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Effect of accel (gibberellins (ga_{4+7}) + benzyladenine) on the shelf life of French beans, *phaseolus vulgaris* L.

J. AMBUKO, E.V, EMONG'OR, S.I. SHIBAIRO & G.N. CHEMINING'WA
Department of Crop Science, University of Nairobi.
P.O Box 29053 Nairobi, Kenya.

Abstract. To determine the effects of Accel on the shelf life of French beans, *Phaseolus vulgaris* L. variety Monel, two field experiments were conducted at the University of Nairobi's Kabete Field Station for two seasons. Accel was sprayed at 12.5, 25.0, 37.5 and 50.0 mg/litre to the bean plants to run off just before flowering. The field experiments were followed by laboratory experiments where the effect of Accel on water content and moisture loss by the French bean pods after storage was determined. Chlorophyll content of fresh pods at harvest and that retained by the pods after eight days of storage was also determined. Increase in Accel concentration led to a linear increase in the water content of pods. Accel reduced moisture loss by the pods thereby reducing the extend of wilting. A pplication of Accel significantly increased fresh pod chlorophyll content and enhanced chlorophyll retention in the pods after storage. The response to increasing Accel concentration was linear.

Introduction

French beans are grown in Kenya mainly for the export market. One of the major problems in French bean production is the high postharvest losses incurred once the crop is harvested (HCDA, 1996). Increased postharvest losses in French beans is a result of lack of organized market facilities such as transportation and temporary storage and the seasonality of the crop (Obara, 1991). Like other horticultural commodities, French beans are highly perishable and rapidly deteriorate after harvest (Ryall and Lipton, 1979). Measures to improve the shelf-life include those that may reduce water loss by pods and improve chlorophyll retention thereby slowing down the yellowing of pods. Cytokinins and Gibberellins (GAs) have been known to retard senescence in plant tissues. Chlorophyll decline in senescing plant tissues is a good indicator of the progress of senescence (Leopold *et al*., 1959). Senescence is accompanied by early losses in chlorophyll, RNA and proteins including many enzymes. These losses could be a result of slower synthesis and/or faster breakdown of the macromolecules (Salisbury and Ross, 1990). Humbeck, *et al*., (1996) reported that during senescence, chlorophyll and photosynthetic proteins are degraded. Exogenous application of cytokinins has been shown to inhibit the degradation of chlorophyll and photosynthetic proteins in detached tissues (Badenoch-Jones, *et al*., 1996 and Van Staden and Joughin, 1988).

Cytokinins have been shown to interfere with senescence in detached tissues of dicotyledons and monocotyledons (Van Staden et al., 1988). Salisbury and Ross (1990) reported the ability of cytokinins to enhance subsequent development of etioplasts into chloroplasts and increase the rate of chlorophyll formation. The senescence delaying ability of cytokinins has been explored in horticultural commodities such as cut flowers, brussel sprouts, broccoli and celery (Van Staden and Joughin, 1988; Salisbury and Ross, 1990).

Symptoms of the final stages of senescence are loss of fresh weight, drying and shriveling. Plant growth regulators (PGRs) are known to have a significant effect on water balance in plant tissues. Gibberellins have been shown to enhance water retention in plant cells, hence increase fresh

weight (Salisbury and Ross, 1990). Addition of Benzyladenine (BA) and gibberellic acid (GA_3) to vase solutions has been reported to improve water uptake and maintain a better water balance thereby increasing cut flowers'vase-life (Bhaskar and Rao, 1998). The objectives of this study were to elucidate the effects of Accel (Benzyladenine + gibberellins GA_{4+7}) on the shelf life of French beans.

Materials and methods

Field experiments were conducted during the short rains in 1998 and the long rains in 1999 to determine the effects of different concentrations of Accel on the shelf life of French beans cultivar Monel. The experiments were carried out at the Kabete Field Station, University of Nairobi. This site lies at an altitude of 1,940 m above sea level and between latitudes 1^0 14' 20² to 1^0 15¢ 15² South and longitudes 36° 44' to 36° 45' East. The mean monthly maximum temperature is 23°C while the mean minimum temperature is 12°C. The area has a bimodal rainfall pattern with peaks in April and November. The annual rainfall is slightly above 1000 mm. The soils are deep, well-drained and friable humic nitosols with kaolinitic clay minerals (Mburu, 1996).

The experimental treatments were laid out in a randomized complete block design with 4 replications. Each experimental plot measured 3m X 3 m. Furrows spaced 40 cm apart were prepared and diammonium phosphate fertilizer applied at a rate of 100 Kg/hectare. Bean seeds were then planted along the furrows at a spacing of 10 cm within the rows. Hand weeding was done to keep the field weed free throughout the experimental period. Dimethoate was sprayed at a rate of 30 ml/20 litres of water to control aphids. Treatments comprised different concentrations of Accel namely 0, 12.5, 25.0, 37.5 and 50.0 mg/litre. Accel is a liquid concentrate containing 20 g a.i/litre (w/w) 6-benzyladenine (BA) and 2 g a.i/litre gibberellins; GA_{4+7} (Abbott Laboratories, North Chicago, USA). Accel was applied to bean plants at 28 days after emergence (DAE), just before flowering.

