of 25/20C. Days to flowering (DTF) decreased with increased PP, especially between 12 and 13 h. The 48-h PP interruption decreased DTF for PPs <24 h for both seedling ages, the effect being more pronounced for 10 d and for the 12-h PP. The 48-h 10C interruption had no effect on DTF. The poppy capsule, from which the gum is harvested, was a larger proportion of the shoot biomass under PPs >14 h, but capsule biomass was a

positive linear function of DTF. DTF depends on PP and biomass at flowering depends on DTF.

595

Volatile Oil and Thymol Accumulation in *Thymus vulgaris*

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The content of essential oil, thymol, and carvacrol in a thymol-type of clonally selected thyme plants during different developmental stages were investigated under greenhouse and field conditions. Plants in the greenhouse were grown from July to November, under natural light and natural light supplemented by a PPF of 200 $\mu mol \cdot m^{-2} \cdot s^{-1}$, provided by HPS lamps, while plants in the field were studied from June to November. Shoot yield and the accumulation of the active principles from greenhouse-grown plants were determined by harvesting the plants at 40-, 60-, and 120-day intervals, while field-grown plants were harvested in August, September, October, and November. Essential oil content, qualitative and quantitative changes in the oil were determined by subjecting the samples to steam distillation and subsequent gas chromatographic analysis. There were important changes in shoot yield, essential oil, thymol, and carvacrol content in the course of plant development. After 120 days of growth under greenhouse conditions, the essential oil content increased by >150%, while thymol content increased by ≈200% compared with the 40-day-old plants. We found some differences in oil content, thymol, and carvacrol accumulation between field- and greenhouse-grown plants. The pattern of crop yield and the accumulation of the major active substances under field and greenhouse conditions are presented and discussed.

598

Artemisinin (Qinghaosu) Production in *Artemisia annua*

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Artemisinin (qinghaosu), an endoperoxide sesquiterpene lactone with antimalarial activity and little human toxicity, is produced in *A. annua* L., a short-day plant with the critical photoperiod of 13.5 h. Artemisinin peaks at full flowering when it is 11 times higher in inflorescences than in leaves. Supplementation of MS medium with BA, kinetin, CCC, or daminozide decreased content in shoot cultures as compared to the control, with the exception of CCC at 6.3 μM. Artemisinin content (percent dry weight) in this experiment did not correlate with shoot number (r = –0.198) but was highly correlated (r = 0.775**) with root number, indicating that although roots do not produce artemisinin, they may be involved in its synthesis. Maximum artemisinin was produced in hormone-free medium. Friable calli were obtained with a combination of BA (4.4 μM) and 2,4-D (4.5 μM), but artemisinin was absent from calli, cells, and cell culture media. Biseriate glandular trichomes are present in leaves and flowers from the earliest developmental stages. Artemisinin was extracted by a 1-min dip in organic solvents from flowers and leaves, indicating that the biseriate glandular trichomes of *A. annua* are the probable site of accumulation or sequestration of artemisinin.

601

Chemical or Air Pruning Influences Containerized Roots of Carambola, Longan, and Mango Seedlings

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Carambola, longan, and mango seedlings were planted in containers coated with paint containing up to 200 ppm $CuCO_3$, and carambola and mango seedlings were planted in containers designed to provide air pruning of roots. Some plants were bare-rooted following a period of growth, and the roots were dried to a constant weight. The remainder of the plants were removed from the containers and planted in silica sand with container medium intact. The new root growth was determined after 3 to 6 months by carefully washing away the sand then removing the exposed roots. Chemical treatment of containers increased total root growth during container production and new root growth after removal from the container for longans. In contrast, chemical treatment did not influence roots of mango or carambola. Air pruning, however, increased the percentage of roots in the upper half of the container and the new root growth following removal from the container for both of these species. No circling roots were visible growing along the sides or bottom of chemically treated containers for longan and air pruning containers for mango and carambola.

736

Induction of Roots on Jujube Softwood Cuttings Using *Agrobacterium rhizogenes*

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Trees of jujube (*Ziziphus jujuba*), particularly older ones, root with great difficulty. A greenhouse experiment was conducted to assess the effects of two strains of *Agrobacterium rhizogenes* (A4 and TR105) on softwood cuttings from two trees—a tree 10 years old not currently bearing flowers, which we called "juvenile" because it still exhibited many juvenile characteristics; and a tree ≈70 years old containing many flower buds, which we called "mature". The cuttings were collected on 11 May 1994 and trimmed to 7.5 cm. Both strain and source of cutting influenced inoculation success—TR105 was more responsive to *A. rhizogenes* than was A4 and the "juvenile" cuttings more responsive than "mature" cuttings. Strain TR105 was very effective in increasing rooting percentages and root number. "Juvenile" cuttings had better rooting percentages, greater root number, and greater root length than did "mature" cuttings. *Agrobacterium rhizogenes* exhibits great potential for rooting other difficult woody ornamental or fruit tree species as well.

740

In Vitro Root Formation of Derooted Jujube Seedlings Induced by *Agrobacterium rhizogenes*

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Jujube (*Ziziphus jujuba*) is a plant whose cuttings root with great difficulty. Several strains of *Agrobacterium rhizogenes* were tested on two segments (proximal and basal) of derooted jujube seedlings in the presence or absence of IBA for induction of roots in vitro. Strains of *A. rhizogenes* used were A4, A4pARC8, TR105, and R1000. Strain, segment of derooted seedling, and IBA influenced inoculation success. Strains A4pARC8 and TR105 were more infective than A4 and R1000. Basal segments were more responsive than proximal ones and 0.5 $mg \cdot liter^{-1}$ 1BA had a positive effect on inoculation success. *Agrobacterium rhizogenes* and IBA were very effective in promoting root formation, root number, root length, and early root emergence. They worked synergistically, but were effective independently as well. A4pARC8 and TR105 were more effective than strains A4 and R1000, and generally more effective than IBA. IBA was unable to eliminate the differential response of the two segments for individual strains.

744

Controlling Citrus Rootstock Sprouting in the Nursery Using Commercially Available NAA

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Tre-Hold, a commercially available sprout inhibitor containing ethylnaphthaleneacetate (NAA) for newly planted citrus trees in orchards was effective to prevent axillary bud growth on rootstock seedlings in the nursery. Tre-Hold applied at formulated concentration (1x), three-fourths (3/4x), and one-half (1/2x) to field-grown and container-grown greenhouse seedlings prevented sprouting. It was possible to control dormancy of individual buds without affecting adjacent buds. When applied to green citrus tissue, no phytotoxicity occurred. Full concentration of Tre-Hold was found to prevent scion bud healing of container-grown trees when the seedling was treated before budding. Application a few days before unwrapping and after the scion bud had healed did not affect bud healing or budling growth.

748

In Situ Prediction of Fresh and Dry Weight of Peach Fruit

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To estimate the effect of treatments or cultural practices over fruit dimensions on peach, such as fresh and dry weight and equatorial and polar diameters (FW, DW, ED and PD, respectively), the use of destructive samples are frequent. These variables are generally not included, due to the time-consuming and research costs involved. With the purpose to determine in situ the FW and DW of fruit of seedling peach trees, two cubic regression models (CRM) were fitted with 1241 and 1119 field observations of FW, DW, and ED. To determine DW, fruits were cut off immediately and dried at 70C for 24-h. These measurements were taken

during growing season of 1984 and 1985. At 2-week intervals, 12 samples were collected each year. Each sample consisted in harvesting randomly five fruits and around the middle part of trees. The CRM were fitted taking the mean of five fruits. FW and DW were used as dependent variables, while ED as independent variable. To validate both models, during the growing season of 1985, 11 samples (five fruits per sample) were taken again from other trees. The real and predicted values of FW and DW were analyzed by a linear regression model (IRM), to know the grade of adjustment between them. The CRM of both variables had significant fit (r^2 = 0.975 and 0.941 for FW and DW, respectively). In contrast, the highest variation coefficient was observed in DW (29.14%), compared with FW (13.4%). In both cubic models, error mean square was the lowest compared to other models. The linear relation between real and predicted values ha values of r^2 = 0.983 and 0.941 for FW and DW, respectively; while the variation coefficients were 9.59% (FW) and 17.32% (DW). The CRM's can be used in future seedling peach experimental works, to predict fruit weight after full bloom until harvest.

752

Inhibition of Polygalacturonase in Tomato Pericarp Tissue by Lysophosphatidylethanolamine: Implications in Fruit Shelf-life

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The pericarp tissue of red mature tomato (*Lycopersicon esculentum* cv. Gagliano) was used to exctract polygalacturonase (PG) enzyme. The technique for assaying PG activity involves measurement of released reducing groups that were linked together in pectin. Since the crude extract of PG from pericarp will contain considerable reducing groups, we found that repeated washings of the cell wall pulp removed much of the sugars and thus minimized the background absorbance without loss of PG activity. There is an inherent perplexity concerning the selection of blank for PG assay. This is because (i) the enzyme extract contains both the substrate (pectin) and product (free reducing groups) involved in the reaction; (ii) the color development with cyanoacetamide requires heating for 10 min. Thus, even though the reaction is terminated with borate buffer (pH 9.0) the breakdown of pectin continues chemically by heat; (iii) the absorbance from both pectin and enzyme together at zero time termination was always lower than the sum of absorbances from pectin alone and enzyme alone. This suggests that when together in the same tube, the enzyme appears to protect the pectin from physical breakdown during the period of 10 min. boil needed to develop color using the cyanoacetamide. Thus, the most appropriate blank is processing separately the solutions of enzyme alone and substrate pectin alone for color development and then adding the two absorbances. Using this improved assay we found that lysophosphatidylethanolamine (LPE) inhibited tomato PG activity. This inhibition appears to depend on the ripening stage of the fruit. Our results suggest that LPE is able to impart firmness to tomato fruit by reducing the PG activity, which in turn could protect the pectin/middle lamellae from enzymic breakdown. The effects of LPE on PG activity are distinct from those of Triton X-100 and lysophosphatidylcholine.

755

Proteins Associated with Germination of Cucumber at Various Temperatures

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Cucumber (*Cucumis sativus* L.) seed require soil temperature to be around 20C for efficient germination. This hinders early planting in cool soils. This study was conducted to determine how germinating seed of cucumber cultivars Earlipik 14 and Arkansas Little Leaf at 13.9, 15.6, and 20C in the dark affected protein formation. Seed were removed from moist chambers at 0, 12, 24, 48, 72, 84, 96, 120, and 168 h. Germination, defined as the radicle being at least 5 mm long, was determined at each time. Germinated and ungerminated seed was prepared for polyacrylamide gel electrophoresis. At 20C, 90% to 100% of seed had germinated by 48 h. At 15.6C, 20% to 50% of seed germinated by 168 h, and at 13.9C, ≈2% of seed had germinated by 168 h. For seed incubated at 20C, concentrations of proteins at 70.1 kDa decreased, while those at 37.4, 43.4, and 50 kDa increased after 24 h, which corresponded to formation and elongation of the majority of radicles. These changes were expressed later for seed germinated at 15.6 and 13.9C. Identification of the proteins is being attempted. The importance of these proteins in germination and early development will be discussed.

756

Nuclear Magnetic Resonance for Monitoring Carbon Metabolism in Sweet Corn

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Understanding carbon metabolism can provide insight into physiological processes regulating yield, senescence, and resistance to pathogens in sweet corn (*Zea mays* L.). This study was conducted to determine if nuclear magnetic resonance (NMR) spectroscopy could be used to monitor changes in carbon metabolism at various growth stages in the *shrunken-2* sweet corn cultivar Illini Gold. The 7th, 9th, and 11th stalk internodes were excised at midwhorl (V9), tassel emergence, 50% silking, and fresh-market harvest stages. The rind was removed and the sap expressed. Carbon-NMR spectroscopy was conducted with a 200.7 MHz machine on the expressed sap. From V9 through 50% silking, peaks in spectra were uniformly grouped from ≈61 to ≈104 ppm. At fresh-market stage, additional peaks were found in the spectra at ≈17 to ≈20 ppm, with the majority of peaks found from ≈57 to ≈104 ppm. The biological importance of these changes in carbon metabolism in sweet corn are not clear. Efforts are under way to identify the carbon-based compounds associated with the peaks.

760

Changes in Tahiti Lime (*Citrus latifolia* Tanaka) Micronutrient Composition Due to Different Rootstocks

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A better understanding of the effect of rootstocks on the nutritional level of citrus leaf would lead to more effective methods of controlling nutrient disorders. An experiment was conducted on 7-year-old Tahiti lime tree grown on nine rootstocks. Fifty 5-month-old leaves from nonfruiting shoots of the spring flush were collected from Tahiti lime by dividing tree canopy into three equal zones (top, center, and base), and the micronutrients were analyzed. The concentrations of Na, Mn, and Fe in the scion differed significantly among different rootstocks. The highest content of Na (2600 ppm), Mn (49.33 ppm), and Fe (118.6 ppm) were observed on Jatti Khatti, Rough Lemon (R.L.)-Arthur, and *Citrus volkameriana,* respectively, while the lowest content were on Rangpur Lime Na (1600 ppm), Rough Lemon M.P. Mn (30.67 ppm) and Kama Khatta Fe (85.67 ppm). The Zn and Cu content in scion leaves did not differ significantly among the different rootstocks.

149 POSTER SESSION 26
Food Science, International Horticulture, Marketing, & Economics/Cross-Commodity

802

Development of a Flavor Profile of 'Gala' Apples Using OSME Sensory Technique

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'Gala' is an early season apple variety that has a distinctive aroma and flavor. Studies were conducted to identify volatile compounds that contribute to 'Gala' aroma. 'Gala' apples were harvested at optimum maturity in a commercial orchard. Volatile compounds were trapped on activated charcoal using dynamic headspace sampling and eluted with carbon disulfide. Odor profiles of the samples were determined using OSME, a method developed at Oregon State Univ. that combines gas chromatography and olfactometry with a time-intensity scale. Three trained panelists described odor characteristics of compounds eluted through a sniff port of a gas chromatograph. Compounds were identified by matching Kovats indices with those of standards and also by mass spectrometry. Butyl acetate, 2-methyl butyl acetate, and pentyl acetate were characteristic of 'Gala' apple. Methyl-2-methyl butyrate, ethyl-2-methyl butyrate, pentyl acetate, and butyl-2-methyl butyrate carried apple-like descriptors.

806

Reduced Atmosphere Storage of Chinese Chestnuts

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Stored Chinese chestnuts (*Castanea molissima* Blume) are extremely susceptible to spoilage by molds. This research was initiated to determine if storage at reduced atmospheres in conjunction with vacuum-infused mycostatic chemicals could reduce mold growth and enhance the quality of stored nuts. Nuts were treated with two levels of buffered sodium propionate and two levels of buffered sodium benzoate and stored either at atmospheric pressure or at 0.17 atmosphere (4.0% O_2) and minimal gas circulation. Relative humidity was maintained at 88%. Mold counts, weight, texture, and moisture content were recorded every 20 days. Mold counts of the chemically treated nuts stored at atmospheric pressure did not differ from untreated nuts. Storage at reduced atmosphere in conjunction with chemical treatment inhibited mold growth, reduced weight loss, and preserved fresh quality and viability of the nuts.

810

Electron and Light Microscopy Structure and Polysaccharide and Pectic Composition of Highbush and Rabbiteye Blueberries

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Rabbiteye (*Vaccinium ashei*) blueberries were harvested in Mississippi and highbush (*V. corymbosum*) blueberries were harvested in Michigan. The berries were rapidly cooled to 5C after harvest and kept at this temperature for 48 h before being analyzed as fresh fruit or freezing for later analyses. Microstructural (light and scanning/transmission electron microscopy) and chemical (pectins, cellulose, hemicellulose, lignin, and fiber) evaluations were performed to evaluate differences between the two types of blueberries. Scanning electron micrographs showed that rabbiteye spp. have thicker epidermal and subepidermal cells than highbush spp. Transmission electron micrographs also showed that rabbiteye spp. have a thicker, more uniform cuticle layer than highbush spp. Rabbiteye spp. contained higher fiber and complex polysaccharides than highbush spp. Although, there were no differences in total pectins, rabbiteye berries had lower water soluble pectins and oxalate soluble pectins than highbush blueberries. Differences in polysaccharides and pectins between highbush and rabbiteye berries indicate that their cell wall components differ. These differences, along with the variation in subepidermal, epidermal and cuticle layers of the skin, provide valuable information to explain the textural differences between rabbiteye and highbush blueberries.

814

Inhibitory Effect of Fresh-cut Spinach on *Listeria monocytogenes*

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Studies.were undertaken to investigate the cause of the bacteriostatic activity of spinach leaves against *Listeria monocytogenes. Listeria monocytogenes* was inoculated at the concentration 104 cells/ml in raw, autoclaved and vacuum filtration sterilized spinach macerates as well as in tryptic soy broth used as control. The concentrations after 24 h at 28C were 10^5, 5 x $l0^6$ and 10^5 cells/ml in respective spinach macerates and 4 x $l0^8$ cells/ml in tryptic soy broth. The anti-Listeria activity was still present in spinach macerates sterilized by vacuum filtration but strongly reduced in autoclaved macerates. Serial dilutions of freeze-dried spinach were tested on the growth of *Listeria monocytogenes* in tryptic soy broth. The minimum concentration for maximum inhibition was 10 mg$\cdot$ml^{-1}. The growth of *Listeria monocytogenes* in tryptic soy broth in mixed cultures with different microbial species isolated from spinach was not inhibited. In conclusion, the bacteriostatic activity against *Listeria monocytogenes* might be due to antimicrobial compounds present in spinach leaves.

818

Cleaning and Total Glycoalkaloid Reduction in 'Great Northern' Beans

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Nightshades (*Solanum* spp.) are weeds that result in production losses of dry beans (*Phaseolus vulgaris*) due to interference and to staining of beans with nightshade berry juice at harvest. A method of cleaning beans stained with the juice of nightshade berries was developed. The method involved fluidizing the beans and gently abrading surface soil from the seedcoat. The beans were analyzed for total glycoalkaloid content, color, and suitability for processing. The total glycoalkaloid content was reduced from 26 mg/100 g to undetectable levels by cleaning. The cleaned beans had higher total light reflectance than unstained beans, but did not differ in Hunter Lab 'a' or 'b' values. Cleaned beans were not significantly different from unstained beans in quality when processed.

822

Description of the Main Cactus Pear Varieties

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Cactus pear production has been an outstanding activity during the last two decades in central Mexico. It has been devoted mainly to fresh consumption for the national market and for exporting to the USA to a lesser extent. Official statistics report ≈200,000 ton of fresh fruit entering the market every year from June to September. Such a volume is supported on a limited stock of varieties that were originally selected by growers. They were first cultivated in backyards and now as commercial orchards under rainfed conditions. With the exception of 'Reyna', there are no formal descriptions of such varieties. This information will be valuable to growers and could provide a background to define breeding goals and strategies. Data was collected in 1992–94 from 12 of the most important cactus pear varieties in central Mexico. The following traits related with fruit quality we registered: fruit weight and color, peel thickness, seed number, and weight and soluble solids. Average fruit size ranged from only 679 in 'Charola' to more than 200 g in 'Cristalina' with 2.8 and 5.6 g of seeds/fruit, respectively. Commercially, white fleshed fruit is highly appreciated, but there is a wide range from yellow and orange to deep red. Edible portion ranges from 46% in 'Cardona' to 64% in 'Centenario', while percent soluble solids showed less variability (13.2–15–9), which seems to be strongly influenced by light and temperature at harvest.

826

Expedition for Cucurbit Germplasm Exchange with China

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Cucumber (*Cucumis sativus* L.), melon (*Cucumis melo* L.), watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai], and luffa (*Luffa aegyptiaca* Mill) accessions were exchanged between scientists of the United States and the People's Republic of China. Exchanges were made during a July 1994 visit of cucurbit research institutions in Shanghai, ZhengZhou, Yangling, Urumqi, Turpan, ChiangJi City, Tianjin, and Beijing. The trip was coordinated by the Office of International Cooperation and Development, USDA. Chinese scientists received elite American accessions with useful traits, and the American scientists received classic accessions that will be preserved for use in the future by interested researchers. Accessions to be included in the USDA germplasm collection were 50 cucumbers, 30 melons, 51 watermelons, and 15 luffas. As a result of the visit, cucurbit scientists in the two countries learned about the programs of their counterparts, and are planning cooperative research for the future.

830

Yield of Three Cultivars of Muskmelon Growth on Transparent Mulch and Floating Rowcover in a Tropical Region

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Muskmelon (*Cucumis melo* L.) is the major cucurbit crop in the Colima state, Mexico. The use transparent plastic mulch continues to increase in that region for high production technology systems of muskmelon, and more recently floating rowcovers were introduced to protect cucurbits from insects (direct pests or vector of viruses) and to increase yield of cucurbit crops. During 1993, yield was evaluated of three cultivars of muskmelon ('Crushier', 'Laguna', and 'Durango') growing on transparent polyethylene mulch alone or with floating rowcover. The cultivar Crushier showed the higher yield 40 ton/ha (77% for export market), followed by 'Durango' with 28.5 ton (77% for export quality) and 'Laguna' with about 23 ton (only 40% of export fruit). There was no significant difference in yield between cultivar growth on transparent mulch plots alone and combined with floating rowcover. Also, floating rowcover excluded (until perfect flowering)

beetles leafminers, sweetpotato whitefly, and aphids, reducing the use of insecticide by 50%.