The data collected include water content, moisture loss, wilting and chlorophyll content of the pods. A random sample of 40 harvested pods was picked at 35, 42 and 49 days after emergence during the short rains and at 38, 45 and 52 days after emergence in the long rains for moisture content determination. The fresh pods were weighed and oven dried at 66 °C to determine the dry weight. The percentage water content was computed using the formula:

$$\textit{Water content \%} = \left(\frac{\textit{Fresh weight} - \textit{Dry weight}}{\textit{Fresh weight}}\right) X\ 100$$

Moisture loss in harvested pods was determined from a sample of 40 pods at 45 DAE n both seasons. The initial fresh weight of the pods was determined and the pods stored under ambient room conditions. The pods were weighed daily to determine the daily water loss during storage. The daily water loss was computed as the weight of pods on the given day subtracted from the initial fresh weight.

A random sample of 40 pods was picked from the harvested pool of pods at 48 and 50 DAE in the short rains and long rains, respectively, for determination of pod wilting. The extend of wilting was determined by carrying out a snapping test on the pods stored at ambient room conditions for 3 days. Each pod at a time was held to leave a space of about 8 cm between the fingers and then bent to form a closed loop. The pods that looped without snapping were considered wilted, while those that snapped before looping were considered turgid hence unwilted (Njeru, 1989). The number of pods that looped was expressed as a percentage of the initial number of pods (40) that was used to do the test.

To determine the chlorophyll content of the pods, a random sample of 10 pods was collected from each experimental unit 42 and 44 DAE the short rains and long rains respectively. Thin slices measuring 0.785 cm^2 obtained from the outer layer of each pod were placed in 4 ml of 0.1N HCl in Methanol (88%) and incubated at 21°C in a dark room for 24 hours. The absorbance of the extracts was measured at a wavelength 653 nm of using a spectrophotometer (WPA S105). The chlorophyll content per unit pod area was calculated using the formula as shown below (Douglas, 1983).

$$\textit{Chlorophyll (mg/cm}^2\textit{ leaf)} = 24.88\ X\ A_{653\ nm},$$

where: A is the absorbance at 653 nm and 24.88 is a molar extinction coefficient. After determination of the initial chlorophyll content of the fresh pods, another sample of 10 pods from each experimental unit was stored atambient room temperature. Chlorophyll retention by the pods after 8 days of storage was determined.

Analysis of variance was performed on the data collected using the general linear models (Proc GLM) procedure of the Statistical Analysis System (SAS) program package (Carey, 1991). Linear, quadratic and cubic orthogonal polynomials were tested and appropriate regression models were used to examine the nature of the response to Accel (Snedecor and Cochran, 1989). Multiple comparisons among means were done using Least Significant Difference (LSD) at P=0.05.

Results

In both the short rains and long rains, application of Accel at 25.0, 37.5 or 50.0 mg/litre significantly increased the water content of pods. There was no difference among these Accel levels. Accel at 12.5 mg/litre had no effect on the water content of the pods (Table 1). In the short rains, Accel at level 25.0, 37.5 and 50.0 mg/litre significantly reduced the percentage of wilted pods whereas level 12.5 mg/litre no effect. Application of Accel did not reduce wilting of pods significantly in the long rains (Table 2). In both seasons, Accel significantly reduced moisture loss from the harvested pods throughout the storage period. The greatest effect was observed from Accel at levels 37.5 and 50.0 mg/litre. Accel at 12.5 mg/litre did not have a significant effect on moisture loss by the pods (Figure 1 and 2). Accel application

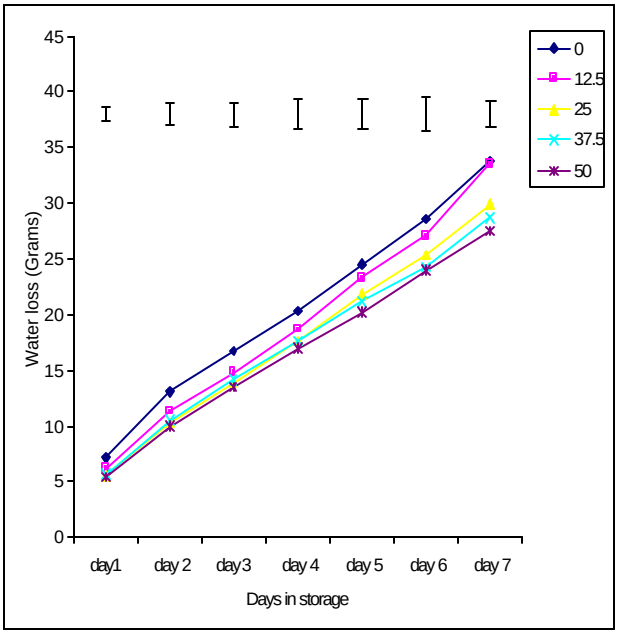

Figure 1. Effect of Accel on water loss in harvested pods (short rains) Vertical bars are LSD bars at P = 0.05

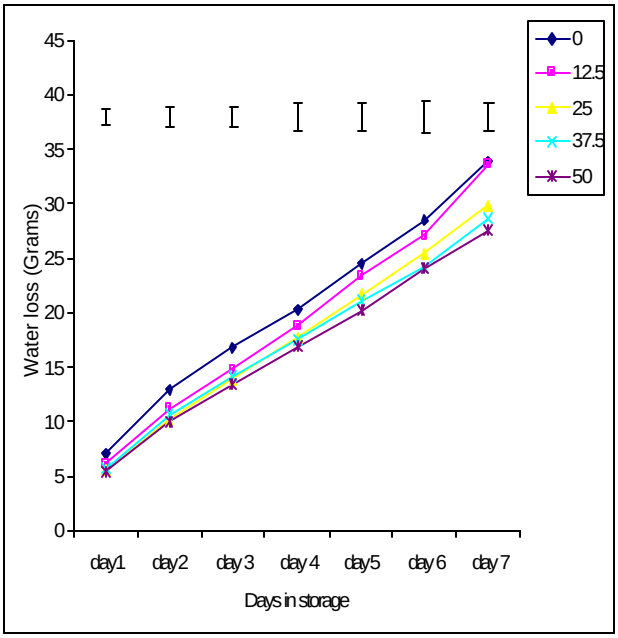

Figure 2. Effect of Accel on water loss in harvested pods (long rains) Vertical bars are LSD bars at P = 0.05

significantly increased pod chlorophyll content in both seasons. In the short rains. The chlorophyll content increased with increasing Accel concentration (Table 3). In the long rains, Accel at 12.5, 25.0, 37.5 and 50.0 mg/litre significantly increased the pod chlorophyll content but their effects were not different from each other (Table 3). Accel significantly increased chlorophyll retention by the pods after 8 days of storage. The response to increasing Accel concentration was linear in both seasons (Table 3).

Discussion

Accel application significantly increased the water content of pods and reduced the rate of water loss by the pods during storage, thereby slowing down the wilting process. Cytokinins are known to enhance dry matter production rather the fresh weight of plant tissues (Emongor, 1995). Gibberellins on the other hand promote fresh weight and succulence at the expense of dry weight (Mutui, 1999). Gibberellins have been reported to increase water uptake and water retention capacity in some plant tissues (Toa – HanZhi et al., 1995). Gibberellins also increase hydrolysis of starch, fructans and sucrose into glucose and fructose molecules (Salisbury and Ross, 1990). These hexoses in turn increase the cell's osmotic potential, making the cell to draw in water from its environment. This results in increased succulence of treated tissues. The enhanced water content of the French bean pods following Accel application may be attributed to this gibberellin effect.

Wilting of senescing detached plant tissues such as leaves, pods and flowers is a result of water loss. Longevity of such tissues depends on their ability to maintain turgidity, which is determined by the balance between the rate of water loss (utilization) and the rate of water supply (Mutui, 1999). Turgidity is necessary for the continuance of normal metabolic activities in the cells (Roger, 1973). Some PGRs have been shown to influence water relations in detached plant tissues such as cut-flowers by enhancing water uptake, therefore delaying wilting (Mayak and Halevy, 1974). The enhanced water uptake serves to maintain cell integrity. Besides delaying water loss, BA is able to reduce ion leakage associated with senescence, thereby maintaining cell integrity (Van Meeteren, 1979). Reduced wilting can therefore be attributed to the enhanced water content of the pods and the improved cell integrity and/or water balance following Accel application.

Application of Accel significantly increased chlorophyll content and retention of the French bean pods. This effect of Accel on chlorophyll content could be attributed to the benzyladenine, which is a cytokinin. Cytokinins delay senescence primarily through their effect on chlorophyll and protein synthesis and/or retention by plant tissues (Salisbury and Ross, 1990; Momotani et al., 1991). Chemical analyses show that leaf senescence is accompanied by early losses in chlorophyll, RNA and proteins, including many enzymes. These losses could be a result of slower synthesis and/or faster breakdown of the chlorophyll, RNA and proteins (Humbeck *et al*., 1996). In the present study, Accel may have slowed down the progress of senescence in French bean pods by slowing down the breakdown of these macromolecules. Van Staden and Joughin (1988) reported that cytokinins delay and/or inhibit chlorophyll breakdown by reducing the rate of protein degradation during senescence. Cytokinins have also been shown to enhance development of etioplasts into chloroplasts and to increase the rate of chlorophyll formation (Salisbury and Ross, 1990). These known Cytokinin effects possibly resulted in the higher chlorophyll content of the treated pods and the higher retention of chlorophyll by the French bean pods after storage.

In conclusion, Accel has the potential to reduce the post harvest loss of green succulent vegetables such as French beans by slowing the progress of senescence. Accel at three levels tested, level 25.0, 37.5 and 50.0 mg/litre all had significant affect on most of the parameters measured. However, since the effect of Accel at 25.0 mg/litre was not significantly different from the higher levels (37.5 and 50.0 mg/litre), this rate may be recommended for commercial application.

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