834

A Survey of Chinese Plants of Potential Ornamental Value for the Southeastern United States

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China, E.H. Wilson's "Mother of Gardens", is a large untouched resource of ornamental plants to this day. Southeastern gardens and arboreta teem with plants from China, which boasts the most diverse temperate flora in the world with more than 30,000 species described. Because of China's unique geography, climate, and floristic similarities to the southeastern United States, many of these ornamental plants should be adaptable. Based on studies of the phytogeography, floristics, history of plan; hunting, and performance of plants already introduced into cultivation from central and southeastern China, ≈500 potentially "new" species of Chinese woody plants are presented for ornamental evaluation. Characterization of the species' geography and climatic preferences in China will allow horticulturists to more accurately predict the species' performance throughout the Southeast. Zone maps exist for the United States and China that equate geographic areas on a temperature basis. However, these zone maps do not reflect the wide microclimatic differences (such as those contributed by elevation) that occur in the climatic zones. The results of this survey should enhance interest in the wonderful diversity of Chinese plants. Maps of areas already explored in the past (George Forrest, Ernest H. Wilson, and other contemporary explorers) as well as maps of suggested areas which have not been fully botanized are presented for review.

838

Nutritional Contribution of Home Gardens in Rural Areas of South Sumatra, Indonesia

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Based on their land physical conditions, house yards in rural areas of South Sumatra can be classified into six major types. Home garden models for each type of house yard had been developed. The objective of this study was to evaluate contributions of the applied models in fulfilling nutritional requirements of rural families in South Sumatra. Results of the study indicated that home gardens could contribute only <12% of protein, <10% of minerals, and <25% of vitamin B required by the families. However, of 40 villages studied, ≈20% and 34% of the families could fully received their vitamins A and C, respectively, by consuming crops produced at home gardens. Low contribution of home gardens on protein, minerals, and vitamin B was mainly related to small acreage, low fertility status of the land, and kind of crops grown. Major sources of vitamins A and C were fruits and vegetables.

842

Horticultural Crops Grown at Home Gardens in Rural Areas of South Sumatra, Indonesia

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A survey has been conducted to evaluate kinds of horticultural crops grown at home gardens at 40 villages in South Sumatra Province. The villages were purposely selected to represent all geomorphological regions of the province, from highland (>1400 m above sea level) to tidal swamp along the coastal. Ten home gardens were randomly selected at each village. Most common horticultural crops found at home gardens were fruits crops such as banana, pineapple, and soursop. Surprisingly, vegetable crops were rarely (<22.0%) found at home gardens. Based on Sorenson's similarity index, it can be concluded that kinds of fruit crops grown were similar at most villages surveys, except for those at altitudes higher than 1000 m above sea level. Average density of perennial fruit tress was 4.6 trees/100 m^2, with a range from 1.7 to 10.9 trees/100 m^2.

846

Comparison of Chromometer Readings and Sensory Evaluations on Plant Color and Quality

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Plant nutrient treatment differences typically are identified through the use of plant height, leaf quantity, leaf area, and dry weight. Plant color differences may be determined quantitatively, by chromometer, or qualitatively, by sensory evaluations. Chromometer readings are easy an unbiased, however, overall plant quality must be determined by sensory evaluation. In this report, the two evaluation methods are compared. Poinsettias were grown in varying nutrient levels to flowering Chromometer readings were taken on one green leaf and one bract leaf of each flowering plant. Two sensory panels composed of commercial growers/retailers (or trained panel) and consumers, evaluated the mature plants into "Florist", "Saleable", or "Non-Saleable" grades. Chromometer and consumer evaluation results were comparable. The trained panel evaluations identified a more specific area of plan acceptance. The chromometer identified only color difference, whereas, the trained panel identified color and plant quality differences. The chromometer and trained panel evaluations, when used together, give complete understanding of treatment effects on quality.

850

An Evaluation of Focus Groups as a Technique to Determine the Market Potential for Wildflower Sod

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Two focus group sessions were conducted to determine the market potential for a new horticultural product, wildflower sod. One session included homeowners with suburban lots and an interest in wildflowers. Another session included landscape professionals, property managers, and garden center operators. Participants viewed a slide presentation about the uses of wildflowers and wildflower sod; a videotape illustrating wildflower sod installation; and a demonstration plot with wildflower sod planted at different spacings (solid, 50%, 25%, or plugs at 1", 18", or 24" centers) and at different times of year (fall, spring). The discussion was conducted by an unbiased facilitator. Participants cited the instant effect of wildflower sod as a major advantage. The price was viewed as acceptable for small areas, especially if sod was broken apart and spaced as plugs. Comments from participants were also used to develop an ideal product description and a marketing plan.

854

Gender Resource Utilization in Integrated Postharvest System for Citrus Fruits

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Integrated postharvest system comprising the fresh-market and juice processing from citrus fruits was the model system selected to evaluate gender participation in fruit agribusiness in Nigeria. This was in realization of the role of women in family support and food security. Results showed 60% of the labor force engaged in citrus processing and fresh fruit marketing are women. Fruit retailing involves partial processing through peeling and short-term modified-atmosphere packaging, while key unit operations of processing cover juice production, handling, and quality control. Retail activities attract higher income relative to factory work. Implications of seasonality in fruit supply in terms of income generation, employment, rural development, and strategies to empower the gender for greater productivity are discussed in the presentation.

171 POSTER SESSION 27
Sustainable Agriculture

804

Chemical and Physical Characteristics of Composts Derived from Waxed Corrugated Cardboard and Other Organic Wastes

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Composting of organic wastes to use as soil amendments or in potting substrates offers great potential for diversion of these wastes from landfills. The chemical and physical characteristics of 12 composts containing (by volume) spent mushroom substrate (50%), waste waxed corrugated cardboard (WCC, 0%, 25% or 50%), and/or pulverized wood wastes (PWW, 50%, 25%, or 0%) were measured during two separate windrow composting periods (14 to 18 weeks). Supple-

mental N was added to some of the composts in the form of poultry manure and/or soybean processing wastes. During the first 8 to 10 weeks, composts containing 50% WCC tended to reach and maintain higher temperatures, but subsequently cooled more rapidly. Microbial activity (CO_2 evolution) also was initially higher in these composts but fell by week 12 to levels, comparable to composts containing 50% PWW. The paraffin wax in WCC-containing composts was degraded almost completely (>95%). Total N (1.2% to 1.6% DW), P (0.30% to 0.55%), and K (0.9% to 1.2%) concentrations were within, typical ranges but highest in composts containing 50% WCC. KCl-extractable NH_4-N (494 mg N/kg) and NO_3 + NO_2-N (281 mg N/kg) were highest and lowest, respectively, in composts containing 50% WCC. Electrical conductivity (4.5 to 8.5 $mS \cdot cm^{-1}$) and pH (7.5 to 8.5) were high in all composts and highest in composts with 50% WCC. Concentrations of phenolic compounds were highest in composts containing 50% WCC, manure, and soybean wastes. C:N ratios of all composts were within an acceptable range (18 to 23.1).

808

Effects of a Legume Winter Cover Crop and Tillage on Production and Nitrogen Nutrition of Sweet Corn

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A split-plot factorial experiment was conducted to examine effects of tillage and winter cover crops on sweet corn. Main plots received tillage or no tillage. Cover crops consisted of hairy vetch, winter rye, or a mix. Nitrogen treatments consisted of either adding or not adding NH_4NO_3 at recommended rates. No significant effects of tillage on sweet corn yields were detected, although yields with tillage were slightly greater. Following rye winter cover crops, adding NH_4NO_3 to corn significantly ($P \leq 0.05$) increased yields by 56% compared to treatments not receiving N. However, following vetch, corn yields obtained without N fertilization equaled those obtained with N fertilization following rye or vetch. It was concluded that 1) nontilled sweet corn was successful and 2) N_2 fixed by vetch was able to sustain sweet corn production completely and was equivalent to a minimum of 70 kg N/ha.

812

A Taste-test Comparison of Organic and Conventional Greenhouse Tomatoes

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'Caruso' tomatoes were grown in a glass greenhouse in Winter and early Spring 1991. All plants were grown in 16-liter nursery pots. Half the plants were grown in a conventional peat-lite medium (Profi-mix) and were fertilized with synthetic water-soluble fertilizer containing micronutrients and (in ppm) 187 N, 46 P, 278 K, 177 Ca, and 48 Mg. The other plants were grown in a potting medium composed of 1 mature compost (chicken manure and leaves) : 1 loam : 2 vermiculite (by volume); this medium was amended with 1.5 kg bone meal (2N–10P–0K) and 3 kg dolomitic lime/m^3. The "organic" treatment was fertilized with a fish emulsion solution containing (in ppm) 150 N, 13 P, and 25 K. The experiment was repeated in 1992 with 'Capello'. In both years, fruit were harvested around the half-ripe to three-quarters ripe stage. All insect control was with insecticidal soap and bio-control agents. A blind taste test was conducted on campus in both years. In 1991, of 70 participants, 73% preferred the "conventional" tomatoes, 20% preferred the organic tomatoes, and 7% expressed no preference. In 1992, of 105 participants, 67% preferred the "conventional" tomatoes, 24% preferred the organic tomatoes, and 10% expressed no preference.

816

Use of Paper De-inking Residues in Potato Production

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In 1991, a project was initiated in collaboration with the Daishowa paper company to characterize de-inking residues resulting from paper recycling in detail and to determine the value of this organic residue as an amendment to agricultural soils. Our objective was to determine the effects of field applications of de-inking residues on potato crop culture. In 1992, 1993, and 1994, experimental plots were established and maintained at the Horticultural Experimental Farm of Laval Univ. A factorial design was composed of four replications of four doses of de-inking residues (0, 15, 30, and 45 $t \cdot ha^{-1}$) combined with four doses of N (0, 45, 90, and 135 $kg \cdot ha^{-1}$). Treatments were applied to a total of 64 plots. The results indicate the importance of adjusting the fertilization to prevent the immobilization of N by the residues. In 1992, as a result of adding de-inking residues, potato yields were increased significantly when sufficient N fertilizer was added. However, significant decreases in yield were noted when a high level of de-inking residues was applied without any adjustment of the C:N ratio. In 1993, potato yields were reduced in treatments having a second application of residue at the highest doses (30 and 45 $t \cdot ha^{-1}$), even when additional N was provide. Interestingly, harvested tubers gave no indication of toxicity effects due to heavy metals or other contaminants. Results also will be discussed in terms of overall potato quality and the incidence of disease.

820

The Use of Rye as a Living Mulch to Control Weeds in Bell Pepper Production

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The possibility of using annual grain rye (*Secale cereale* L.) as a living mulch between rows of black plastic mulch was investigated. Rye was seeded immediately after plastic was laid and ≈30 days before transplanting bell pepper (*Capsicum annuum* L.) seedlings. Rye growth was controlled by postemergence herbicides and mowing or was left unmowed. These treatments were compared to a weedy control, cultivation, and standard preemergence herbicides for their effect on weed control and bell pepper yield. Within the rye treatments, the unmowed rye provided the best weed control and significantly decreased the number and size of weeds between crop rows. The rye cover crop also significantly reduced the yield of peppers. In both the mowed and unmowed rye treatments, total marketable yield was reduced 50% compared to clean cultivated and herbicide-treated plots. Further work is needed to minimize the competition between the living mulch and the crop.

824

Growth and Yield of Vegetables with Composted Yard Waste Soil Amendment

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Composted yard waste (CYW) soil applications at rates from 0 to 224 $t \cdot ha^{-1}$ and with or without preplant fertilizer were evaluated over a 3 years. In year 1, the applications were made in early March, with a succession of crops grown continuously until year 2. During year 2 the entire area was kept as clean fallow, but plot integrity was maintained. Soil samples were taken periodically for chemical analysis. In late March of year 3, a second application of CYW was overlaid on one half of each previously treated plot, and pole beans were grown. Nitrogen tie-up occurred only with the 224 $t \cdot ha^{-1}$ when no fertilizer was added during year 1 for all crops studied. Where fertilizer was added, no visual symptoms of deficiency occurred with any of the crops; however, with some crops, yields were reduced. CYW application in year 3 resulted in visual symptoms of N deficiency (extreme leaf yellowing) in pole beans along with yield reduction even when fertilizer was added. This was the result of immature CYW used in that year. CYW degradation occurred during the fallow period in year 2, as shown by decreasing organic matter levels in the soil. During year 3, pole bean yields were ≈4% higher where intermediate to high levels of CYW rates were used during year 1 but no additional during year 3 compared to the control plots. In general, CYW for vegetable production was useful when sufficient fertilizer was used to overcome the high initial C:N ratio.

828

Biosolids–Yard Trimming Composts Increases Bell Pepper (*Capsicum annuum* L.) and Cucumber (*Cucumis sativus* L.) Yields

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Composts may improve crop growth in sandy soils. A biosolids-yard trimming compost (C) was incorporated into sandy soil at 134 $t \cdot ha^{-1}$ (49.7% moisture) before applying polyethylene mulch. Fertilizer (F) was applied at 0%, 50%, and 100% of the grower's rate (71N–39P–44K $t \cdot ha^{-1}$ broadcast and 283N–278K $t \cdot ha^{-1}$ banded in bed centers). 'Elisa' pepper transplants were planted 20 Jan. 1994. Marketable fruit weights were 20, 31, and 32 $t \cdot ha^{-1}$ without C and 30, 35, and 32 $t \cdot ha^{-1}$ with C for 0%, 50%, and 100% F, respectively. Pepper fruit weights increased with increasing F rates and were higher in plots with C than without C.

Without removing mulch, 'Thunder' cucumbers were seeded on 26 Sept. 1994. Marketable fruit weights were similar at the three F levels, but were 23 and 27 t·ha^{-1} without and with C, respectively. One application of C significantly increased bell pepper yields and a subsequent cucumber crop.

832

Economic Analysis of Low-input and Conventional Vegetable Production Systems in Southern Georgia

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Research results are presented from a multi-year study on vegetable production in southern Georgia that compared two low-input production systems to the conventional rye cover crop technology. The low-input systems use beneficial insect principles as a substitute for conventional pesticide controls, but pesticides are used if needed. Preliminary results from the low-input systems using crimson and subterranean clovers indicate that crimson clover produces better yields and can "catch up" to the conventional rye system. The higher yields of the rye technology can be offset by the cost reductions associated with the low-input technologies. Production budgets were developed for 3 years of eggplant and 2 years of fresh-market tomato and bell pepper to reveal expected net returns under the low-input and conventional systems.

836

Alternative Strategies for Small Fruit Production: A Summary of a Northeast SARE Project

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Fourteen cooperators representing four universities and the USDA/ARS developed a 5-year program of research and education for small fruit production in the northeastern United States. The objectives were to develop and test alternative production practices for strawberries and raspberries, to analyze the economic feasibility of sustainable production practices, to evaluate grower acceptance of sustainable technology, and to deliver the knowledge based on this research to the farming public. Specific research efforts determined strawberry and raspberry cultivar susceptibility to insects and disease and the influence of various cultural practices on crop susceptibility to disease, insects, and weed competition. Farmers indicated a willingness to adopt new sustainable technologies, even if profits might be reduced. However, they were not willing to commit more management time to such technology. Information delivery channels included a newsletter, more than 150 public presentations, and more than 100 publications.

840

Sustainable Production of Native Aromatic and Medicinal Herbs in Cordoba Province, Argentina

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The province of Cordoba in central Argentina is naturally rich in aromatic and medicinal herbs that are in high demand as ingredients in teas and herbal medicines. Most of the herbs sold are harvested from natural populations, and this activity is a primary source of income for families in the Sierra de Cordoba region. As a result of over-collection and other poor harvesting practices, many native plant populations have been reduced in size or extirpated. The economic consequence of the gradual decline of this resource has been a loss of real income in rural areas coupled with a pattern of emigration from small towns to larger cities. PRODEMA is a collaborative effort by universities in Argentina and the United States, with the sponsorship of the Cordoba government, to domesticate and to market the most commercially important species. Horticultural research has focused on the development of propagation techniques and identification and selection of desirable chemotypes.

844

Scoring and Girdling Pretreatment of Sweetgum, Chinkapin Oak, and Hackberry Trees for Shitake Mushroon Production

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To determine if production of shiitake mushrooms [*Lentinus edodes* (Berk.) Pegler] could. be increased, sweetgums (*Liquidamber straciflua*) chinkapin oaks (*Quercus muehlenbergii*) and hackberries (*Celtis occidentalis*) were scored or girdled in May 1993. Scoring was done by removing a 3-cm-wide strip of bark in a spiral from around the tree so that the end was ≈5 cm below the starting point. Girdling was done similarly, forming a continuous ring. For each tree species, there were three replications of the three treatments. In May 1994, the trees were felled, cut into 100-cm sections, and the logs were inoculated with shiitake mushroom spawn. In Oct. 1994, when production began, 30% of the logs from scored oak trees produced a total of 1720 g of shiitake mushrooms; from the girdled oak trees 36% of the logs produced a total of 963 g; and 28% of logs from control trees produced 704 g. Although a higher percentage of scored and girdled sweetgum logs came into production, the yield of mushrooms from controls was equal to that of girdled and higher than that of the scored.

848

Compost Mulch, Canola Cover Crops, and Herbicides affect soil Fertility, Apple Tree Yield, and Nutrition

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Three orchard groundcover management systems (GMSs) were established in a newly planted apple (*Malus domestica* cvs. Liberty, Nova Easygro, and NY84828-12 on Malling 9 rootstock) orchard on a silty-clay loam soil (Aeric Ochraqualf). The GMSs were applied in 2-m-wide strips within tree rows as follows: 1) a 6-cm-thick mulch layer of composed manure, straw, sawdust, and vegetable plant wastes applied in May 1992 and 1994; 2) a "green manure" cover crop of canola (*Brassica campestris* cv. Humus) seeded in mid-August each year and tilled under the following May; and 3) Post-emergence applications of N-(phosphonomethyl) glycine (glyphosate) herbicide (2.0 kg a.i./ha) in mid-May and July each year. After 3 years of GMS treatments, apple tree growth and trunk cross-sectional area were similar in all three systems. Fruit yield and yield efficiency were greater in glyphosate and compost than in canola GMSs, and 'Liberty' was the most productive cultivar. Topsoil N, P, K, Ca, Mg, Zn, and organic matter content were all substantially greater in the compost GMS. Leaf N, K, and P concentrations were consistently greater in trees in compost plots; leaf Ca, Mg, Cu, and Zn concentrations were lower in compost GMS. Weed growth was rank and difficult to control in the compost mulch, but this GMS substantially enhanced orchard soil fertility.

852

Legume Ground Covers for Low-input Pecan Management

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Perennial legume ground covers were evaluated to supply N and increase beneficial arthropod densities in pecan orchards. Treatments were pure stands and a mixture of 'Kenland' red clover (*Trifolium pratense* L.) and 'Louisiana S-I' white clover (*Trifolium repense* L.). The control plot was a grass sod. Nitrogen was applied at 0 to 200 kg·ha^{-1} in 50-kg intervals to the trees in the grass plots, but no N was applied to the legume plots. Aphids and beneficial arthropods were monitored in legumes and pecan canopies. Beneficial arthropods monitored were Coccinellidae, Chrysopidae, *Nabis*, *Syrphid*, and spiders. The most abundant beneficial arthropods were spiders, Coccinellidae, Chrysopidae, and *Nabis* respectively. In pecan canopies, spiders, Coccinellidae, Chrysopidae were the most abundant. The legumes supplied ≤156 kg N/ha to the pecan trees.

856

Response of Association Vesicular–Arbuscular Mycorrhizal Fungi with *Citrus macrophylla* W. Rootstock

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Citrus macrophylla is an important citrus rootstock for Mexican lemon (*Citrus aurantifolia* S.). Citrus are highly dependent of vesicular–arbuscular mycorrhizal (VAM) fungi. Four *Glomus* species were screened for their symbiotic response with *C. macrophylla* . Seedlings were inoculated with VAM fungi in pots containing sterilized soil. After 3 and 4 months, plants were harvested. *Glomus fasciculatum* (following by *G. intraradices*) gave the greatest improvements in growth, resulting in larger plant height and higher shoot dry weight. *Glomus aggregatum, G. mosseae*, and control plants showed the lowest rates of growth. Plants inoculated with the first three species showed the highest percent of root length colonized. However *G. aggregatum* gave the highest values of visual den-

sity of endophyte in root and soil hyphae. Root colonization and soil hyphae were lowest in plants with *G. mosseae*.

861

Agroecological Study and Determination of Yield Potential of Garambullo (*Myrtillocactus geometrizans*) in Queretaro, Mexico

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The garambullo is a native cactus that grows wild in the semiarid region of central and northeastern Mexico. It is highly appreciated by local people for the quality of its fruits and as a pigment source for the food industry. However, there is no information available about its real production potential. The main objective of this work is to collect field data about tree density, phenology, and yield components of natural stands. Six plots (2000 m^2 each) were randomly selected where garambullo grows wild in southwestern Querétaro and the following data was collected: number and distance among trees, age distribution, blossom and harvest season, fruit weight and number/tree, fruit/areole, areoles/fruiting arm, arms/branch and branches per tree. Tree density and yield varied greatly among plots and trees, from less than 20 to 237 trees/ha, and from less than 100 to 10,000 fruits/tree. Average fruit weight was 0.97 g and mean yield/tree was 2.79 kg. Possibilities for increasing yield efficiency will be discussed.

865

Comparing Two Methods of Estimating the Population of Indigenous Rhizobia

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The growth pouch method and test-tube method were compared to determine to most probable number of indigenous rhizobia population on the island of Guam. Soil samples were collected from three locations, with soil types of Akina, Pulantat, and Guam cobbly clay. *Macroptilium atropurpureum* and *Leucaena leucocephala* were used as indicator plants of *Bradyrhizobium* spp. and *Rhizobium* spp., respectively. An advantage of the test-tube method is requiring less replenishment of N-free solution during the incubation period. The modified method is used in classrooms to demonstrate the phenomenon of biological N fixation by leguminous plants.

873

Effects of De-inking Sludge on soil Properties and Corn Growth

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The large amount of organic carbon content present in de-inking residues makes them attractive for use in agricultural soils as an organic soil amendment. Greenhouse bioessays were undertaken to evaluate the agronomic value of de-inking sludge (DS). It was incorporated in a sandy soil to study the effects of different rates of de-inking residue amendments and N fertilizer combinations on soil properties and growth of corn. Particular attention was given to trace element concentrations. In a split factorial design, three variables were investigated: harvest time (after 20, 40, and 60 days), application rates of DS (0, 35, 70, and 105 $t \cdot ha^{-1}$), and four N rates (0, 140, 280, and 420 $kg \cdot ha^{-1}$). Chemical analyses of the fresh residues did not indicate the presence of heavy metals at levels potentially toxic to the environment. Soil chemical properties were clearly improved following the incorporation of DS. For example, adding different amounts of DS had a significant impact on the pH, the cation exchange capacity, and soil moisture. In addition, salinity was not affected with DS application. Seed germination was high in all the treatments and was not significantly influenced by DS application. Moreover, results on vegetative growth indicated a good relationship between the C:N ratio and biomass production. The DS combined with supplemental fertilizer seems to have a positive effect on plant growth. Overall, these results suggest that the limiting factor in de-inking paper sludge valorization is the amount of N available to the plant. Also, no other toxic products were found that could be harmful to the environment.

1021

Cotton Gin Trash, Rice Hulls, and Poultry Litter as Soil Amendments in Mid-south Vegetables

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Soil fertility studies conducted in commercial vegetable fields to examine alternative uses of mid-south agricultural wastes as soil amendments included work with poultry litter, cotton gin trash, and rice hulls. Poultry litter applications ranging from 0.3 to 0.9 $Mg \cdot ha^{-1}$ resulted in significant increases in spinach, cabbage, turnip greens, and collard yields grown in soils damaged by precision leveling or in sandy soils with low organic matter; however, positive yield response to litter applied to undamaged soils was variable. Raw rice hulls applied at rates ranging from 2 to 44 $Mg \cdot ha^{-1}$ resulted in reduced cabbage yield. Trials with cotton gin trash and cover crops on yield of cabbage, broccoli, southern pea, snap bean, and cucumber indicate significant problems with weeds following use of raw gin trash. Composting alleviated most weed problems, but no yield response was apparent at composted gin trash rates ≤ 9.6 $Mg \cdot ha^{-1}$. High rates (60 $Mg \cdot ha^{-1}$) of composted gin trash on damaged soil significantly improved cabbage yield. There were increases in soil pH and Ca levels. Research was supported by a SAREIACE grant.

180 POSTER SESSION 28
Culture & Management/Woody Ornamentals

573

Weed Control Strategies for Field- and Container-grown Herbaceous Perennials

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Fourteen herbicides or herbicide combinations, a wood chip mulch, a chipped rubber tire mulch, and a newspaper mulch were evaluated for weed control efficacy and potential phytotoxicity using 12 species of herbaceous perennials under field-growing conditions. Nineteen herbicides or herbicide combinations were similarly evaluated under container-growing conditions using 11 species of herbaceous perennials. The effect of herbicide application time also was monitored through application of herbicides to dormant and actively growing plants. Herbicides and mulch treatments were compared to weeded and nonweeded controls. Herbicide phytotoxicity effects were dependent on the age and species of the herbaceous perennial and herbicide application timing. Herbicide injury was generally greater for newly established plants compared to established plants. Although injury was usually reduced when herbicides were applied to dormant plants, injury was sometimes greater when herbicides were applied in early spring compared to applications made in late spring after complete herbaceous perennial emergence. This effect resulted in injury to young shoots that had emerged before the earliest possible time that herbicides could be applied in early spring. A wood chip mulch provided the most effective weed control and highest quality plants under field growing conditions. Several of the herbicides evaluated demonstrated potential for weed control in both field and container herbaceous perennial production systems and landscape plantings.

582

Growth and Nutrient Status of Containerized Shrubs Grown in Composts Containing Waxed Corrugated Cardboard and Other Organic Wastes

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Four containerized deciduous ornamental shrubs, [silverleaf dogwood (*Cornus alba* L. 'Argenteo-marginata'), red-osier dogwood (*Comus sericea* L.), ninebark (*Physocarpus opulifolius* L.), and deutzia (*Deutzia gracilis* L.)] were grown in 12 composts containing (by volume) spent mushroom substrate (50%), waxed corrugated cardboard (WCC; 0%, 25%, or 50%), and/or pulverized wood wastes (PWW; 50%, 25%, and 0%). Supplemental N as poultry manure and/or soybean wastes was added to some composts. Growth (shoot dry weight, average of two seasons) of all species was better or similar in most composts compared with two controls (100% pine bark and 80% pine bark : 15% peat : 5% sand). Deutzia grew best in 50% WCC composts and other species in 25% WCC composts. Porosity characteristics of the composts were acceptable for container growing (50% to 60% total; 25% to 30% aeration). Total soluble salts were initially high and potentially phytotoxic, particularly in the 50% WCC composts but were quickly

leached and resulted in no injury to plants. There were no symptoms of nutrient deficiencies or toxicities in any of the species tested. Foliar nutrient (N, I P, K, Ca, Mg, Mn, Zn, and Fe) concentrations in all species were within normal ranges, except for low Mn and Fe concentrations in red-osier dogwood during the second season.

586

Shelters Improve Tree Establishment under Herbaceous Competition

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We investigated how shelters and competing herbaceous vegetation affected tree growth and water relations during establishment. A bunch-type forage grass was concurrently seeded around 1-year-old bigtooth maple (*Acer grandidentatum*) and gambel oak (*Quercus gambelii*) planted in a silt loam field soil. During the second year following planting, irrigation was withheld, and midday water potential was measured twice to determine differences in water stress. At the end of the season, we measured total survival, elongative growth, and leaf area, as well as root growth of trees without competition. In the presence of competing vegetation, trees in shelters were less water stressed by –1.0 MPa than those without shelters. All maples without shelters and with competition died, and oak survival was 28%. Survival of both species in shelters was 86%. All trees without competing vegetation survived, but shelters affected maples differently than oaks. Maples without shelters had multiple stems that resulted in less shoot elongation and coarse roots but higher leaf area than those in shelters, and there were no differences in midday water potential. By contrast leaf area, elongation, and root growth of oaks in shelters were not different from those without shelters, but water potential was less negative. Tree shelters mitigated the effects of competition during establishment, but overall growth in shelters varied with species as oaks did not grow as well as maples.

590

Chemical Pinching of Bougainvillea with Off-Shoot-O®

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The response of 'Barbara Karst' bougainvillea to the chemical pinching agent Off-Shoot-O® (OSO; methyl esters of fatty acids), was evaluated. Liners were transplanted 4 Apr. 1994 into 3.8-liter containers of soilless medium. OSO at 0 (+pruning), 7.8, 15.6, 31.2, 62.5, 125, and 250 ml·liter^{-1} was applied over the top on 24 May to 20 replications per OSO concentration and 10 replications per control. On 25 May, OSO was reapplied to 10 replications per OSO concentration. Treatments were applied using a compressed-air backpack sprayer that delivered 82 + 3 and 93 ±2 liter·ha^{-1} at 2.8 kg·cm^{-2} on 24 and 25 May, respectively. Crown phytotoxicity was recorded 1, 2, 7, and 13 days after the initial application on a scale of 0 = no injury to 10 = plant death. A growth index and number of stems <5, 5 to <10, 10 to <15, and >15 cm long were recorded 23 May and 7 July. The best overall response was to the 15.6 + 15.6 ml·liter^{-1} application, despite the slight but commercially acceptable foliar injury (mean rating = 2.3+0.2). This treatment was similar to the pruned control in growth and number of stems.

594

Recycling Irrigation Water in Nursery Production

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Overhead sprinkler systems in nurseries use large amount of water and fertilizers and generate runoff losses that may alter the quality of surface or subsurface water. Moreover, the cost associated with these losses is important. Water recycling may reduce that cost and the losses to the environment. Our objective was to evaluate the performance of two recycling systems (recycling and storing water in a tank and recycling solution through subirrigation on capillary mats) relative to a conventional overhead sprinkler system with no recycling. Two species (*Prunus* x *Cistena* and *Spirea japonica* 'Little Princess') and seven substrates were used on plots subject to these irrigation practices. Treatments were compared for the water balance and the plant growth. After the first season, preliminary results showed that water and nutrient consumption were 65% less for sprinkler irrigation with recycling and with subirrigation on capillary mats. Plant yield and soil water content were statistically the same for the three treatments.

599

Evaluation of Four Irrigation Systems for Containerized Ornamentals

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Containerized *Cotoneaster dammeri* 'Coral Beauty' and Forsythia 'Northern Gold' were grown in a 2 bark : 1 peat : 1 sand (by volume) medium containing 5 kg·m^{-3} Nutricote 16N–4.4P–8.1K, Type 140, under four irrigation regimes: drip (DR; 20 min/day; two periods), overhead (OV; 90 min/day; two periods), overhead pulse (OP; 28 min/day; four periods), and subirrigation (SU). Volumes of 0.33, 0.35, and 0.14 liters·day^{-1} were delivered to each container in the DR, OV, and OP systems, respectively. SU was supplied from a geotextile-covered sand bed. End-of-season dry weights of Cotoneaster and Forsythia were 41% and 55% greater, respectively, in SU-grown plants compared to their OV-irrigated counterparts. Differences in growth between the other three regimes were minor for both species. Pre-dawn and dusk water potentials did not differ between plants in the four regimes, but midday potentials were slightly lower in SU- and DI-irrigated plants. End-of-season foliar N and P content differed only slightly between irrigation treatments, but K levels were significantly higher in SU plants. The reasons for better growth under SU remain obscure but may be related to improved medium nutrient retention and improved fertilizer use efficiency under an irrigation regime in which water moves upwards from the pot base to top.

785

Effects of Some Growth Retardants on Shoot and Root Growth of Two Cool-season Turfgrasses

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Effects of mefluidide, paclobutrazol, and their mixture on shoot and root growth of perennial ryegrass (*Lolium perenne* L. 'Wendy') and creeping red fescue (*Festuca rubra* L. 'Dawson') were studied under container culture. Mefluidide applied alone or in combination with paclobutrazol caused significant reduction in shoot and root growth of perennial ryegrass and red fescue. These treatments also enhanced turf green color of both species and increased their root–shoot percentage, with no major effect on turf quality. Paclobutrazol applied alone reduced shoot height of perennial ryegrass and red fescue by 10% and 32%, respectively, and caused little reduction in their shoot weights, with no effect on turf quality and color. Although paclobutrazol applied alone reduced the root length and percentage of root–shoot dry weight of perennial ryegrass, it did not affect red fescue.

787

Development of Field-grown Wildflower Sod

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In a study examining the potential for production of a field grown wildflower sod, 29 annual and perennial wildflower species were evaluated. Species selection for the study was based on lack of a large taproot, adaptability to the southeastern climate, flowering period, and potential for surviving root undercutting. Species were individually seeded in 1-m^2 plots in Fall 1993 and Spring 1994 to determine an optimum planting time. In early Spring 1994, fall seeded plots were undercut at a 5 cm depth with a hand held sod cutter. Spring planted species were undercut in early summer. After undercutting, sod pieces were placed on clear plastic under overhead irrigation for 7 weeks then transplanted to prepared field sites. Ratings for flower appearance, root mat density, top growth vigor and fresh root weights were taken at the time of undercutting and after transplanting. Fall-planted species had a higher survival rate than spring-planted species. Species with the highest ratings and greatest increase in fresh root weights from the time of undercutting to transplanting were yarrow (*Achillea millefolium*), oxeye daisy (*Chrysanthemum leucanthemum*), lance-leaf coreopsis (*Coreopsis lanceolata*), plains coreopsis (*Coreopsis tinctoria*), blanketflower (*Gaillardia aristata*), lemon mint (*Monarda citriodora*), blackeyed Susan (*Rudbeckia hirta*), and moss verbena (*Verbena tenuisecta*).

789

Weed Control Strategies for Wildflower Plantings

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Several approaches can be taken to minimize weed intrusion of wildflower plantings. To suppress existing weed seeds, the primary and most important cul-

tural practice is proper seedbed preparation. Research has shown that short-term preemergent herbicides, multiple tillings, solarization, and fumigation can result in good weed control during the initial year of wildflower establishment. Other strategies include increased seeding rates, use of aggressive species, and selective herbicides.

791

Effects of Hydrosource on Growth of Ornamental Annuals in Landscape Beds

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Ornamental annuals were planted in field beds amended to a depth of 15 cm with 0, 98, 196, or 392 $g \cdot m^{-3}$ of Hydrosource (Western Polyacrylamide, Castle Rock, Colo.). Hydrosource is a sodium-based, cross-linked, polyacrylamide hydrogel. *Salvia splendens* 'Redtop' and *Catharanthus roseus* 'Peppermint Cooler' were planted on 3 June 1993 and sampled for dry shoot weight and growth index 6 and 12 weeks after planting. *Salvia splendens* 'Red Hot Sally' and *Begonia sempervirens* 'Vodka' were planted on 13 June 1994 in the same beds, with no additional amendments added, and were sampled for dry shoot weight and inflorescence weight 5 and 10 weeks after planting. Plants were irrigated as needed in both years until the first sampling date, and then irrigation ceased. For 1993, a dry experimental period, amending beds with Hydrosource increased dry weight and growth index of both annuals after 12 weeks. In 1994, a wet experimental period, Hydrosource increased shoot weight of plants after 5 weeks, but no differences existed among the weights of the plants after 12 weeks. The inflorescence weight increased with Hydrosource for salvia after 12 weeks. The data indicated that Hydrosource can increase growth of annuals during drought and have no detrimental effect on growth during a wet growing season.

793

Comparison of Near-infrared Reflectance Spectroscopy and Standard Laboratory Analysis of Turf Soil Profile

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The ability to predict moisture and organic matter contents as well as soil particle size distribution of a golf course turf media with the use of near infrared reflectance spectroscopy (NIRS) was investigated. This study compared a new quick test, NIRS, with the use of wet chemical analysis for the evaluation of different soil characteristics. Samples were taken from greens and fairways of central Pennsylvania golf courses and from two turfgrass research centers at The Pennsylvania State Univ. Fresh samples were vertically scanned by 1.27-cm increments, from 400 to 2500 nm, with a near infrared monochromator. Moisture and organic matter contents were evaluated in the laboratory. The pipette method was used to determine the particle size distribution. Correlations of 84% and higher were obtained for the sand, silt, and clay values as well as for the moisture and organic matter contents. NIRS analysis of soil characteristics could become a convenient, rapid, and inexpensive alternative to wet chemical analysis for golf course management.

795

Evaluation of Fibrous-rooted Begonia Cultivars for the Landscape in West-central Florida

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Fibrous-rooted begonia cultivars were evaluated for days to flower, flower size, flower color, leaf characteristics, plant dimensions and appearance during two seasons, Spring and Fall 1994. In spring, days from sowing to first flower among 62 cultivars ranged from 49 days for 'Ambassador Coral', 'Ambassador Soft Pink', 'Prelude Coral' and 'Varsity Rose' to 89 days for 'Olympia Red'. Flower diameter ranged from 2.8 cm for 'Gin' to 5.5 cm for 'Lotto Pink'. At 126 days after sowing, plant height ranged from 16.5 cm for 'Ambassador White' to 31.1 cm for 'Encore Light Pink'. Subjective ratings showed cultivars were different with respect to floriferousness. In fall, days from sowing to first flower among 69 cultivars ranged from 76 days for 'Atlanta White', 'Atlanta Pink' and 'Victory White' to 114 days for 'Olympia Red'. Flower diameter ranged from 2.7 cm for 'Roxy White' to 6.9 cm for 'Lotto Pink'. Plant height at 118 days after sowing ranged from 5.1 cm for 'Ambassador White' and 'Lotto Scarlet' to 19.7 cm for 'All Round Dark Rose/Dark Leaved'. Subjective ratings showed differences among the cultivars in appearance of foliage and floriferousness.

797

Soil Water, NH_4, and NO_3 Retention in Low-maintenance Annual Landscape Beds Amended with a Hydophilic Polymer

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Two experiments were conducted in which a polyacrylamide gel (Hydrosource, Western Polyacrylamide) was incorporated into 56 x 38-cm, raised, concrete beds, 20 cm deep, with a drain pipe in the center of each bed. In Expt. 1, treatments included (in grams of i.a. N) 0, 186, 372, or 558 plus 0 or 366 g hydrogel/m^2, for a total of eight treatments. Each treatment was replicated three times. Petunia plants were transplanted into each plot for a total of 30 plants per treatment. Plants were kept well watered. Polymer incorporation had no effect on soil water retention, soil NO_3 or NH_4 retention, or plant growth. Expt. 2 included treatments of 0 or 186 g of ai N and 0 or 366 g hydrogel/m^2. Each treatment was replicated six times with 10 plants per replication, resulting in a total of 60 plants per treatment. Minimal irrigation was imposed on treatments. This study demonstrated that under suboptimal conditions of minimal irrigation and fertilization, polymer incorporation significantly increased soil moisture (17%), NH_4 retention (83%), and NO_3 retention where additional N was added (64%) compared to soils without polymer.

799

Soil Nutrient Dynamics following Composted De-inked Paper Sludges and Municipal Waste Compost Applications in Sod Production

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Increasing costs associated with the disposal of industrial and urban wastes necessitate the development of alternatives which are economical and environmentally safe. With >3000 ha in Quebec, sod production represents an interesting alternative for the use of new amendments, such as composted de-inked paper sludges and municipal waste compost. The objective of this trial was to evaluate the potential benefits of these amendments (nutrient retention in the root zone and chemical and physical soil benefits) and question potential environmental hazards. Chemical dynamics of N, P, K, micronutrients and heavy metals were examined over four soil layers (0 to 15, 15 to 30, 30 to 60, an >60 cm) on sandy and clay soil. Preliminary results for 1993 and 1994 indicate that nutrient concentrations in water extract are high following the establishment of sites. When sod is absent, high concentrations of lead (500 $mg \cdot kg^{-1}$ in urban compost) show only a slight trend to accumulate. Nevertheless, this new approach toward using industrial and urban composts seems to be adequate and economically attractive.

801

Influences of Shade Leaves on Ground Cover and Sward Height of Turfgrass

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Five experiments were performed from Jan. to Nov. 1993 with ornamental and sportive purpose turfgrass species [*Axonopus araujoi* Valls (nomen nudum); *A. compressus* var. compressus (Swartz) Beauv.; *A. barretoi* Valls (nomen nudum); *Stenotaphrum secundatum* (Walt) O. Kuntze; and *Zoysia matrella* (L.) Merr.] to evaluate percent ground cover and sward heights under four levels of shade. The design was in randomized blocks, with four treatments (0%, 50%, 75%, and 87% of shade) and four replications; the results were submitted to variance and regression analysis. All the species seemed to be sensitive to shade, increasing the sward heights and decreasing the percent ground cover at the highest shade levels; *S. secundatum* and *Z. matrella* were the most affected grasses, showing the greatest differences in characteristics evaluated among treatments.

805

Effect of Composted Paper Sludges and Municipal Waste Compost Amendments on the Growth of Kentucky Bluegrass

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In Quebec, commercial sod is produced on >3000 ha. Generally, ≈20 months are required to produce market-ready sod. When conditions are suitable, harvest of marketable sod is possible within a year. However, intensive management may

result in soil compaction and a reduction of the organic matter content. Considering the increasing amount of amendment available, sod production fields could be interesting for their disposal. In this study, visual quality and sod root growth was examined following an application of an organic amendment at 50, 100, and 150 $t \cdot ha^{-1}$, incorporated to depth of 6 or 20 cm. Plots established on a sandy soil receiving organic amendments had higher visual quality ratings. Bulk density was significantly reduced following compost or paper sludge application to a heavy soil. The shearing strength required to tear sod amended with compost was significantly higher in comparison with control and paper sludge treatments.

813

Evaluation of the Efficiency of Winter Protections against Winter Damage on *Poa annua* Golf Greens

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Extensive winterkill of golf greens is a major problem in northern climates. In this study, the efficiency of several protective covering materials used to shelter *Poa annua* golf greens from winter damages was evaluated over 2 years. The bioclimatological environment under these protective covers was studied at crown level and at 5, 10, and 20 cm under the ground Treatments (permeable and impermeable covers, curled wood Excelsior mat, straw mulch protected by an impermeable cover, geotextile material with an impermeable cover, and air space under an impermeable cover) were compared to a control treatment without protection. Results indicate that temperature profile was strongly influenced by both winter protection covers and snow depth Temperatures at crown level were stable and just below 0C under plots covered with a significant amount of snow. However, temperatures varied considerably, when snow cover was <15 cm. Snow thermal conductivity was increased by periods of rain during the winter. Impermeable covers minimized the negative effect of this change in the insulation properties of the snow cover by limiting temperature fluctuations at the crown level. Temperature profiles under permeable covers were similar to profiles observed on control plots. Temperature profiles were comparable for 5 and 10 cm air space treatments and were not significantly different when compared to impermeable covers spread directly on the turf. Straw with an impermeable cover and Excelsior mats maintained crown level temperatures at >0C and the incidence of disease was higher under these highly insulative materials.

837

Post-transplant Effects of Mechanical and Chemical Correction of Circling Roots on Shumard Oak

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Shumard oak (*Quercus shumardii* Buckl.) were grown in 2.3-liter (#1) containers painted on interior surfaces with Spin Out™ (100 g $Cu(OH)_2$/liter, or not. Seedlings were transplanted to the field and root observation boxes in June and October. The effects of two mechanical root-pruning techniques, traditional (cutting roots on exterior rootball surfaces) and butterfly pruning (splitting and splaying the rootball apart), to correct circling roots were compared with Spin Out-treated seedlings. Only the Spin Out-treated seedlings and fall-transplanted nonpruned controls had a net increase in height and caliper after 2 years in the field. Few roots >1.5 mm in diameter were severed in June with mechanical pruning techniques, while butterfly pruning severed roots up to 8.5 mm in diameter in October. Root regeneration shifted from predominantly small roots ≤0.5 mm in diameter in June to roots of between 0.5 and 1.5 mm in diameter in October. Spin Out-treated seedlings regenerated substantially more roots with diameters <1.0 mm at both transplant times. While midday water potentials were similar among treatments, Spin Out-treated seedlings had the least negative predawn water potentials, suggesting better recovery from midday water stress, particularly following October transplanting.

181 POSTER SESSION 29
Stress Physiology/Cross-Commodity

803

Wound-induced Free-radical Formation in Corn Seedlings

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Recent studies performed at the Univ. of Sheffield (Sheffield, England) have established a correlation between the onset of senescence and the loss of viability in plants with a development of stable free-radicals that can be observed by Electron Paramagnetic Resonance (EPR) spectroscopy. We explored the possibility of free-radical formation following root injury of corn seedlings (*Zea mays* L.). Free radical signals were detected by EPR spectroscopy at 9.5 GHz. In all cases, we observed a single-line free-radical signal (g value ≈2.004) superimposed with six-line EPR spectrum from Mn_2 + ions naturally present in the plant tissues. We determined a consistent increase in the intensity of single-line EPR signal after inducing root injury. This signal presumably is attributed to a quinone-derived radical and, as speculated, is associated with stressed respiratory transport chains. Based on our results, we suggest that free-radical reactions can be induced by root injury. Furthermore, an appearance of free-radical signal in the root may serve as an indication of a stress, natural and induced. If the precursors of observed free-radical signal can be determined, this will provide better insight on free-radical processes in plants followed by an injury. This work used the resources of the Illinois EPR Research Center (NIH P4 1 -RR0 1811).

807

In Vitro Effects of Formaldehyde on Douglas Fir Pollen

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There is increasing interest in using methanol and other alcohol fuels as an alternative energy source in the United States and developing nations. However, methanol-fueled vehicles have higher direct emissions of formaldehyde (HCHO) than gasoline-fueled vehicles, which has led to concern about increases in atmospheric concentration of HCHO. Formaldehyde at concentrations of 300, 600, 900, and 1200 μM reduced germination of hydrated Douglas-fir (*Pseudotsuga menziesii*) pollen in vitro. HCHO concentrations and pH in media containing pollen decreased during the 25-h incubation, with decreases proportional to HCHO concentration. This effect was not seen with heat-killed pollen, which suggests a detoxification mechanism. Ion leakage (measured as electrical conductivity) of pollen increased within 20 h in all HCHO treatments compared to controls. Stress also was indicated by TTC staining, which also decreased after HCHO treatment compared to controls.

809

Recovery from "Near-lethal" Stress by Soaking Plant Tissue in Water

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Previously, we reported that plant recovery from "near-lethal" (NL) (sublethal) stresses depended on stage of development and poststress environment (PSE). Dormant red-osier dogwood (*Cornus sericea*) plants exposed to NL heat, freezing, and hydrogen cyanamide either died or were severely injured when stored at 0C or recovered at 23C and nautral condition. Exposure of dormant stem tissues of red oak (*Quercus rubra*), paper birch (*Betula papyrifera*) and European mountain ash (*Sorbus aucuparia*), to heat stress also resulted in higher ion leakage when they were stored at 0C PSE for 3 weeks. Soaking NL-heat-stressed (49C for 1 hour) stem tissue of red-osier dogwood in double distilled water for 48 hours before incubating at 0C PSE for 2 and 12 weeks resulted in lower ion leakage and 80% tissue survival. NL-stressed tissue had higher sodium and similar potassium leakage at 0C PSE. At 23C, PSE NL stress had no effect on leakage of these specific ion.

811

Photoinhibition and Iron Deficiency in Mango

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Photoinhibition (PI; light stress) was studied in leaves of 3-year-old, potted, mango plants, following changes in chlorophyll fluorescence characteristics. Iron deficiency was induced by calcareous soil mix. It was found that during summer days, the photochemical quantum yield (measured as Fv : Fm) was reduced by 15% to 30% in sun-exposed leaves by noon (under 2000 $\mu mol \cdot m^{-2} \cdot s^{-1}$). This apparent PI was mostly recovered by the next day. In Fe-deficient plants, the reversible PI was enhanced further. In addition, Fe-deficiency increased the "I" phase (i.e., the Q_B-nonreducing centers) and the non-photochemical quenching (q^N) and reduced the photochemical quenching (q^P). Photosynthesis rates in the deficient plants were half the control rates. Overnight chilling at 7C, which by itself did not affect the Fv : Fm ratio much, dramatically increased the susceptibility of the plants to photodamage on the following day (indicated by fluorescence and gas exchange assays). This postchilling PI was mostly irreversible but could slowly (within about 1 week) be recovered in a thermostated greenhouse. These results agree with our observations of field-grown Fe-deficient mango trees that develop severe necrosis and leaf-drop each autumn in the Jordan Valley when the days are still sunny and warm and the nights turn cold.

815

Paclobutrazol Influences Salinity Responses of Peach and Olive

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We studied the effect of a 200-$mg \cdot liter^{-1}$ foliar application of paclobutrazol (PBZ) on growth and physiological responses of *Prunus persica* 'Nemaguard' (salt-sensitive) and *Olea europea* 'Manzanillo' (salt-tolerant) to salt stress. One-year-old trees were grown in 3 sand : 3 field soil : 4 pine bark media in 20-cm pots in a greenhouse and were irrigated with nutrient solutions adjusted with 0, 9,18, or 36 mmol NaCl for peach and 0, 36, 72, 108 mmol NaCl for olive. Dry weight, photosynthesis, and leaf conductance decreased with increasing salinity for both species. However, leaf expansion rate was unaffected by NaCl. PBZ reduced dry weight for peach only, but PBZ increased photosynthesis and reduced leaf expansion rate for both species. Relative water content was decreased by salt but increased by PBZ. PBZ reduced the foliar Na and Cl content in peach but not olive. Olive had less Na in leaves than peach at 36 mmol NaCl, accumulated less C in leaves in all salt treatments, and had higher foliar Na without symptom expression. PBZ may reduce salt stress in sensitive species like peach by reducing foliar Na and Cl accumulation but has less influence on the salinity response of the more salt-tolerant olive.

817

Influence of Ambient UV-A and UV-B on Growth, Chlorosis, and Flavonoid Content of Cucumber

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The influence of ambient UV radiation on growth, chlorosis, and flavonoid content was examined in four cultivars of cucumber ('Ashley', 'Poinsett', 'Marketmore', and 'Salad Bush'). Plants were grown from seed in UV exclusion chambers consisting of UV transmitting plexiglass (10% T, 285 nm), lined with 3- or 5-mil Llumar (10% T, 399 or 404 nm) to exclude UV-A and UV-B, 5-mil polyester (10%T, 319 nm) to exclude UVB, or cellulose acetate (10% T, 291 nm) to transmit UV-A and UV-B. Plants were grown in 15 cm plastic pots containing vermiculite and were fertilized daily with nutrient solution. Despite their differential sensitivity to supplemental UV-B radiation, all four cultivars responded similarly to the exclusion treatments. After 19 to 21 days, plants grown under ambient UV-A and UV-B generally had less stem, leaf, and root biomass and less total height and total leaf area than those grown under conditions in which UV-A and UV-B or only UV-B was excluded. Flavonoid content, leaf number, and floral development were unaffected by UV. These findings demonstrate the extreme sensitivity of cucumber to current levels of solar UV radiation.

819

Nuclear Magnetic Resonance Imaging of Grape Buds during the Photoperiodic Induction of Dormancy

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Changes in water status have been associated with various stages of dormancy and freezing tolerance in woody perennials. Recent studies in apple indicate that changes in the state (bound vs. free) of bud water are strongly correlated with the end of dormancy. In this study nuclear magnetic resonance imaging (NMRI) was used to monitor changes in the state of bud water during the photoperiodic induction of endo-dormancy in *Vitis riparia*. Bud water status was monitored using proton relaxation times from T1 and T2 images determined at 2, 4, and 6 weeks of long (LD) or short (SD) photoperiod treatments. Bud dormancy was determined by monitoring budbreak in plants defoliated after photoperiod treatments. NMRI allowed nondestructive monitoring of changes in tissue water state. T1 and T2 maps indicated changes in the state of the water in bud and stem tissues during the 6 weeks of treatment. Differences in relaxation times for nondormant and dormancy-induced (reversible) buds were not clear. However, T2 relaxation times were lower in the dormant buds than in the nondormant buds.

823

Cold Hardiness of Floral Buds in Three Southern Highbush Blueberry (*Vaccinium coymbosum* x *V. Darrowi*) Cultivars

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Late spring frosts are a major concern to blueberry growers in the southeastern United States. Cold hardiness of flower buds (stages 4 to 6) was evaluated in three southern highbush blueberry cultivars ('Cooper', 'O'Neal', and 'Gulfcoast'). Differential thermal analysis (DTA) and tissue browning tests revealed that the critical temperature and ovary damage occurred at –11C in 'Cooper', –12C in 'O'Neal', and –13C in 'Gulfcoast'.

829

Cloning of Mannose 6-phosphate Reductase from Celery.

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In celery, photosynthetic carbon partitioning between mannitol and sucrose is highly dependent on developmental (leaf age) and environmental (salt stress) factors. Mannose 6-phosphate reductase (M6PR) mediates a key step in mannitol biosynthesis and may regulate partitioning between sucrose and mannitol. We have constructed a cDNA library and have isolated M6PR-specific clones. Before library construction, poly(A)$^+$ RNA, extracted from newly fully expanded leaves, was translated in vitro. A single polypeptide (35.1 kD), immunoprecipitated with M6PR-specific antisera, accounted for ≈5% of the total ^{35}S incorporated into TCA-precipitated products. Parity between the molecular masses of the immunoprecipitated product and authentic M6PR indicated minimal posttranslational modification. The unidirectional primary library, constructed in UniZap XR vector (Stratagene), consisted of 1.53 million plaque forming-units (pfus) of which <0.4% were nonrecombinant, as estimated by "blue/white"' screening. After a single amplification, ≈0.14% of the 200,000 pfus screened with M6PR-specific antisera were identified as putative M6PR clones. Following two further rounds of screening and in vivo excision of the pBluescript phagemids their identity as full length M6PR clones was confirmed as follows: 1) IPTG-induced expression of M6PR activity in crude extracts; 2) IPTG-induced expression of a polypeptide that specifically interacted with M6PR antisera and with identical mobility (on SDS gels) to authentic M6PR; 3) 100% sequence homology to an internal peptide from a tryptic digest of purified M6PR. Based on these criteria, we conclude that we successfully cloned M6PR. The sequence is similar to several reductases from both plants and animals including an aldose 6-phosphate reductase from apple. Supported by USDA-NRI grant 940-1439.

831

Chill-responsive Proteins in Blueberry: Are They Associated with Dormancy or Cold Acclimation?

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To survive winters, woody perennials of temperate zone must enter into

endodormancy. Resuming spring growth requires sufficient exposure to low temperature or chill units (CUs) in winter, referred to as chilling requirement (CR), which also plays a role in the development of freezing tolerance (cold acclimation; CA). Physiological studies on the breaking of dormancy have focused on identifying markers, such as appearance or disappearance of proteins in response to varying degrees of CU accumulation. However, whether these changes are associated with breaking dormancy or CA is not clear. We conducted a study, using greenhouse blueberry (*Vaccinium* section *Cyanococcus*) plants, to address this question Three blueberry cultivars ('Bluecrop', 'Tifblue', and 'Gulfcoast'), having CRs of ≈1200, 600, and 400 CUs, respectively, first were exposed to 4° for long enough to provide CUs equivalent to one-half of their respective CRs. This treatment resulted in CA. Plants were then transferred to 15C for 2 weeks (a treatment which should not negate CU accumulation but did result in deacclimation). Before and after each treatment cold hardiness (using a controlled freezing bath) and dormancy status (observe budbreak after placing shoots in water at 20C for 2 to 3 weeks) of floral buds were determined. Proteins were extracted from buds collected, simultaneously and separated by SDS-PAGE. To determine the association of dehydrin-like proteins with dormancy or CA, electroblots were probed with anti-dehydrin antibody. The relationship of protein and western blots data to cold acclimation and dormancy are presented.

833

CITPATH: Diagnostic and Hypertext Software for Fungal Diseases of Citrus Foliage and Fruit

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Fungal diseases have their greatest impact on citrus in Florida by reducing tree vigor, fruit yield, and quality. Given the complex etiology of these diseases, this software was developed to facilitate diagnosis of symptoms and to explain the dynamics of *Alternaria* brown spot of mandarins, greasy spot, melanose, *Phytophthora* brown rot, post-bloom fruit drop, and sour orange scab. CITPATH includes a diagnostic key to identify symptoms of the major fungal diseases of citrus foliage and fruit in Florida and a hypertext program containing a description and graphic display of symptoms, maps of geographic occurrence, diagrams of disease development, and management strategies. Users can also consult a list of citrus cultivars susceptible to specific diseases and a reciprocal list of diseases affecting specific cultivars. Chemical control methods are discussed briefly with reference to the current Florida Citrus Spray Guide, a hardcopy of which is included with the software purchase. Developed for commercial growers, county extension programs, citrus horticulture classes, and master gardeners, this software is available on CD-ROM disks containing other citrus databases and as a separate disk for MS-DOS-based computers.

835

Image Analysis Study of Aluminum Effects on Osmotic Behavior of Red Beet (*Beta vulgaris* L.) Protoplasts

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The hypothesis that Al^{3+} interferes with membrane biophysical properties has been tested. Plasma membrane expansion/contraction in protoplasts isolated from red beet was induced by decreasing or increasing the osmolarity of extracellular solutions. The percentage of lysed protoplasts was measured to characterize the effects of Al^{3+} on the ability of protoplasts to increase their plasma membrane surface area. In control solutions (800 mM sorbitol), 31.4% of protoplasts lysed following osmotic dilution from 1200 mM. Al^{3+} treatment (5 mM) decreased the proportion of lysed protoplasts by 7.7% and Ca^{2+} (5 mM) by 17% compared to control. Lanthanum (La^{3+}), however, proved to be the most efficient ion for protection against lysis (3.3%). Under hypertonic solutions, Al^{3+} treatment helped protoplasts maintain their roundness, diameter, and cross-sectional area compared to the control (1.5 M sorbitol), thus, altering the protoplasts "roundness" as determined by image analysis parameters. The results suggest that a decrease in the proportion of lysed protoplasts in the presence of Al^{3+} may be induced due to changes in membrane permeability to water.

839

The Effects of Salinity on *Hibiscus syriacus* and *H. hamabo* Seed Germination

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In this experiment, the effects of salinity from 0.0%, 0.5%, 1.0%, and 5.0 % NaCl on *Hibiscus syriacus* L. and *Hibiscus hamabo* Sieb. & Zucc. seed germination with various temperature and Ca treatments was investigated in petri dishes with 10 ml of distilled water or with the appropriate saline solution. At 11 days after treatment, the highest germination rate was obtained at 20C with *H. syriacus* and 25C with *H. hamabo* without NaCl and Ca treatments. At 25C, only *H. hamabo* seeds germinated with 1% NaCl, with dry and fresh weight increasing as Ca concentration increased. With 0.5% NaCl treatment, the germination rate of *H. hamabo* and *H. syriacus* increased as Ca concentrations (0.0, 13.35, and 133.5 mM) increased. Without NaCl treatments, hypocotyl and leaf length and width of *H. syriacus* were longer than those of *H. hamabo;* with NaCl treatments, the inverse was true.

841

Growth Effects of Uniconazole, Gibberellin, and Calcium on Salt Injuries of *Hibiscus syriacus* and *H. hamabo* seedlings

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Shoot length, leaf length and width, root length, and crown diameter were affected by 0.0-, 0.5-, 1.0-, and 5.0-mg·liter^{-1} uniconazole drench and 25- or 50-mg·liter^{-1} GA_3 spray but not significantly by 0.0%, 2.5%, and 5.0% NaCl. Leaf width of *H. syriacus* Sieb. & Zucc. was not affected and that of *H. syriacus* L. significantly decreased, as NaCl concentration increased. Effect of NaCl on *H. syriacus* leaf width was offset by treatment with uniconazole but not by GA_3 treatment. With 2.5% NaCl, dry weight of *H. hamabo* treated with uniconazole or GA_3 increased and that of treated *H. syriacus* decreased. With 5.0% NaCl, dry weight of both species decreased with uniconazole or GA_3. Calcium at 13.35 or 133.5 mM decreased the reduction of dry weight by NaCl treatment. The dry : fresh weight ratio of *H. hamabo* and *H. syriacus* treated with NaCl plus uniconazole was higher than that only treated with NaCl. GA_3 treatment with NaCl did not affect the dry : fresh weight ratio for either species

843

CD-ROM Image Analysis Used in Determining Disease Severity in Dogwoods under Physiological Stress

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CD-ROM technology, scanners, and image capture software have enabled an alternate approach to determining disease severity. When estimating disease damage, information on disease severity may be as important as information on disease incidence. Disease incidence is the proportion of leaves infected on each tree; disease severity is the number of lesions or amount of tissue damage per tree. The Mielke and Langdon scale was used to determine the incidence of dogwood anthracnose on dogwoods under physiological stress; the CD-ROM system was used to determine the severity of the disease. Dogwood seedlings were exposed to four shade and three water levels for 12 weeks. Leaf images were stored on a photo-CD for image analysis. Water availability at 100% water-holding capacity significantly increased disease severity on dogwood leaves inoculated in vitro. The system allowed detection of a significant effect of water availability on susceptibility of the leaf to dogwood anthracnose that was not detected when incidence of infection was evaluated on a whole-plant basis

847

Physiological Effects of Uniconazole, Gibberellin, and Calcium on Salt Injuries of *Hibiscus syriacus* and *H. hamabo* Seedlings

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Salt injury was induced by 5% (w/v) NaCl drenching on *Hibiscus hamabo* Sieb. & Zucc. and *H. syriacus* L. seedlings. Total chlorophyll content of *H. hamabo* was higher than that of *H. syriacus.* Uniconazole (0.0, 0.5, 1.0, and 5.0 mg·liter^{-1}) treatment increased and 25- or 50-mg·liter^{-1} GA_3 treatment decreased chlorophyll content of *H. hamabo.* Total chlorophyll content of *H. syriacus* was not

affected by uniconazole or GA_3. Total carbohydrate content of *H. syriacus* was more accumulated than that of *H. homabo.* Total carbohydrate content of *H. hamabo* was more decreased than that of *H. syriacus* by Ca (13.35 or 133.5 mM), uniconazole, or GA_3 in relation to total carbohydrate contents. Protein contents of *H. hamabo* were higher than those of *H. syriacus.* Uniconazole or GA_3 increased those of *H. hamabo* and decreased those of *H. syriacus*. Peroxidase activity of *H. hamabo* was higher than that of *H. syriacus.* Uniconazole decreased that of *H. hamabo* and increased that of *H. syriacus.* GA_3 or Ca (13.35 mM) treatment increased that of both species. ATPase activity of *H. hamabo* was higher than that of *H. syriacus*. Uniconazole (5 mg•liter^{-1}), GA_3, or Ca decreased that of *H. hamabo* increased that of *H. syriacus*.

851

A Zinc-binding Protein in Citrus with Homology to Plant Chitinases

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A 5-kDa zinc-binding protein (ZBP) accumulates in the phloem above the graft union in citrus trees affected by two citrus decline disorders, citrus blight and Macrophylla decline. Citrus blight and Macrophylla decline are decline disorders of unknown etiology. Citrus blight has historically been restricted to humid production regions, and Macrophylla decline occurs in arid regions. A causal agent has not been identified for either disorder. Levels of the 5 kDa ZBP are increased 2.5- and 1.5-fold, respectively, in the phloems above the graft union in trees with citrus blight and Macrophylla decline. The protein was purified from citrus phloem and a partial N-terminal sequence was obtained. The protein has homology to the cystein-rich chitin binding domain of several plant chitinases and hevein. Hevein and class I chitinases, which have this N-terminal chitin binding domain, have antifungal activity and antibacterial activity and are induced by wounding and several other stresses. Oligonucleotides corresponding to the greatest conserved region in the N-terminal domain of the ZBP were produced. They were used as primers for PCR reactions against a citrus leaf cDNA library. Four PCR products were obtained from these reactions. The products are being subcloned and sequenced. They will be used to probe the citrus cDNA library to obtain the cDNA clone for the 5 kDa ZBP.

182 POSTER SESSION 30
Education & Extension

764

Student Laboratory Exercise to Understand Air and Water Relations in Container Substrates

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The concepts of container water-holding capacity and air-filled porosity are important yet complicated for students interested in containerized crop production; however, both of these concepts can be observed and understood more completely if students develop a moisture retention curve. Our objectives were to describe an easy-to-construct and economical apparatus for creating a moisture retention curve and then to compare this curve with one generated by standard methods. The student method (column method) is constructed from plastic pipe cut into 5-cm sections. The sections of pipe are individually packed with a substrate then stacked and taped together, resulting in a 60-cm column of the substrate. The column is saturated and allowed to drain for 24 h. Then, the column is taken apart and the water content of each section determined gravimetrically. The water content of each section is graphed against height so that the result is a moisture retention curve. Data are presented to show the curve developed from the column method is similar to the curve developed by standard soil moisture tension method. The moisture retention curve can provide a better understanding of water and air holding capacities of substrates.

768

Using Internet in Distance Education

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In Spring 1994, a 2-h course in Agricultural Meteorology was handled primarily by e-mail. Six off-campus students asked to take the course by e-mail, and two on-campus students voted to join them. Seven students communicated with each other and the instructor via VAX-mail on the UF IFAS Computer Network [ICON]. The remaining student used a NASA supplied link to Internet. A few students used V-mail on ICON's VAX, in preference to the basic MAIL facility. A good textbook was found indispensable because the rest of the course content flowed through the network. The conversational characteristic of e-mail messages accommodated questions about the text and a term paper topic well. There is a tradeoff of commuting costs vs. computer and modem costs. Each participant worked at an individual—an advantage for students who have production responsibilities. Those students ranked the course as highly desirable [compared with the average for other courses in the department 1.33 vs. 1.39 (where 1 is top score and 5 lowest)]. Procrastination is a hazard, and the keyboard is a limiting factor. Both the preparation for and conduction of the course is more time consuming than conventional methods. This time requirement is expected to decrease with familiarity, the use of graphics, and commercial links to Internet.

772

Taxas Grapefruit Tree Size, Leaf Loss, and Yield Relationships: A Computer Training Program on Estimating Fruit Loss for Insurance Adjustors

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To meet the Federal Crop Insurance's need to estimate the fruit crop on young citrus trees with no bearing history and partial fruit loss, the relationships between tree age, trunk and canopy size, and yields were studied. Pertinent data taken over many years from 1- to 7-year-old trees were analyzed using SAS regression procedures. The correlations for tree age x trunk diameter and truck diameter x canopy size were highly significant with $R^2 > 0.80$. Although its R^2 was only 0.20, the canopy size x yield correlation provided an acceptable estimate of the potential yields of grapefruit trees ≤6 years of age. The effect of 20% to 80% leaf loss on subsequent yields was determined in a field experiment, and the results included with a training guide on estimating leaf loss. The whole program was designed to provide a method by which insurance adjusters with little previous citrus experience could estimate postfreeze yield losses.

776

Testing of Interactive Multimedia Instruction in Postsecondary Plant Materials Courses

Mark Zampardo, Gary Kling,* and *Christopher Lindsey*, Dept. of Horticulture, Univ. of Illinois, Urbana, IL 61801

An integrated teaching system was developed and tested on students enrolled in a woody landscape plants identification course. A Microsoft Windows-based system incorporates high-quality digital images and text in an interactive computer environment. The goal of the software program was to enhance retention of course material through the use of many images along with accompanying text and a variety of special features. In alternating 4-week periods, one-half of the students in class were randomly selected and given password access to the software. The other half served as a control group. All students continued to receive traditional lecture and laboratory presentations of the material, including weekly slide coverage of each plant. The exams incorporated material from lectures and labs and included slide images from which students were to identify the plant taxa. The study took into account time on the computer and test scores. Results showed that increased time on the computer was positively correlated with increased test scores. Student performance on the slide portions of the exams were consistently higher for computer users than control groups.

780

Student Software Usage Patterns in a Computer-based Interactive Program for Woody Landscape Plant Instruction

Christopher Lindsey, Gary Kling,* and *Mark Zampardo*, Dept. of Horticulture, Univ. of Illinois, Urbana, IL 61801

UIPLANTS is a program developed under Microsoft Windows to help students in woody plant materials courses. Its many options include an encyclope-

dic format that displays 256-color high-resolution images of plant identification characteristics and ornamental features coupled with text, side by side image comparisons, "book markers" to return to selected screens, and a slide show that runs a display of images in a user-defined format. The system is being used to study how students learn information presented to them through computers and which program features are most effective in improving plant knowledge. Through computer logging of all student activity within the program and surveys given to the test groups, some basic usage patterns were derived. Students using the program with no incentive tended to use the program in a more comprehensive manner, switching back and forth between the slide show and encyclopedic entries with equal time spent in each. The comparison and "bookmark" features were used but less frequently. Half of the students, given an extra credit incentive based on time, followed this same usage pattern, but the other half simply used the slide show with minimal student–computer interaction.

784

Providing Students with Tools to Increase Their Academic Success

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In an elective course titled "Be A Master Student", freshmen in The Pennsylvania State Univ.'s College of Agricultural Sciences were introduced to subjects ranging from university policies and procedures to skill enhancement in note-taking, test-taking, and time management techniques. A broad knowledge of agricultural sciences at local, state, national, and international levels was developed with the goal to relate agriculture to individual and societal needs. Mentoring relationships between students and faculty developed, not only with course instructors, but also with other faculty through required interviews and one-on-one discussions. Two volunteer faculty instructors taught 20 students per section. The number of sections has increased from four in 1990 to 13 in 1994. More than 70% of incoming freshmen opted to schedule the course in 1994. Student surveys indicated that >90% of those who enrolled would recommend the class to a close friend. Performance tracking shows that studentswho enrolled in the class maintained higher grade point averages than students who did not enroll. A higher rate of retention also has been documented for students who complete "Be A Master Student"!

788

A Community Service Approach for a Landscape Design Course: Design and Installation of a Habitat for Humanity Residential Landscape

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Landscape design courses typically include real-life projects in which students integrate design principles and selection of plants and materials. Such projects also allow students to sharpen their graphical and interpersonal communication skills; they draw plans to satisfy a client. For one project in our course, students do all of that work plus contribute to the off-campus community via the Habitat for Humanity program. Students gain not only the traditional experience of designing a residential landscape on a strict budget but also the experience of competing to create the plan to be chosen by a committee of decisionmakers. The students gain further practical hands-on experience because they install the landscape. This type of community service project allows horticulture students to earn the satisfaction of seeing a site evolve from an empty lot to a finished landscape, knowing they are enhancing a homeowner' s and the community's environment.

792

The Influence of Plant Form on Human Health and Well Being

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Research has shown that people respond physiologically and psychologically to scenes of urban and natural landscapes. Viewing nature has been associated with improvements in health, and there is evidence that people have a preference for certain tree forms. Human responses to different tree forms (spreading, columnar, and rounded) and nonliving urban elements were examined. Blood pressure, skin temperature, and emotional states of participants were measured while viewing computer-enhanced slides of urban and residential settings. Respondents were calmer when viewing trees than when viewing nonliving urban elements, and they expressed strong preferences for some tree scenes

796

Institutions of a Horticulture Curriculum at College of the Ozarks

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College of the Ozarks is a private, liberal arts college in southwestern Missouri, and the Agriculture Dept. has recently begun instituting a variety of horticulture courses in an effort to meet the increasing student interest in horticultural science. The objective is to educate and train students in the horticulture fundamentals and specific production areas (advanced courses). Also, the College is in the process of constructing teaching and demonstration gardens to be used in conjunction with classroom instruction. These gardens will include a plant materials collection and horticultural crop production areas. Additionally, as the College requires that students work part-time at any of several work "stations" on campus, students have the opportunity to gain experience in landscaping or in production greenhouses on campus. Currently, the college has 10,000 ft^2 of greenhouse space that is operated for the purposes of producing plants for campus landscaping, maintaining a ≥6000 orchid collection, and producing plants for seasonal sales. The college intends to integrate the classroom instruction, experiences in the teaching gardens, and the required work experiences to provide students with a complete horticultural education. Comments and suggestions for this budding endeavor are highly sought after.

800

Pesticides and the Baby Food Industry: A Case Study

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We present the decision case titled "One Size Does Not Fit All" developed for use in a capstone experience in the College of Agriculture and Natural Resources. The decision case requires an oral and written presentation of a solution to a problem posed in the case. Students work in small groups comprised of students with many majors within the college. The case study is based on the recent NRC report titled "Pesticides in the Diets of Infants and Children," and the perceptions of the public concerning pesticides, baby food, and children. We outline how this case study was developed, the support material supplied to the students, and the experiences and observations that we have made as a result of using this case study. In addition, we outline how this case study could be modified to address other questions related to pesticides and food safety in a classroom setting.

821

The Americans with Disabilities Act: A Case Study of a University Teaching Garden

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The Americans with Disabilities Act (ADA) requires public entities to be readily accessible to individuals with disabilities, including public gardens. However, managers of such gardens are not likely to be familiar with the language of ADA or with what steps they must take to be in compliance. This study served to summarize the requirements of ADA as they pertain to a small public garden. In addition, the Purdue Univ. Horticulture Gardens (PUHG) were evaluated to determine the current level of compliance with ADA and to identify areas in need of attention. The result was an action plan, not only useful for PUHG, but one that can be adapted by other public gardens.

825

A Print-on-demand System for Producing Instructional and Extension Materials

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A Print-on-Demand (POD) System was developed to expand the availability of printed extension and educational materials. The layouts are developed on a computer using text files and digital images. Images can be edited with graphics programs before insertion into the layouts. The completed materials are stored, in final format, on disk and are printed on an as-needed basis or distributed over computer networks. The system greatly reduces the production time to a finished product and gives great flexibility in revising publications. The basic POD system consists of a computer, a mass storage device, and a printer. Photo CDs and video capture are the most common sources of digital images. Photo CDs produce higher-quality images but require more time to get the digitized images due

to commercial processing. For Photo CDs, the images are photographed with a 35-mm camera and sent for processing and digitizing. With live video capture, a video camera is connected directly to a computer and images are digitized in real time. Tape recorded images also can be used, but the image quality is less than live video. Video images are digitized at 72 pixels per inch (ppi), and Photo CD images are available at >3000 ppi. Video images are best digitized at twice their desired size and reduced to final size when increasing the resolution.

827

Teaching Horticultural Marketing to Undergraduate Students

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Most horticultural students at Fort Valley State College (1890 land grant college) have little or no background in aspects of horticultural marketing. We offer a course in Marketing Technology to address this lack of background in horticultural marketing. In this course, students learn how to obtain a business license and a tax number. The significance of financial planning is stressed through practice. Students learn the strategies involved in merchandising and pricing, the proper display techniques, and the importance of advertising. Field-trips to local horticultural businesses allow for students to interact with professionals in horticulture. Students are required to do reports on each field-trip taken in the course.

988

Job Satisfaction in Public Horticulture

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Much has been written about how job satisfaction may or may not affect production, morale, and quality of work. However, most job satisfaction studies have been conducted in the area of manufacturing and management, but none have been conducted in the field of public horticulture. Job satisfaction was examined in 245 employees from 30 public horticulture institutions in the mid-Atlantic region of the American Association of Botanic Gardens and Arboreta (AABGA) using the Job Descriptive Index (JDI) and Job in General (JIG). Our purpose was to determine if differences in job satisfaction existed based on an individual' s job (management, horticulture, or other), sex, or other demographic information. In general, public horticulture employees reported satisfaction with work on their current job, supervision of co-workers, and their jobs in general, but showed dissatisfaction with their opportunities for promotion. They were ambivalent about their current pay. However, significant differences ($P < 0.05$) were seen between the sexes on satisfaction with current pay and among management, horticulture, and other staff on work on current job, current pay, opportunities for promotion, and co-workers.

991

Fruit Teaching Garden as a Collaborative Project between Horticulture and Agriculture Education

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A Teaching Fruit-Garden Project was developed as a joint project between two classes in Horticulture and Agricultural Education to develop a teaching resource for college classes, area kindergarten to 12th grade (K–12) schools, and members of the community who were interested in fruit and edible landscaping. Our teaching goal was to develop a sense of involvement in course subject matter among students. The project was based on coordination of team activity, writing across the curriculum, and hands-on learning. Final product in the horticulture course was a proposal consistent with low maintenance; sustainable production principles, including choice of fruit species and cultivars; management plan; and a preliminary site plan. Final products in agriculture education were self-contained teaching modules for K–12 school teachers, including sample lesson plans, projects, and teaching materials. Students liked combining efforts between the two classes. They also liked the idea that their efforts contributed to an on-going service to the community.

999

Student Teaching and Research Initiative through Volunteer Employment

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Student Teaching and Research Initiative through Volunteer Employment (STRIVE) is an innovative new program developed collaboratively by faculty and students to offer students work experience opportunities in the Dept. of Horticulture while assisting with horticultural needs. The program promotes volunteerism and education while strengthening participating faculty, staff, and students in areas of research, teaching, or public service. STRIVE requires a voluntary commitment of 3 h/week in an area agreed on by participants and their supervisors. Participants are formally acknowledged by the department for their contributions after completing the semester-long program. Students participating thus far have assisted in teaching laboratories, program development, and greenhouse management.

1004

Synergy between a Gerontology Program and a 4-H Informal Horticulture Education Program

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Youth interest in horticulture may be improved with the help of the elderly. The percentage of elderly people in the United States is growing at a greater rate than any other age group. The loss of life decision-making capabilities and the control of retirement home environments can lead to stress and depression. To counteract this problem, some institutions have used horticulture or pet therapy as tools to improve the quality of life for the elderly. We describe a 4-H horticulture education program that depends on mentoring skills of older adults to deliver hands-on, experiential-based 4-H program. In Project Exploring Aging through Shared Experiences (EASE), Pillemer et al. (1994) used as a framework for an intergenerational gardening experience. Students learn basic horticulture concepts from and with senior citizens though hands-on activities in a setting that is similar to the well-established SERIES program. Projects range from single-event terrariums to on-going summer gardens.

1007

Characterization of Leca Clay Pebbles as a Growing Medium for Geranium (*Pelargonium hortorum*) Stock Plant Production

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Leca clay pebbles were characterized and tested as a possible growing-medium for use in floriculture production systems that recycle irrigation water. Leca clay pebbles are light porous particles made by heating clay. X-ray diffraction tests indicate that high manufacturing temperatures (1100C) result in final particles composed primarily of quartz. Water-holding capacity was determined by pressure plate apparatus at eight pressures. Leca particles that were 4 to 8 mm retained more water than particles sized 12 to 18 mm. The bulk density of the particles were 0.43 and 0.37 g/cc for the 48-mm and the 12- to 18-mm particles, respectively. The pH of the leca particles was 7.77. The cation exchange capacity of the leca particles was relatively low compared to a standard soilless growing medium of 1 pine bark : 1 peat : 1 perlite (by volume). Leca particles have a CEC of o.82 me/100 g Ca and 6.36 me/100 g K, where the CEC of the previously mentioned soilless.medium was 24.21 me/100g Ca and 30.08 me/100 g K. Leca clay pebbles were tested as growing medium for the production of geraniums (*Pelargonium hortorum*) stock plants.

1012

Developing a Model System for Cost-effective Floriculture Extension Program Delivery through Greenhouse Crop Management Associations

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Current and future plans for reductions in federal and state funding suggest that government supported programs must find ways to reduce costs while maintaining or expanding programs. The current model of extension, with an agent for each commodity in every county is not likely to survive. Furthermore, the days when university-based specialists could afford to make house calls also are probably limited. Yet, the need for extension support in the floriculture industry is as great as ever. Increased chemical costs and regulatory pressure are restricting grower options and making it increasingly important that information dissemination and technology transfer occur in timely and appropriate ways. To try to meet the needs of the floriculture industry in Pennsylvania, we have begun a program to help develop independent greenhouse crop management associations to work with milti-county and university-based extension specialists to improve program delivery to the member greenhouses. The first of these associations has been established in the Capital Region in central Pennsylvania and is providing IPM

scouting and crop management services to member greenhouses. Development of associations and linkages with and the role of extension are discussed.

1015

Woody Plants for the Fresh-flower Market

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Woody cut-flower plots were planted in Mar 1994 in Lane, Okla. Eight species with 10 replications each were chosen for their potential variety of fresh-cut stems and foliage, fruit, and flowers. Not only were the woody species planted for demonstrative purposes at field days and workshops, but they also were used for harvest and analysis of their vase life. Local florists also were exposed to new potential species and queried for their initial impression of the plants' aesthetic qualities and their likelihood of acceptance by the florists' patrons.

1020

Water-quality Education Program Affects Consumer Behavior and Attitudes

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A multi-faceted extension education program to reduce consumer contributions to nonpoint source pollution by encouraging proper landscape management was initiated in Prince William County, Va., and funded through the USDA-extension service. The program now is being replicated in several counties in Virginia, primarily in the Chesapeake Bay watershed. The program recruits participants through educational field days, advertisement and other means. Educational techniques include one-on-one assistance from Master Gardener volunteers and the use of Extension publications developed for this program. Publications developed include *The Virginia Gardener Easy Reference to Sustainable Landscape Management and Water Quality Protection*—a concise reference of Virginia Cooperative Extension landscaping recommendations that includes a calendar for recording fertilizer and pesticide applications, IPM, and other maintenance activities. *The Virginia Gardener Guide to Water-wise Landscaping,* was recently added to supplement the program in the area of water conservation. In Prince William County, over 700 people have participated. Most of those who complete the program report being more satisfied with their lawn appearance and spending less money. Participation also resulted in consumers being more likely to seek soil test information before applying fertilizer. Other effects include greater participation in leaf composting and grass clipping recycling and greater awareness of nonpoint source pollution.

1023

Master Gardener's Public Demonstration Garden Offers Success beyond Educating the Public

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The Penobscot County (Maine) Master Gardeners (MGs) initiated a demonstration garden in 1994, on a 0.75-acre plot at the Univ. of Maine's sustainable agriculture farm. In addition to producing public education through on-site events, newspaper articles and weekly television broadcasts, the garden is the venue for these program successes. 1) New MGs see the garden as an on-going volunteer project and 2) grow as gardeners by working in the garden. 3) The Garden helps develop the camaraderie that begins among MGs during their training. 4) Advanced training is easily accomplished in the garden. 5) The garden provides an infrastructure for new project, 6) accomplishes positive public relations for Cooperative Extension and the MG program, and is an excellent MG recruitment tool.

1026

Trial Gardening in Cyberspace

Robert D. Berghage[1], Dennis J. Wolnick[1], E. Jay Holcomb[1], and *John E. Erwin[2]*, [1]The Pennsylvania State Univ., University Park, PA 16802; [2]The Univ. of Minnesota, St. Paul, MN 55108

The Internet offers many new and unique opportunities to disseminate information. The development of the World Wide Web (WWW) and information browsers like Netscap, Mosaic, and simple-to-use server software like MacHTTP provides means to allow low-cost access to information, including pictures and graphics previously unavailable to most people. The Pennsylvania State Univ. variety trial garden annually tests >1000 plants. Information is gathered on garden and pack performance, and photos of superior plants and varieties are taken. To provide wider access to this information, we have begun development of a Cyberspace trial garden on the internet. This server contains a wide variety of garden trial information developed from trials conducted in State College and Dauphin, Pa.. This server and a similar effort at Univ. of Minnesota are being constructed cooperatively. Hot links are provided between the server in Pennsylvania and the one in Minnesota, providing users with seamless access to information from both servers.

1028

Farmer's Bookshelf Information System for Predicting Phosphorus Requirements of Some Hawii Soils

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Most soils of Hawaii contain high amounts of iron- and aluminum oxides or amorphous alumino silicate clays, which react strongly with P making it virtually unavailable for plant uptake. Acceptable crop production is not possible unless adequate P fertilizers are applied. Growers need to know if a soil needs P and if so how much. The Farmer's Bookshelf hypermedia information system, which runs under the software HyperCard, can quickly provide these answers. A screen is displayed in which the soil series and the crop to be grown are specified through pull-down menus. The user then enters the Truogextractable P value of the soil and clicks on a "Calculate" button. The soil solution P value is calculated and compared to the minimum soil solution P needed to adequately grow the crop (80% to 95% of maximum yield). If the value is greater than the minimum value, then P fertilizer is not recommended. Otherwise, the program recommends the amount of fertilizer to add as P, P_2O_5, and treble superphosphate in pound per 1000 square feet and pound per acre. The recommendations, presented in a table, can then be printed for clientele use.

69 WORKSHOP 11
Variation in Expression and Stability of Transgenes in Horticultural Crops

1053

Phenotypic and Genetic Stability of Petunias Expressing Sense and Antisense RNAs of Endogenous Genes

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The target of many genetic engineering experiments is to inhibit the expression of an endogenous gene. For example, research in my laboratory attempts to suppress the expression of ethylene biosynthetic pathway genes to inhibit the production of ethylene and delay flower senescence. The silencing of endogenous genes is generally accomplished by engineering plants to express either antisense or sense RNAs homologous to the target sequence. The mechanism by which gene silencing occurs is not clearly understood. Genetic and molecular analyses of transgene-induced silencing has revealed both meiotically reversible and fully stable phenotypes resulting from the expression of the transgene. In several cases, the mechanisms potentially involved in the silencing of the transgene and concomitant reversion of phenotype have been studied. These include transgene copy number, configuration of the integrated DNA, level of transgene RNA, and environmental factors. In many cases the silencing of transgenes was correlated with DNA methylation. These phenomena and the implications for engineering horticultural crops to express transgenes will be discussed in this workshop.

1054

Phenotypic Stability of Transgenic Citrus

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We have produced a number of transgenic citrus plants via *Agrobacterium*-mediated transformation of seedling stem segments with a vector plasmid containing a β-glucuronidase (GUS) gene. All regenerated green shoots produced in our experiments are assayed histochemically for expression of GUS by cutting a section from the base of the shoot. Many of the shoots express GUS only in sectors, which vary in size from shoot to shoot. Analyses suggest that sectored

regenerated shoots are chimeric, consisting of nontransformed cells as well as transformed cells. However, plants derived from shoots with large GUS+ sectors in the original assays do not necessarily contain the GUS gene; conversely, some plants derived from shoots with small sectors appear solidly transformed. Plants that appear solidly transformed have maintained gene expression for up to 5 years. None of the transgenic plants have obviously altered morphologies. It has not been possible to analyze progeny plants because of the long juvenile periods and polyembryony of the primary transformants. However, because citrus is clonally propagated, long-term phenotypic stability of primary transformants is the most important factor in producing useful transgenic plants.

1055

Stability of PRV Resistance in Transgenic Papaya

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Transgenic papaya lines carrying the coat protein gene (CP) of papaya ringspot virus (PRV) strain HA 5-1 display PRV reactions ranging from complete susceptibility (39-3 & 39-4), to slight delay in onset of symptoms (39-1) and attenuation of symptoms (60-3), to high-level resistance (55-1, 63-1). Normal Mendelian segregation of transgene expression was lost in R1 of 39-3 and 39-4, and inbred R1 60-3 gave an aberrant 1:1 ratio. R0 55-1 plants were resistant in the field (Hawaii) for 2 years following manual and/or aphid inoculation, and the high-level resistance remained stable in the R1 after repeated manual inoculations in the greenhouse and graft inoculation for up to 1 year (Cornell). However, inoculation with PRV HA-Oahu strain produced symptoms in some plants at Cornell (9% after 6 weeks) and in Hawaii (50% after 1 year). Two 55-1 and one 60-3 plant subsequently underwent remission of symptoms and became ELISA-negative (Hawaii). Transmission of PRV isolates from symptomatic 55-1 plants to other CP+ 55-1 bioassay plants was unsuccessful.

1056

Our Experience on the Effect of Gene Stability and Expression on Development of Virus-resistant Fruits and Vegetables Expressing Genes from Different Viruses

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Our laboratory has focused on the development of virus-resistant plants through the use of pathogen-derived resistance. We have analyzed transgenic plants, including tobacco, cucumbers, melons, squash, chrysanthemum, tomato, papaya, and lettuce, that contain the coat protein genes of viruses belonging to the potyvirus, tospovirus, nepovirus, cucumovirus, and comovirus groups. Field and greenhouse trials have generally shown that resistance is not correlated to the expression level of the coat protein gene—in a number of cases, plants that expressed low amounts of coat protein showed excellent resistance. However, we have found that transgenic progenies from a particular plant often vary in their resistance to virus infection. These observations will be discussed as they relate to gene stability.

105 WORKSHOP 13
Computer and Electronic Systems Applications in Horticulture

1057

Utilizing Electronic Mail List Discussion Groups on the Internet to Enhance Communication in Specific Commodity Groups

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Electronic discussion groups provide a forum in which to enhance the exchange of information between university researchers, extension agents and specialists, students, and their clientele; farmers, wholesalers/brokers, retailers and direct marketers as well as other colleagues in the same field. Three electronic discussion groups; Apple-Crop-Mg, Veg-Prod-Mg, and Direct-Mkt have been implemented and have been extremely effective in providing a unique forum for the sharing of knowledge. Over 400 subscribers are on-line with these groups from more than 30 states, four Canadian Provinces and three other countries. Participant surveys cite the ease of use, the timeliness of replies (often within 24 h), the ability to glean timely information for files and newsletters. These groups have been a valuable communication tool reaching a broad audience rapidly and cost effectively.

WWWhat in the WWWorld is the WWWeb?

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The World Wide Web (WWW) provides users with a graphical computer interface to access digital information from Internet locations around the world. This information may be in the form of text, images, motion pictures, or sound. Web "pages" may also provide near-instantaneous links to other pages with related interests and information, and have the capability of allowing users to fill out forms on-line requesting additional information or services. WWW access is becoming increasingly available to individuals either through direct network links or by a modem connection through an Internet provider, the latter method generally requiring either SLIP or PPP service to establish a link. The background of WWW, its potential, and its future development will be discussed.

Horticulture on the Web—A Tool to Communicate the Depth and Breadth of the Discipline has Finally Arrived

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A tool with enough power and versatility to communicate the depth and breadth of the art and science of horticulture has emerged with the development of the World Wide Web. First created to meet the rapid communication needs of high-energy particle physicists, the Web has proven to be a powerful information-providing tool enabling communication with *all* the diverse audiences of horticulture. Web-browsing software is multimedia in nature, and graphically based. Information can be colorful, interactive, commercial, amateur, or arcane, depending on the skill and objectives of the information provider. The target audience can be school children, horticultural producers, home gardeners, or academic researchers. Access to the Web is inexpensive and becoming widely available. These features enable audiences that previously had difficulty accessing the vast stores of horticultural information that reside within the confines of academic and governmental libraries to get that information from their schools or homes. The ever-growing demand for information, the need to integrate Web technology into teaching at all levels, and the adoption of the Web as a resource for distribution of peer-reviewed scholarly work has led to the development of various creative solutions among academic, professional, and avocational horticulturists. Some of these will be examined in detail during the workshop.

106 WORKSHOP 14
Impact of Specific Long-term Fruit Breeding Programs on Local, National, and International Industries

1060

Sweet Cherry Breeding in Canada: 1915 to 1995

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Sweet cherry breeding started at Vineland and Summerland in 1915 and 1924 and has resulted in the naming and introduction of 11 and 18 cultivars, respectively. 'Victor' and 'Van' were the first cultivars named from Vineland and Summerland, respectively, in 1925 and 1944. 'Van' has become a popular cultivar in North America and Europe. The main objective in these breeding programs has been to develop cultivars that produce large quantities of firm-fleshed, crack-free, flavorful, large, black cherries with a range of maturity dates to extend the season of harvest. In the 1960's, the development of self-fertile cultivars was added to the objective of the programs. Already several self-fertile cultivars and advanced breeding selections have been named and introduced from Canada.

The programs have also contributed to the assignment of cultivars to different pollen-incompatibility groups and verification of pedigree of sweet cherry cultivars. The impact of these long-term breeding programs in Canada and abroad will be discussed in detail.

107 WORKSHOP 15
Measuring Soil and Plant Water Status to Indicate Irrigation Needs in Horticultural Crops

1061

The Strengths and Weaknesses of Scheduling Irrigations Based on Soil Water Content Measurements and ET Models

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Several soil moisture measuring sensors are used to schedule irrigation of horticultural crops. However, without precise knowledge on root distribution, these devices may not provide accurate data on soil moisture conditions around the majority of roots. Also, some devices are expensive and/or require a tedious calibration and careful maintenance, limiting their use by growers. ET models have been successfully used for many crops grown in arid climates; however some models are not very precise and do not account for seasonal differences in plant water needs. Moreover, in humid regions it is difficult to assess the magnitude of rainfall contribution to the plant water needs particularly when only a part of the root system is irrigated. Research is needed to characterize plant variables which are useful for scheduling irrigation.

1062

Plant Water Status as an Index of Irrigation Needs in Deciduous Fruit Trees

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To be useful for indicating plant water needs, any measure of plant stress should be closely related to some of the known short- and medium-term plant stress responses, such as stomatal closure and reduced rates of expansive growth. Midday stem water potential (SWP) has proven to be a useful index of stress in a number of fruit trees. Day-to-day fluctuations in SWP under well-irrigated conditions is well-correlated to midday vapor pressure deficit, and hence can be used to predict a non-stressed baseline. Measurement of SWP helped to explain the results of a 3-year deficit irrigation study in mature prunes, which showed that deficit irrigation could have either positive or negative impacts on tree productivity, depending on soil conditions. Mild to moderate water stress was economically beneficial. In cherry, SWP was correlated to both leaf stomatal conductance and rates of shoot growth, with shoot growth essentially stopping once SWP dropped to between –1.5 to –1.7 MPa. In pear, increased fruit size, decreased fruit soluble solids, and increased green color were all associated with increases in SWP.

1063

The Use of Sap Flow Gauges for Estimating Transpiration

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New electronic biosensors that directly monitor plant physiological and morphological processes are now being developed for use in research and commercial applications. Although methods for measuring sap flow by applying heat to stems have been used for more than 20 years, they have usually been intrusive, required empirical calibrations and conversions, and been too fragile for rugged commercial environments. A more-promising method for monitoring sap flow is balancing the thermal fluxes into and out of a stem segment using heat sources wrapped around a stem. Constant heat-balance sap-flow gauges have been used for the direct, accurate, non-invasive, and continuous measurement of sap flow rate in many herbaceous and woody plants, including forest and fruit trees, vines, landscaping shrubs, and numerous agronomic plants. The performance of sap-flow gauges has steadily improved as they have been used in a wider range of basic and applied research. Research is now being conducted to use these gauges as on-line sensors to schedule irrigations, monitor plant stress, and even control the greenhouse environment.

1064

Monitoring Crop Water Status and Irrigation Needs Using Multispectral Airborne Sensors

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Water application efficiency can be improved by directly monitoring plant water status rather than depending on soil moisture measurements or modeled ET estimates. Plants receiving sufficient water through their roots have cooler leaves than those that are water-stressed, leading to the development of the Crop Water Stress Index based on hand-held infrared thermometry. Substantial error can occur in partial canopies, however, as exposed hot soil contributes to deceptively warm temperature readings. Mathematically comparing red and near-infrared reflectances provides a measure of vegetative cover, and this information was combined with thermal radiance to give a two-dimensional index capable of detecting water stress even with a low percentage of canopy cover. Thermal, red, and near-infrared images acquired over subsurface drip-irrigated cantaloupe fields demonstrated the method's ability to detect areas with clogged emitters, insufficient irrigation rate, and system water leaks.

109 WORKSHOP 17
Use of Introgression and Exotic Germplasm in the Improvement of Vegetable Species

1065

The Important Role of Germplasm in Improving Carrot, Onion, and Garlic

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Genetic improvement of carrot, onion, and garlic has depended upon introgression of alleles from foreign cultivars, from wild forms of cultivated species, and from wild species. Introgression of Asian germplasm in European carrots has resulted in more than a doubling of carotene content; wild carrot has provided two of the most widely used male-sterile cytoplasms for production of hybrids; and *Daucus capillifolius* has been used as a source of resistance to carrot fly. Onion male-sterile cytoplasm used for hybrid production has its origins in a species related to onion, while resistance to several diseases originated in foreign cultivars. Production of true garlic seed has depended on a broad germplasm base for its success. More examples and germplasm utilization strategies will be discussed.

1066

The Wild and the Beautiful: Exotic Sources for Improving *Capsicum* (Pepper)

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The genus *Capsicum* provides a bountiful source of extraordinary genetic diversity with which to improve the cultivated species. Approximately 23 species are recognized within the genus. Five major cultivated species are derived from different ancestral stocks found in three distinct centers of origin. Mexico is the primary center for *C. annuum*, with Guatemala a secondary center; Amazonian for *C. chinense* and *C. frutescens*, and Peru and Bolivia for *C. baccatum* and *C. pubescens*. Several wild species are crossable to *C. annuum*, the most commercialized species. *Capsicum* inhabits a vast array of ecological zones. The wild species furnish a variation of mating systems, plant–animal interaction, patterns of speciation, and other intriguing biological features. However, their potential value for improvement of *Capsicum* cultivars is under-exploited. Such genetic resources clearly deserve more intensive investigation.

111 WORKSHOP 17A
Organic Production of Herbs and Medicinal Plants

1050

Organic Production of Angelica

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Angelica (*Angelica archangelica*) is a tall biennial grown for its root-bound active ingredients. A research was conducted to adapt conventional angelica production methods to organic principles and nordic growing conditions. Seeds should be stratified for 7 to 8 weeks before sowing and transplant production done in multicellular trays filled with compost-peat media and supplemented with organic soluble fertilization. A sequential sampling program was conducted to better-understand the dry matter and active ingredients accumulation patterns over the growing seasons. In light of these results, the recommended production schedule consists of a fall planting and a harvest the following fall. In this manner, both dry matter yield and active ingredient concentration in the root are improved. Root yields increase linearly with planting densities up to 111,111 plants/ha. After 5 years of research, most of the limiting factors have been studied and the problems solved. Our research clearly shows how much yield, quality, and profitability of a newly introduced crop can be improved when a comprehensive research program is implemented.

1051

Organic Cultivation of Camomile in North America

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Camomile (*Chamomilla recutita* Rauschert) is an annual plant from the Asteraceae. Camomile is one of the most frequently used medicinal plants, and has a commanding place in the world market. The flower heads are used in pharmaceutical preparations, and the cosmetic and beverage industries. The extracts from camomile flowers, to mention some, are known to have the most-effective sedative (3.29x compared to papaverin), antidepressive, tumor -protective, antiinflammatory, and accelerative properties in the regeneration of skin tissues. It is considered a panecia, due to its strong effects among many others, in the treatment of gastric ulcers, stomatology, respiratory complications, nephritis and nephrolithiasis (dilution of the kidney stones), and urinary bladder stones (cystolithiasis). Recently, successful research programs have been carried out to develop new camomile varieties with higher flower yield and better content of the active substances, suitable for mechanical harvesting under conventional cultivation. Apart from growing consumer demand for organically grown herbal products, the use of some herbicides and insecticides has resulted in the shifts of the content of active substances. The yield stability, content, and composition of the active substances under organic cultivation, particularly in areas with extreme climatic conditions, such as northern North America, should be investigated. We identified and introduced new camomile varieties and studied their suitability for organic field cultivation in Quebec, Canada. We studied over-wintering ability, yield potentials, and the content and composition of essential oil, flavonoids, and coumarins under field conditions. The physiology of the new varieties, particularly the relationship between photosynthesis and yield formation, and the accumulation of the active substances under different cultivation conditions remain to be studied.

1052

Pest and Weed Control in Crops, A Non-chemical Approach

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Crops that are produced without manufactured fertilizers and protected from plant pests and weeds without manufactured chemicals are gaining in popularity among consumers. Non-chemical methods of plant protection, such as the development of biocides from plants, would be desirable for environmental and economic reasons and because of pesticide tolerance of some plant pathogens and insects. Extracts and their individual ingredients from several plant species have been used experimentally against plant pathogenic bacteria, insects, and weeds. There are problems, however, that make the use of biocides difficult: low concentration of active ingredients in the plants; purification of active ingredients from dozens of secondary compounds; instability of the active ingredients when exposed to light and air; and the mode of action is little understood or unknown. The technological and scientific advances that could allow the use of non-chemical based plant protection systems and the problems with such systems will be considered and discussed.

114 WORKSHOP 18
Advanced Root and Rhizosphere Analysis Systems

1067

WinRHIZO™, a Root-measuring System with a Unique Overlap Correction Method

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WinRHIZO™ is a new root measuring system (1993) based on an optical scanner instead of a video camera. Scanners produce high-quality images, free of illumination problems, over large areas (typically 11 x 17 inches). They are also extremely easy to use, and do not need to be recalibrated each time the optical set up or the resolution is changed. Different lighting systems are also available. WinRHIZO™ is an interactive system; the user can see on screen with color codes what the system is measuring and can make corrections if needed. WinRHIZO™ has the capacity to detect overlapping root parts and to compensate for them in the final results. It measures total length, projected area, surface area, and root length for different width intervals chosen by the user. The results are shown in a printable histogram placed above the image. The system also counts root tips and branching points. It is possible to verify the width at different points along the root by clicking them in the image. WinRHIZO™ can analyze whole images or different parts of them. It runs on IBM-compatible software under Microsoft Windows 3.1 or NT, and on Macintosh computers.

1068

Computer Classification of Roots from Digitized Video Images

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Manual methods for estimating root length are tedious and time-consuming. Image capture and analysis systems can be used to obtain precise measurements of root length and growth angle. Root activity can also be determined through analysis of the mean pixel intensity of a digitized image. Both commercial (the IBM-compatible ICAS System) and public domain (the Macintosh-based NIH Image) image capture and analysis software have been used to analyze intact root systems. Examples of ICAS classification of hydroponic and soil-grown root systems will be presented. Advantages of the NIH Image software for analysis of micro-gravity experiments aboard the Space Shuttle will be discussed.

1069

Root Growth and Biological, Chemical, and Physical Gradients in CIPS

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Verticle gradients of moisture, salinity, specific fertilizer ions, and pH in the root zone in the closed, insulated pallet system (CIPS) are relatively stable compared with those in the open container system (OCS). Establishment of the VA mycorrhizal fungus *Glomus intraradices* and maintenance of the biocontrol fungus *Trichoderma harzianum* and the entomopathogenic nematode *Steinernema carpocapsae* were greater in CIPS than in control OCS. In CIPS, percent corn root length colonized by *G. intraradices* was greatest in roots in the top stratum of the root medium. Colonization was significantly greater in copper-coated root-containment pouches. Population maintenance in CIPS of *T. harzianum*, initially uniformly inoculated throughout the root medium, was highest in the top stratum of the root medium where K^+ and NO_3^- concentrations were highest. Efficacy of *S.*

carpocapsae in parasitizing *Galleria mellonella* larvae, while greater in CIPS, was significantly related to host plant in CIPS but not in OCS. Inoculation with bacterial antagonists *Bacillus cereus*, *Enterobacter aerogenes*, and *Serratia plymuthica* significantly increased plant growth in CIPS, but not in OCS. *Phytophthora cinnomomi* root rot infection readily occurred in inoculated plants, but did not spread to noninoculated plants in CIPS when roots were contained within plant pouches. Because of the stability of the root zone parameters and the lack of leaching-dilution of exudates, volatiles, and other materials from the root zone, CIPS is an excellent system for evaluating effects of microorganism and other factors on root growth and development.

1070

Statistical Analysis of Root Count Data

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The minirhizotron approach for studying the dynamics of root systems is gaining acceptance; however, problems have arisen in the analysis of data. The purposes of this study were to determine if analysis of variance (ANOVA) was appropriate for root count data, and to evaluate transformation procedures to utilize ANOVA. In peach, apple, and strawberry root count data, the variance of treatment means was positively correlated with the mean, violating assumptions of ANOVA. A transformation based on Taylor's power law as a first approximation, followed by a trial and error approach, developed transformations that reduced the correlation of variance and mean.

147 WORKSHOP 22
Core Collections: A Strategy for Management of Plant Genetic Resources

1071

The Role of Core Subsets in Maintenance and Use of Germplasm Collections

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The National Plant Germplasm System (NPGS) is responsible for the acquisition, maintenance, evaluation, and distribution of genetic diversity of crop plants important to U.S. agriculture. The NPGS collections currently include more than 425,000 accessions representing more than 8000 species. The curators of the individual active collections face many challenges, including preserving the maximum amount of genetic diversity in active collections, encouraging the use of the germplasm in the collections, and operating with limited resources. During the past 5 years, the NPGS curators and the 40 Germplasm Committees have been evaluating how core subsets can help in meeting these challenges. A set of general guidelines and procedures for developing core subsets has been developed.

1072

Development and Use of Core Subsets of Cool-season Food Legume Germplasm Collections

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Core subsets have been selected for the USDA chickpea (*Cicer arietinum*), lentil (*Lens culinaris*), and pea (*Pisum sativum*) germplasm collections. These subsets are specifically intended to increase the efficiency of the utilization of the entire collections of these taxa. The cores consist of 13% of the 3873 chickpeas, 12% of the 2390 lentils, and 17.5% of the 2886 pea accessions. They were selected by a proportional logarithmic model, and also contain additional accessions based upon documented concentrations of diversity. Each core has been screened for disease reactions, and results suggest that the cores can effectively direct germplasm users toward portions of the entire collections that contain resistant germplasm. These cores have also been useful for those interested in assessing the adaptation potential of these crops in new environments, because the entire range of adaptation is represented. Although cores may not always enhance access to germplasm with unique or extremely rare characteristics, the legume cores have been very useful for directing users toward desirable germplasm from defined geographic areas, and assisting users at the preliminary stages of germplasm evaluation.

1073

Use of Core Subsets in Developing Germplasm Collections of Clonally Propagated Crops

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Core subsets have been formed in several clonally propagated crops; for pear (*Pyrus*), strawberry (*Fragaria*), mint (*Mentha*), currant (*Ribes*), blackberry (*Rubus*), blueberry (*Vaccinium*), apple (*Malus*), and pecan [*Carya illinoinensis* (Wangenh.) K. Koch]. Criteria for selecting entries into each core varies, as does the use each core receives. Core subsets have been selected for each of the major collections maintained at NCGR-Corvallis (pear, strawberry, mint, currant, blackberry, and blueberry). In general, core subsets include 10% of the full collection. Entries were selected on the basis of horticultural characteristics and species representation. Management of the collection is facilitated by recognition of core entries, which are frequently distributed. The 2500 accessions of the *Malus* collection are represented in a core subset of 200 accessions. Of those, 100 represent the 35 known species, while 100 accessions were selected from elite clones on the basis of horticultural characteristics. The core has been successfully used to find a superior virus indicator. Entries have been propagated in test orchards in five states. The core strategy was used to compare the pecan cultivar collection to seedlings from native populations throughout the species range. The analysis revealed gaps in the ex situ collection, and may have implications for in situ conservation. A core subset (26 cultivars) was selected by stratified sampling within the geographic regions to mirror the allele frequency of the cultivar collection, consciously including extreme expressions of each horticultural trait evaluated. The availability of the diverse subset has effected management and distribution.

1074

Alternatives to Core Subsets

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The USDA/ARS National Small Grains Collection currently contains more than 40,000 accessions of common and durum wheats, and about 6000 accessions of other *Triticum* species. The Wheat Crop Advisory Committee has discussed the use of core subsets in screening this vast collection for traits of interest in breeding. The collection curator is assembling a subset, stratified by geography and morphology, for distribution in response to nonspecific requests and diversity evaluation. However, we have concluded that no subset(s) can be identified, in advance, that would be useful in screening for parental germplasm with traits of interest to breeding programs. Resistances and other traits are often rare in the collection, but the initial subset used for screening can be enriched for the trait of interest by selecting accessions based on knowledge of environmental conditions or occurrence of pests in geographic regions. New database technology will be very useful in this effort.

158 WORKSHOP 24
Quantification of Plant Dormancy

1075

Quantification of Dormancy—Physiological and Biochemical Approaches

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Quantification of seed dormancy has been achieved by measuring physiological, biochemical, and molecular changes accompanying dormancy release, as well as dormancy development. At the physiological level, dormancy is quantified in terms of stratification time, strength of embryo covering structures, embryo growth potential, responsiveness to light, and to temperatures and other changes. At the biochemical level, dormancy has been related to hormone (abscisic acid, gibberellin, etc.) levels, respiratory activity, and other metabolic functions. At the molecular and cellular level, dormancy has been associated with RNA and protein synthesizing ability and with gene expression. Our recent studies with lettuce seeds using gibberellin biosynthesis inhibitors indicate that the amount of gibberellin produced during seed soak may mediate dormancy release and is quantitatively related to the level of dormancy. Examples of quantifiable

changes associated with dormancy will be described. Whether a quantifiable change reflects a causal relationship with dormancy release or development, or is a consequence thereof, will be discussed.

1076

Quantification of Seed Dormancy of Deciduous Orchard Species

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Forcing plant material has long been used to determine dormancy intensity (DI) in woody species. Forcing with growth regulators may enhance this ability. Some forcing with naturally occurring hormones may be showing us the actual DI of certain materials. But, measurements of DI that use caustic, near-lethal treatments, or metabolic agents may be all or nothing breaking indicators acting on mechanisms other than the dormancy mechanism and thus not as useful in determining DI. It is possible to cause a meristem to break without completely breaking dormancy. Measurement of normal post-dormancy growth is necessary to determine the effect of a DI agent. DI breaking treatments that act on the dormancy mechanism can cause a temporary growth flush, but, unless the extent of that growth flush is measured and compared with the growth flush of the same normally broken plant material, its true effect remains unknown. In some plant material, the safest way to determine DI is to determine the chilling required to produce normal growth. This assumes that the vernalization requirement and temperature response curves are known for the plant in question. In peach, for instance, vernalization at 2C will cause seeds to germinate, but the resulting seedlings will be physiologically dwarfed. Vernalization at 6C or at 2C cycled with higher temperatures within the vernalization range results in normal seedlings. This indicates that, for chilling to progress normally, vernalization per se must be interspersed or concomitant with growth heat units. Vernalization, therefore, has a low temperature driven component and a heat requiring development and/or growth component. Vernalization driving conditions are slowly being elucidated. Each clarification requires modification of dormancy models. DI does not equal dormancy status!

1077

Quantification of Bud Dormancy—Physiological Approaches

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The purpose of this presentation is to discuss the value of identifying growth stages of bud dormancy numerically. The Degree Growth Stage Model (°GS Model) will be used to quantify the annual growth stages and the various developmental stages of endo-, eco-, and paradormancy. The model is divided into 360°GS's, illustrated either as a sine curve or a circle, that serve as a timeline for the cyclical passage of temperate woody plants, through five distinct point events (growth stages). The sine curve illustrates the relative degree of development of the segment events between the point events. This paper will focus on the °GS model as a relative method of quantifying the various segment events and improving our communication of the annual physiological processes of temperate woody plants. In addition, recent evidence on altering dormancy, and its impact on dormancy models, will be presented.

1078

Use of Hormones and Growth Regulators in Quantifying Bud Dormancy

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At the beginning and near to the end of the endodormant period, cytokinin-type growth regulators are effective to end dormancy in apple. The same growth regulators are not effective during the middle of this period. Terminal buds require less chilling than lateral buds to emerge from the dormant period. Lateral buds on decapitated shoots also require less chilling, indicating that auxin may be involved in dormancy. Replacing the terminal with IAA keeps water in bound state in the lateral buds, indicating the effect of IAA in dormancy. We have developed the theory that the beginning and the end of the winter-dormant period is governed by apical dominance. It appears that only this period can be manipulated either with dormancy avoidance methods or with dormancy-breaking chemicals. The central portion of the dormant period is not subject to manipulation. Therefore, it is important that the depth of the dormancy is quantified. Certain growth regulators can be used for determining the state of bud dormancy. Thidiazuron gives results within 2 to 4 days.

159 WORKSHOP 25
Contributions of Canadian Agriculture to the Introduction, Evaluation, and Testing of Woody Ornamental Trees and Shrubs for Use in Plant Breed Programs

1079

First Results of Woody Ornamental Trial Network in Québec

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The "Réseau d'essais des plantes ligneuses ornementales du Québec" (REPLOQ) is a research project initiated in 1982 with the mandate to elaborate, develop, and coordinate a cooperative research project to evaluate the winter hardiness of ornamental plants. Systematic evaluation trials provided information on growth potential and hardiness of woody trees and shrubs evaluated over a 5-year period in the principal growing regions of Québec. Zonal range covered was 2 to 5b in the Canadian system. Adequate field testing is critical for new introductions and, since 1984, more than 400 species and cultivars have been introduced and eight evaluated in each climatic zone. Propagation methods, as well as their potential for ornamental purpose, were described. In the 1984 plantation, 30 ornamental species and cultivars were evaluated. Winter damage data observed on each plant during this period were analyzed by Clusters analysis and five groups of plants were determined. Trees, flowering shrubs, and foliage shrubs were discussed separately and winter damages of each group were submitted to "Correspondence analyses" to identify plant response to climatic conditions. Growth and production potentials were defined by SAS analysis. Hardiness zone of each species was detailed, established, or modified.

161 WORKSHOP 27
Use of Plant Sap Tests for Determining Nutrient Status of Horticultural Crops

1080

Testing Petiole Sap for Nitrate and Potassium: A Comparison of Different Analytical Techniques

*Carl J. Rosen**, *Mohamed Errebhi*, and *Wang Wenshan*, Dept. of Soil Science, Univ. of Minnesota, St. Paul, MN 55108.

An important aspect of establishing critical sap nutrient concentrations for diagnostic purposes is to determine the accuracy and precision of the analytical method used. We compared a Cardy flat membrane NO_3 electrode, a Hach portable NO_3 electrode, and a Wescan N analyzer for their ability to determine NO_3 concentrations in sap of potato petioles. The Hach and Wescan instruments require diluted sap, while nondiluted sap can be used with the Cardy. Nitrate-N concentrations in nondiluted petiole sap measured with the Cardy electrode were 100 to 200 mg·liter^{-1} higher than the other two methods. Using sap diluted with 0.15 M $Al_2(SO_4)_3$ tended to lower Cardy NO_3 readings to concentrations closer to the other methods, but made the procedure more complicated for practical use. We also compared a Cardy K electrode with flame emission spectroscopy for determining K concentrations in sap. Using nondiluted sap with the Cardy procedure resulted in K concentrations 1000 to 1700 mg·liter^{-1} lower than those determined by flame emission. Diluting sap with 0.15 M $Al_2(SO_4)_3$ for use with the Cardy electrode resulted K concentrations similar to those determined by flame emission. Implications for using the electrodes for diagnostic purposes will be discussed.

1081

Leaf Petiole NO_3-N and K Analysis for Greenhouse-grown Flowering Potted and Bedding Plants

John A. Biernbaum, William Argo,* and *Janet Pumford*, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824-1325.

Unlike vegetable and fruit crops, where petiole analysis has been used for many years, root media analysis is the primary method of checking fertility status of container-grown flowering greenhouse crops. With the emphasis on lower constant water-soluble fertilizer rates to prevent nutrient runoff, petiole analysis may be a better indicator of N and K status. During Fall 1993, samples were collected from 10 flowering pot plant species subirrigated with either 50, 100, or 200 mg•liter^{-1} N and K concentrations. During Spring 1995, samples were collected from major bedding plant species and Easter lilies. Sap was extracted using a hydraulic press and nitrate and potassium were measured with the Cardy flat electrode ion meters. Sampling methods and protocols will be presented with results of sampling technique experiments. Floriculture plant nutrition researchers were contacted to identify other research in progress, potential applications, and possible concerns with using this technique. Further research needed will be identified.

1082

Research and Field Experiences with Petiole Sap Testing of Vegetables and Strawberries in Florida

*George J. Hochmuth**, Horticultural Sciences Dept., PO Box 110690, Univ. of Florida, Gainesville, FL 32611-0690.

Vegetable producers are under increasing pressure to minimize production inputs such as water and fertilizers. Research on fertilizer placement and scheduling, soil testing, and drip irrigation fertigation has provided technologies to enable vegetable growers to produce profitable yields of high-quality vegetables while reducing nutrient inputs. Plant tissue testing has been an integral part of nutrient management on the farm. Although plant sap testing has been evaluated for more than 70 years, only recently has testing technology been developed to the point where farm use is facilitated. Researchers in several states, including Florida, have evaluated various methods for determining nitrate-N and K concentrations in petiole sap. Researchers in Florida have developed petiole sap sufficiency ranges for the major vegetable crops and strawberries, and these guidelines are widely used by vegetable growers and crop consultants as an aid for making informed fertilization decisions. In this workshop, research results and field experiences with fresh sap testing for N and K will be discussed, including field test equipment, testing methods, and current test applications.

172 WORKSHOP 28
Multimedia Computer Applications for Horticulture Teaching and Extension

1083

Using Adobe Photoshop and CD-ROM to Enhance and Store a Greenhouse Slide Collection

*Virginia R. Walter**, California Polytechnic State Univ., Environmental Horticultural Science Dept., San Luis Obispo, CA 93407.

Presenting slides as part of any horticulture course can be time-consuming and often does not allow students independent viewing. A CD-ROM format can store enough digitized images and text to allow students to systematically view images at their own pace and enhance the classroom instructors ability to communicate desired information rapidly. A Macintosh-formatted model using greenhouse images created from scanned slides will be demonstrated and methods of implementation will be discussed.

1084

Utilizing Digital Images in Extension and Instructional Materials and Their Dissemination using Internet

*James McConnell**, College of Agriculture and Life Sciences, Univ. of Guam, Mangilao, GU 96923.

Options for acquiring digital images are explored. Photo CDs, scanned images, and video capture are the most common sources of images. Photo CDs produce the highest-quality images, but require more time to get the digitized images due to commercial processing. For Photo CDs, the images are photographed with a 35-mm camera and sent for processing and digitizing. Slide and flat bed scanning is time consuming when working with bulk quantities of images. With live video capture, a video camera is directly connected to a computer and images are digitized in real time. Tape-recorded images can be also be used, but the image quality is less than live video. VWeb server allows rapid dissemination of the materials. This procedure greatly reduces the production time to a finished product, gives flexibility in revising publications and allows a greater variety of materials to be produced.

1085

CD-ROM Delivers an Extensive Library of Plant Data

*Edward F. Gilman and Gregory L. Davis**, Environmental Horticulture Dept., Univ. of Florida, Gainesville, FL 32611.

Horticulturists can access an extensive library of data, text, photographs, line drawings, and landscape designs from CD-ROM. In tests conducted in Florida, classroom students successfully accessed this library in a computer lab to study plant identification. This made it unnecessary to duplicate slides for student self-learning. It also builds confidence in students' ability to use computers. The Cooperative Extension Service and Divisions of Forestry in the southern states also have enjoyed access to this technology. Customers of their services have been pleased with the quick access to reliable information. Most are pleased with the information received over the telephone or during their visit to the office. Information generated by the computer programs on CD-ROM has been faxed, mailed. or hand-delivered to customers. Cooperative Extension employees and Master Gardeners are pleased with the quick, easy access to information. Many report that the programs have replaced the need to page through a large number of books to gain access to plant information. This saves time and gives employees a renewed sense of pride in their work.

1086

Incorporating Hypertext Applications into Horticulture Educational Programs

*Steven E. Newman**, Dept. of Horticulture, Colorado State Univ., Fort Collins, CO 80523-1173.

Hypertext applications have grown from highlighted index referencing tools used in "help" windows to sophisticated file sharing between many computers linked via the World Wide Web (WWW). Software such as Mosaic makes this link easy and convenient by using "Hypertext Markup Language" (HTML). Most universities and many companies have installed WWW servers and have provided disk space for general use. Horticulture departments and many botanical gardens across the country and all over the world are adapting to this technology by providing access to extension information sheets, newsletters, and selected manuscripts. Pesticide chemical manufacturers are also establishing WWW servers with the intent on providing rapid access to pesticide labels and material safety data sheets (MSDS). For local classroom use, HTML using a WWW server can provide an innovative and alternative means for delivering lecture material.

1087

Enhance Learning Via Interactive Multimedia Presentations

*Douglas C Needham**, Dept. of Horticulture & LA, Oklahoma State Univ., 360 Ag Hall, Stillwater, OK 74078-0511.

Computer-based authoring tools, e.g. Macromedia Authorware©, allow one to produce interactive applications or computer-based training modules for horticulture teaching and extension. These applications are useful not only as presentation tools, but also as supplementary instruction, whereby a student can interact with an application at his/her own convenience and learning level. "Interactive Lessons for Introductory Horticulture©" is one example of an application used in OSU's HORT 1013: Principles of Horticultural Science course. Students are able to navigate to various topics by selecting chapters and topics within chapters. The information is not just presented, but rather acted upon by the student through movable objects, touch-sensitive areas, text, audio and video clips, etc. Student learning should be enhanced by the variety of stimuli and the ability to review an entire presentation or portion thereof at will.

173 WORKSHOP 29
Seed Storage

1088

Water Status of Seeds

*A.G. Taylor**, Dept. of Horticultural Sciences, New York State Agricultural Experiment Station, Cornell Univ., Geneva, NY 14456.

Four topics are presented on the status of water in seeds; 1) methods to express moisture content (MC), 2) methods to determine MC, 3) relationship between relative humidity (RH) and MC, and 4) utility of water activity measurements in seeds. Seed MC is expressed on a fresh-weight basis in commerce and seed technology, while dry weight basis is used in physiological or biophysical literature. Conversion equations are available for the fresh and dry weight measurements. Moisture testing methods are grouped as primary and secondary. Primary methods are direct methods in which the water is removed and determined, while the secondary methods are indirect methods that rely on a chemical or physical characteristic that changes with MC. The oven method is the most common primary technique and the electronic moisture meter is widely used as a nondestructive secondary technique. The relation between RH and MC is known as an isotherm, and three zones of water binding are observed. The RH and the seed composition, in particular the lipid content, determines the MC. Seeds with low lipid content have a greater equilibrium MC than seeds with high lipid content. Water activity, defined as the ratio of water vapor of the seed over the water vapor of pure water at a particular temperature, is related to water potential in a log-linear relationship. Water activity (aw) can be used to define the water status of any species, regardless of composition.

1089

Seed Storage—The Short and Long of It

*Eric E. Roos** and *C.W. Vertucci*, USDA/ARS National Seed Storage Laboratory, 1111 South Mason St., Fort Collins, CO 80521-4500.

Practical experience has generally been the source of guidance for seed storage from one season to the next. Our ancestors soon realized that avoiding moist warm conditions and protecting seeds from predators was necessary if seeds were to survive till the next planting season. Simple experiments, using different combinations of temperature and seed moisture content and/or relative humidity, showed that much longer storage periods could be attained by lowering one or both of these factors. Drying seeds and storing them in air-tight containers, or even under vacuum, at subambient temperatures could produce longevities of years or even decades. Many myths were recorded in the popular literature about longevities of centuries or even millennia. Recent research on the biochemistry and biophysics of deterioration have led to new theories on longevity that have turned our thinking upside down. A discussion of both practicalities of storage and theoretical aspects will be presented. Simplified recommendations are proposed for determining the most cost-effective approach for seed storage under various environmental and economic conditions.

1090

Population-based Models of Seed Viability Loss during Storage: What's the Use?

*Kent J. Bradford**, Dept. of Vegetable Crops, Univ. of California, Davis, CA 95616-8631.

In 1981, R.H. Ellis and E.H. Roberts published a classic paper on the quantification of aging and survival in seeds (Seed Sci. & Technol. 9:373). This paper and subsequent refinements described a model of seed aging in storage that was based on the fact that to a good approximation, deaths over time in a seed population are normally distributed. The model provides a quantitative description of seed longevity across a wide range of storage temperatures and moisture contents. Despite its theoretical importance and practical success, the Ellis–Roberts approach has not been widely adopted by the seed industry to assess seed quality and predict longevity in storage. This may be due, in part, to the rather unfamiliar statistics (probit analysis) used in the model and the apparent complexity of the equations. It will be the argument of this presentation, however, that the precise quantification of seed longevity that this model affords is less significant than the insight that it provides into the nature of seed populations and how to think about them. The objective of this presentation will be to demystify the Ellis–Roberts model and illustrate with concrete examples how the application of population-based thinking is advantageous in many aspects of seed storage and quality assessment.

9 ACB ORALS
(Abstracts 1200–1217)

1200

Cutting Production and Flowering Shoots from *Penstemon* and *Dianthus* Stock Plants

*Dean S. Dushack** and *Douglas A. Hopper*, Dept. of Horticulture, Colorado State Univ., Fort Collins, CO 80523.

Stock plants of two perennial species (*Penstemon* and *Dianthus*) were grown in either a warm (16C NT) or cool (10C NT) greenhouse under either natural-day (ND) or long-day (LD) continuous-lighting treatments. Black plastic curtains were placed between the treatments from 1600 to 0800 HR. Starting Apr. 1994 through Jan.1995, the number of cuttings produced and the number of flowering shoots per plant were recorded at ≈3-week intervals. Preliminary analysis shows significantly more cuttings were produced by *Dianthus* in a warm vs. a cool greenhouse under both ND and LD photoperiods. *Penstemon* showed only a slight trend toward more cuttings produced in a warm greenhouse. Conversely, *Dianthus* produced fewer flowering stems in ND as compared with LD conditions in the warm house, due mainly to a greater proportion of stems remaining vegetative in the ND photoperiod. No significant differences in number of flowering stems of *Penstemon* occurred between any of the treatment combinations.

1201

High-permeability Experimental Polyethylene Polymers for Modified-atmosphere Packaging

*Eric W. Gay** and *Randolph M. Beaudry*, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824.

O_2 and CO_2 permeabilities were determined for experimental polyethylene polymers (Dow Plastics, Freeport, Texas) in relation to low-density polyethylene (LDPE) films for the packaging of horticultural commodities. A stainless steel flow-through permeability cell was used to determine O_2 and CO_2 permeabilities at 0, 5, 10, 15, 20 and 25C for the polymers. Data were fitted to the Arrhenius' relationship and the Arrhenius' constant and energy of activation were determined. In addition, flow-through containers of sealed cherry tomatoes at room temperature were used to determine ethylene permeability of the polymers. The new polymers were several times more permeable than LDPE to O_2, CO_2, and ethylene. The results were incorporated into a model for predicting O_2 concentrations over a temperature range for sliced apple fruit. The greater permeability of the new polymers will improve control of O_2 and CO_2 in modified atmosphere packages and enhance flexibility of package design.

1202

The Impact of White-tailed Deer Browsing on Wisconsin Native Landscapes and Croplands

Laura Weiss, Univ. of Wisconsin, Madison, WI 53706.

This research was done to examine the damage to vegetation due to white-tailed deer (*Odocoileus virginianus*). Deer damage is an alarming problem in the agricultural setting, but a growing concern is the "browsing damage" to the natural habitat. Forests and their undergrowth are not able to regenerate under the heavy browsing pressure. This is posing serious problems that are in the progress of being remedied.

1203

Developing a Usage Plan for a University Teaching Garden

*Heidi L. Hoel**, Dept. of Horticulture, Univ. of Wisconsin, Madison, WI 53715.

The Allen Centennial Gardens are located at the Univ. of Wisconsin–Madison on the grounds of the National Historical site, the house of the first four deans of the College of Agriculture and Life Sciences. The 2.5-acre garden, developed and managed primarily by the Dept. of Horticulture, replaced the old teaching and display garden space taken over in building additions. Within the past 10 years the grounds have been designed and transformed into a garden, with 26 indi-

vidual collection gardens, including: turf, fruit and vegetable gardens, classic ornamental gardens (with both herbaceous and woody perennials), and a rock alpine garden. As it receives its finishing touches, an education plan is being developed to complement the education purpose of the garden; the goal of the garden is to become an active site for learning through both observation and interaction with the garden collections. The two main themes of the learning experience are: 1) the biology of the diverse and unique plant collections (including: culture, practices, and production), and 2) the aesthetics of the garden (the organization of space, form, topography, and color). Implementation of education programs will occur on the following four levels: first the university (first the horticulture department, second other departments and university functions); second, area high schools groups; third, community and professional groups; and fourth, elementary school groups. The education programs will include mapping, internships, classes, meetings, volunteerism, and tours. The Allen Centennial Gardens, with its education mission, has already and will continue to be a meeting grounds for the university community, and a meetings ground for both the professional community and Madison-area community.

1204

A Comparison of Huckleberry (*Vaccinium pahalae*) and Bilberry (*Vaccinium myrtillus*) Shoot Culture Performance on Different Support Systems

Linda J. Walker, R.B. Rogers,* and *M.A.L. Smith*, Dept. of Horticulture, Univ. of Illinois, 1201 South Dorner Drive, Urbana, IL 61801-4778.

In vitro cell cultures of huckleberry and bilberry are sources of phytochemicals for use as food colorants and bioactive chemopreventives. Shoot cultures provide a convenient, presterile source of explants for production of callus rich in extractable pigments or other chemicals. Efficient callus formation only occurs with good-quality shoots. In this study, liquid and gelled support systems were compared in terms of their effect on shoot growth. Gellan gum-based support resulted in excellent shoot proliferation and suitable shoot length for huckleberry cultures, whereas bilberry performed slightly better on agar and agar/gellan gum support. Bilberry had a more-rapid growth rate than huckleberry. Hyperhydricity was found with the use of rafts for both species. These shoot cultures have been used as vegetative explants for callus, and have produced vivid anthocyanins in solution cultures.

1205

Ornamental Grasses, Are They Acceptable Alternatives for Low-maintenance Landscapes?

Traci Armstrong, J.E. Wolfe III, J.C. Bradley,* and *J.M. Zajicek*, Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133.

Ornamental grasses are currently growing in popularity and are being used in parks, public plantings, and commercial landscapes. This study was developed to determine the esthetic appeal of 12 ornamental grasses and evaluate public attitude toward the use of these grasses in low-maintenance landscapes. Grasses were selected for this evaluation using the following criteria: recommendations of experts in the ornamental grass field; material used in the nursery trade; and recommendations in popular literature. Two field sites were prepared and planted in the Spring 1991 and 1992. Both sites were maintained and irrigated to enhance the survivability of the grasses. The survey was conducted on several dates in the Fall 1992. Participants responded to questions regarding ornamental grass use, and the need for research on water conservation in landscapes. In addition, participants were asked to rank the individual grass species as to their acceptability for landscape use. The results of the survey indicate that visual aesthetics are a major factor in public acceptance of landscape materials. In addition, the majority of ornamental grasses tested in this study were acceptable alternatives for low-maintenance landscapes with native and introduced species equal in performance.

1206

Effects of Different Durations and Timing of Far-red-deficient Environments on Chrysanthemum Growth

Glenn Carey, Gary Bachman,* and *Margaret McMahon*, Depts. of Horticulture and Crop Science, 202 Kottman Hall, The Ohio State Univ., Columbus, OH 43210.

The effect on plant height and internode length of 'Iridon' chrysanthemum by far-red-deficient environments for two different durations was evaluated. Far-red deficiency was achieved by placing plants under double-walled polycarbonate panels filled with 6% (w/v) copper sulfate ($CuSO_4$) solution. Controls were polycarbonate panels without $CuSO_4$ solution. The plants were divided at random into four groups. One group was exposed all day to the $CuSO_4$-filtered (ADCu) environment and another to all-day clear (ADCl) environment. Another set of plants were grown under $CuSO_4$ filters and moved under clear filters 1 h before sunset each day (EODCl), while the last set of plants were grown under clear panels and moved under $CuSO_4$ panels 1 h before sunset each day (EODCu). Plants moved at the end of the day were moved back to their original chambers after dark each night. The experiment was replicated. Overall change in plant height and average internode lengths were measured. The results were compared to ADCl (control). A 31% reduction in plant height was observed for EODCl, 42% reduction for ADCu, and 25% reduction for EODCu. Average internode length was reduced 11% for EODCl, 14% for EODCu, and 33% for ADCu.

1207

Fertilizers and irrigation Techniques for Container Nursery Stock Production

Laurie Robinson-Hipple, Faye Propsam, James B. Calkins,* and *Bert T. Swanson*, Dept of Horticultural Science, Univ. of Minnesota, 1970 Folwell Ave., St. Paul, MN 55108.

Media fertility, plant nutrient availability, and subsequent plant nutrition are critical factors in the production of quality landscape plant materials. The method of mixing slow-release fertilizers into the media prior to planting is becoming more widespread. This study evaluates different controlled-release fertilizers, their rates of release, and three methods of irrigation regarding water-use efficiency and effects on plant growth performance. The combined effects of fertility and irrigation practices on nutrient loss to the environment are also being monitored. Although the ranking of fertility treatments, based on plant quality, varied among species, Woodace 21–4–10, Sierra 17–6–10, Sierra High N (24–4–6, Scotts 20–7–10, (270–26.67 lb/yd^3), Woodace 20–5–10, Polyon 25–4–12, Nutricote 18–6–8 (270–30 lb/yd^3), and Nutricote 18–6–8 (270–20 lb/yd^3) produced high-quality plants for most of the species evaluated. The control and Nutri-Pak 18–6–12 treatments resulted in relatively poor-quality plants across the board. The effects of irrigation techniques on leachate analysis are being completed.

1210

Citrus Situation in Iran

*Sadeghi Hossain**, College of Agricultural Sciences, Sari, Iran.

Citrus was planted in about 50 countries and its world production in 1992 was >70 M t. Ninety percent of this production was in countries located at 20°–40° lat.N&S. Citrus history in Iran goes back 800 to 1000 years, and is planted in various regions, from the tropical south (28°) to the Mediterranean north (38°). Iran, with 3 million tons of production, is 7th in the world in production and is the first horticultural product in the country. Orange, mandarin, sweet lemon, and lime, with 1.8, 0.6, 0.25, and 0.25 million tons, respectively, are the main species. Processing industries are active, and produce 9000 t of concentrate. Exports to other countries was little, and, in 1993, was only 30,000. There is a good market in middle-Asian countries.

1211

Promoting the Residential Habitat Garden through Education

*James Johnson** (Mary Haque, Advisor), Dept. of Horticulture, Clemson Univ., Clemson, SC 29634-0375.

As the need to design residential landscapes in an environmentally sensitive manner becomes more apparent, the demand for educational materials and activities that promote the habitat garden is growing. In response to this need, an educational plan, ranging from the publication of a booklet to the implementation of a demonstration garden, has been undertaken. The booklet should serve both the homeowner and the professional designer interested in wildlife-sensitive designs. Horticultural faculty and students are being organized to implement one of my designs on the Clemson Univ. campus to demonstrate the habitat garden concepts found in the booklet. Working with local homeowners by designing and having their yards certified by the National Wildlife Federation as "Backyard Wildlife Habitats" has also served to promote the habitat garden. I am also working with the Dept. of Horticulture and senior citizen volunteers to raise money to build a demonstration garden in the South Carolina State Botanical Garden. The incorporation of written materials, designs, certifications, and demonstration gardens into an educational package has resulted in a community effort to promote the habitat garden.

1213

Composted Poultry Litter as a Low-cost Media Amendment

*Matt Welch** and *D.L. Creech*, Dept. of Agriculture, PO Box 13000 Stephen F. Austin State Univ., Nacogdoches, TX 75962.

The poultry industry is a $1 billion industry in Texas, with most production centered in eastern Texas. The nursery industry is a $600 million industry, with 25% of the producers located in eastern Texas. With hundreds of millions of birds produced each year, and each bird producing ≈2 lb of manure, waste disposal is a growing problem. Composted poultry litter was mixed with composted pine bark to create five media with varying percentages of poultry litter as a component: 0%, 5%, 10%, 20%, and 40%. A randomized complete-block design was used with poultry litter rates as main plots and plant species tested as subplots. Five species included: tomato, marigold, *Cortaderia selloana*, Asian jasmine, and *Salvia leucantha*. Prior to planting, all 1-gal containers were leached with 1000 ml of water, the leachate collected, and tested for conductivity. Plant growth measurements to be presented include plant height and dry weight. The results of media and leaf tissue nutrient analysis will be presented.

1214

The Effect of Salinity on Strawberry Stress and Growth on Two Soil Types

*Patricia Swearingin**, Horticulture Program, Northwest Missouri State Univ., Maryville, MO 61468.

Plants of strawberry (*Fragaria* x *ananassa* cv. Tristar) of the same size were grown in 4-inch plastic plots either containing sand or organic soil mix. Plants were watered with solutions of 10, 25, and 50 mM of NaCl, and some with distilled water used as control. Under sunny conditions, the chlorophyll fluorescence measurements indicated that plants growing in sandy soil with 50 and 25 mM of NaCl with Fv/Fm values less than 0.40 tend to show salinity stress after 10 days with 50 mM NaCl, and after 15 days with 25 mM NaCl. Plants grown in organic soil mix do not show stress symptoms at any of the given NaCl concentrations. Plants growing under cloudy days do not show stress symptoms, whether or not the plants were grown in sandy soil or organic soil mix. No significant differences were detected on the total average shoot and root dry weights of plants grown in sandy soils and organic soil mix. However, highly significant differences was detected on the total average shoot dry weight growing under organic soil mix. These data indicate that organic matter reduces the effect of Na^+ and Cl^- on strawberry plant growth by decreasing the physiological stress during bright, sunny days. Plant tissue analysis shows that plants grown in organic soil mix absorb far less Na^+ and Cl^- than in sandy soil. Also, it does seem that strawberry plants can tolerate low concentrations of NaCl ions in the soil solution.

1215

RAPD Banding Patterns in Sweetpotato Infected with *Fusarium lateritium*

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Chlorotic leaf distortion is a common disease of sweetpotato caused by *Fusarium lateritium.* This fungus is unique among Fusarium species in that it grows epiphytically on leaves and shoot tips of sweetpotato. *Fusarium lateritium* mycelia appear as white masses on leaves, and this fungus can cause chlorosis under periods of bright sunlight. When environmental conditions are not favorable for growth, this organism is not readily observed on sweetpotato. The objective of this research was to see if DNA of *F. lateritium* is amplified using PCR techniques during amplification of sweetpotato DNA. Our results show cTAB extracts of sweetpotato inoculated with *F. lateritium* have additional bands not present in a control free of *F. lateritium.* Furthermore, these bands correspond to banding patterns obtained from the *F. lateritium* isolate DNA when amplified alone. Researchers who use sweetpotato tissue in PCR-based research, e.g., phylogenetic research, should be aware of these amplified products. This situation is further compounded because numerous *F. lateritium* biotypes are present in the environment.

1216

Effects of Chilling, Ethanol, and Heat Shock on Enzyme Expression in Cucumber Seedling Roots

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Chilling-sensitive cucumber seedlings that are treated with ethanol or heat-shocked have shown an increase in chilling tolerance. The mechanisms that regulate this response have not been identified. Cucumber seeds were germinated for 24 h and then treated with 500 mM ethanol for 2 h or heat-shocked at 40C for 3 h. Immediately after treatment, roots were excised and catalase activity was assayed. Another set of control and treated seeds were chilled for 72 h and catalase was assayed at the end of the chilling period. Comparisons will be presented between catalase activity levels before and after chilling, as well as between the control and treated groups. Treatments of ethanol and heat shock resulted in an increase in catalase activity when compared to controls.

1217

Growth and Economic Assessments of Kenaf Core as the Major Component in Greenhouse Potting Media

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Two types of ground kenaf core (fresh and aged) were used in concentrations from 70% to 100% (v/v) in combination with peat for use as greenhouse potting media, and were compared to two commercial mixes in completely randomized-block designs. Greenhouse crops of Boston fern (*Nephrolepis*), Impatiens, and pansies (*Viola*) were grown in the different mixes. Irrigation was conducted regularly, based primarily on the average need of all the plants. Kenaf-based media did not retain water as well as the commercial mixes; consequently, impatiens and pansies displayed slower growth rates. However, no differences were noted for fern growth in 70% kenaf compared to commercial mixes. A second study on plants that were grouped by media type and watered as needed provided different results. Ferns grew equally well in all media, but Impatiens grew best in 70% fresh kenaf. Kenaf-based media were less costly than the commercial mixes, and the cost decreased steadily as the kenaf proportion increased. The lower cost of kenaf, coupled with the decreasing availability of peat, should make kenaf-based media an attractive alternative to conventional greenhouse potting media.

28 ACB POSTER COMPETITION

1220

Response of Wetland Taro Yield and Weeds to Preplant Establishment of Azolla in Hawaii

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Azolla (*Azolla filiculoides*) is a floating fern that maintains a symbiotic relationship with an N-fixing blue-green algae. In many parts of Asia, azolla is used as a green manure in flooded rice cultivation. Taro (*Colocasia esculenta*) grown under flooded conditions is used to produce a traditional Hawaiian staple, poi. Azolla has been present in Hawaii for many years, but is not used in a controlled way for either nutrient augmentation of production sites or weed suppression. In this experiment, azolla was removed from a stream on the island of Kauai and multiplied in a nursery pond. Phosphoric acid was added to the nursery pond as a nutrient (P = 5 ppm) at 5-day intervals to accelerate azolla growth. Azolla was moved from the nursery pond and added to taro production plots at a seeding rate of 488 $kg \cdot m^{-2}$. Phosphoric acid was used in production plots to hasten coverage of the water surface by azolla. Ten days after azolla inoculation, production plots were covered and taro seed pieces were planted. Weed dry weights from conventional and azolla covered plots were recorded 91 days after taro planting. Taro corms were harvested 315 days after planting. Weed dry weight in azolla plots was 86% less than conventional plots. Azolla delayed taro maturity, causing a 41% reduction in marketable corm yield.

1222

The Effect of Bud Thinning on Yield Compensation in 'Kotata' and 'Marion' Trailing Blackberry

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Mature 'Kotata' and 'Marion' trailing blackberry plants were studied in 1994. In 'Kotata', canes were subjected to 0%, 25%, 50%, 75%, or 100% primary bud removal in Feb. 1994. In 'Marion' 0, 55, or 100 primary buds were removed per dm^2 from fruiting sections (panels). Primary bud removal did not subsequently affect yield per cane or per dm^2 in either cultivar. Yield compensation occurred through production of secondary laterals, which were as fruitful as primary laterals.

1224

Transient Expression of β-Glucuronidase (GUS) Activity in Embryogenic Callus Tissue of Alkaligrass (*Puccinellia distans*) using Particle Bombardment

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Callus induction and regeneration of alkaligrass (*Puccinellia distans*) was developed in our laboratory for use in transformation studies of turfgrass. Particle bombardment of the embryogenic callus is being evaluated using a helium particle inflow gun constructed at Colorado State Univ., according to the design of Philippe et al. (Ohio State Univ., 1993). Its utility in delivering DNA to plant cells is being tested by measuring the frequency of transient gene expression of a reporter gene (GUS pBI121) in embryogenic callus of alkaligrass. Varying pressure of helium and the distance of the calli in the chamber are also being evaluated for efficiency in transformation.

1226

The Effect of a Competitor Species on the Seedling Development of *Lythrum salicaria*

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Purple loosestrife (*Lythrum salicaria*) is a plant that was originally introduced to the United States as an ornamental, but was soon found to be invasive in wetland habitats. *Lythrum* reduces plant and wildlife diversity in these areas and causes the extinction of rare species. Our research was conducted to determine if another species planted along with *Lythrum* would act as a competitor and reduce the invasive characteristics of the plant. We also compared this with its invasiveness in different types of media (peatmoss and sand) to determine if its ability to take over was related to the media in which it was growing. The competitor species we chose was cordgrass (Spartina pectinata) because it is a typical grass native to wetlands. We varied the planting times of the *Lythrum* and *Spartina* in different pots and recorded germination rates and the final dry weights of both species. We found significant differences among the plants at each planting time and between the plants in the peatmoss and sand.

1228

$Cu(OH)_2$ Affects the Growth and Root Structure of Two Woody Ornamental Species

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Root girdling and deformation are problems that occur in containerized woody ornamentals. Two small trees, the coarse-rooted *Magnolia* x *loebneri* 'Leonard Messel' (grown in 5-gal containers), and the fine-rooted *Crataegus* x *viridis* 'Winterking' (6' bare root), were transplanted into 10-gal containers, some of which were treated with "SpinOut" [a latex paint containing 100 g $Cu(OH)_2$/liter]. The plants were grown in a pot-in-pot system for 3 months, after which new roots were analyzed for mat formation and branching pattern. No significant differences in shoot growth that could be attributed to the $Cu(OH)_2$ treatment were observed. The treated containers prevented both root encirclement and reformation of matted roots, and resulted in a more-dense and fibrous root system than that observed in untreated containers. The differences were greatest with the coarse-rooted magnolia. The use of containers treated with copper compounds may be an effective means to reduce root problems commonly observed in modern containerized ornamental production.

1230

Propagation of a Threatened Plant Species: American Hart's-Tongue Fern

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Phyllitis scolopendrium var. *americana* is a rare North American fern species whose range is being threatened by habitat alteration. Research efforts were undertaken to ensure survival of the southern population by applying horticultural techniques to propagate new plants for reintroduction. Several techniques were used to induce spore germination. Aseptic techniques included direct plating of spores onto agar medium in petri dishes and dusting spores into test tubes filled with liquid medium. Spores were spread onto soil samples taken from the fern habitats and onto various other propagation media. Prothalli grown in nutrient solution were transferred onto various nonsterile conventional horticultural media. Results indicated that germination in the nutrient solution and subsequent transfer of prothalli was more efficient and promoted survival of propagules compared to subculture from solidified medium.

1232

Agrobacterium rhizogenes Influences in Vitro Morphogenesis in Stem Segments of Woody Plants

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Agrobacterium rhizogenes is a valuable new tool for inducing adventitious roots in difficult-to-root ornamentals To evaluate species and strain interactions, three ornamental species were chosen: *Hydrangea quercifolia, Pyrus calleryana,* and *Photinia* x *fraserii.* Terminal shoots (2.5 cm long) were collected at bud swelling and then immersed in bleach (20% v/v) for 10 min with stirring. They were rinsed three times in sterile distilled water and cultured individually in test tubes containing 15 ml of Murashige and Skoog medium. After 3 weeks, the uncontaminated shoots were divided into five groups: four strains of *A. rhizogenes* and a control. There was a significant effect of strain and species in the production of callus and organs from the shoot tips. The presence of strain by host interaction was observed In the morphogenic response of explants.

1234

Physiological and Biochemical Changes on the Roots of Aeroponically Grown, Phosphate-starved Tomatoes

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Phosphate starvation in plants results in altered biochemical and physiological responses. We are interested in understanding the changes that occur in response to phosphate starvation in the roots of tomato plants. Plants were grown in an aeroponic system developed by L.A. Peterson at the Univ. of Wisconsin. Aeroponically grown tomato plants were treated with various concentrations of phosphate, ranging from to 250 mM. Phosphate-starved plants exhibited significantly higher root to shoot ratios and a 40% decrease in the chlorophyll content of the leaves. Several changes in essential nutrient content were also observed. The phosphate concentration of both root and shoot tissues decreased as the Pi content of the nutrient solution decreased. Whereas the ratio of phosphate content in roots compared to the shoots did not change significantly in response to Pi starvation. Phosphate-starved plants accumulated significantly higher amount of magnesium in stem tissues. Furthermore, it also resulted in an increased accumulation of potassium in roots. Interestingly, the total extractable RNA from phosphate-starved roots was 1/5th of that of control roots. There was also a noticeable decrease (50%) in the total extractable RNA content of leaves from phosphate-starved plants.

1244

Can Designers Work Horticulture Education into the Process of Public Horticulture?

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A 5-acre neighborhood park in Longmont, Colo., was designed for a senior design class. A series of town meetings coordinated with special interest groups was used to develop the design. The first goal of the town meetings was to provide the community with a sense of ownership of the park. Park requirements included a protected wetland, recreational needs, and circulation to other parks and open space. The design integrated facilities placement, recreational equipment, bird viewing areas, a wetland interpretive walk, and ease of maintenance and accessibility. Input from the town meetings led to several design manipulations. Native vegetation was reclaimed with native forbs and grasses. The use of native plantings integrated into the design will be reviewed as will the input from the several groups. This will focus on the educational process and impact on the final document without a loss of integrity of the design.

1248

The Effect of Heat Shock, ABA, and Salicylic Acid on Induction of Chilling Tolerance in Cucumber Seedling Roots

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Chilling injury can be a serious problem during field germination of sensitive crop species. Because heat shock has been shown to induce chilling tolerance of

germinating cucumber seeds, an experiment was initiated to determine the effectiveness of other treatments. Cucumber seeds germinated 20 to 24 h were either heat-shocked at 50C for 2 min or treated with ABA or salicylic acid for 4 h. Following treatment, the germinated seeds were chilled at 2C for 96, 120, or 144 h and then incubated at 25C to determine growth effects on the developing root. All treatments induced chilling tolerance compared to the controls, with ABA and heat shock being most effective after chilling. There did not appear to be an additive response when heat shock was used in combination with ABA. The evidence for different treatment mechanisms will be discussed.

1250

The Response of Stem Girdling and Covering Material on Air-layering Propagation of Rubber Plants

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A greenhouse study was conducted to determine the influence of four stem girdling methods and the use of three covering materials on air-layering propagation of rubber plants (*Ficus elastica* L.). Stem girdling methods consisted of a control, slit, copper wire, and debarking. Black plastic, clear plastic, and aluminum foil were the covering materials used. Results from this study showed that all of the covering materials responded similarly when compared to the control. All of the stem girdling treatments stimulate the number of roots, root growth, and root fresh weight when compared to the control. However, the debarking treatment produced the greatest number of roots, root length, and root fresh weight.