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RESEARCH ARTICLE

Effects of Early and Late Harvest on Agronomic Performance and Stability of Late Blight Resistant (R-gene Free) Potato Genotypes

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Abstract

Late blight is an important constraint to potato production and genotype resistance is an effective disease control mesure. Ten late blight resistant potato genotypes (R-gene free) were assessed for yield performance and stability at early (90 days) and late harvest (120 days) at two locations in Kenya during two years. Significant differences ($P < 0.05$) in area under disease progress curves (AUDPC) were detected among potato genotypes. Resistant genotypes free of R-genes had significantly ($P < 0.05$) higher yield at late than early harvest, perhaps due to increased tuber bulking period. The rank of genotypes for AUDPC, late blight resistance, and tuber yield varied across seasons and locations (environment). Additive main effects and multiplicative interaction (AMMI) analysis of tuber yield and late blight resistance resulted in significant ($P < 0.05$) effects of genotypes (G) and environments (E). The proportion of genotypic variance was larger than the environmental variance and the G × E interactions. For tuber yield, the G, E, and G × E interactions accounted for 42.9, 39.6 and 17.5%; and 53.4, 29.7, and 16.9% at early and late harvests, respectively. For AUDPC, G, E, and G × E accounted for 80.2, 5.0, and 14.8%; as well as 82.3, 4.6, and 13% for early and late harvests, respectively. The resistance of potato genotypes without R-genes varied. Selective deployment of resistant genotypes can improve potato tuber yield.

Key words: AMMI analysis, harvest dates, *Phytophthora infestans*, R-gene free genotypes, *Solanum tuberosum*, yield

Introduction

Late blight disease, caused by *Phytophthora infestans* (Mont. De Bary) is a significant constraint in potato production (Turkeensteen and Zimnoch-Gucowska 2002). The disease is a major threat to potato cultivation in the tropical highlands, and yield losses vary from 35 to 75%, depending on cultivar susceptibility and environmental conditions (Ojiambo et al. 2001, Olanya et al. 2001). Although late blight can be controlled by fungicide applications, costs are prohibitive to most of the small-scale farmers and the detrimental effects of inappropriate fungicide applications are of tremendous concern. Similarly, fungicide effectiveness is often constrained by lack of sufficient knowledge of disease management practices by small-scale potato growers (Nyankanga et al. 2004).

The use of host plant resistance is the most effective and economically viable late blight management options especially for the resource-constrained potato farmers (Landeo 2002). Potato genotypes without major resistant (R) genes have partial resistance to late blight and are often stable and durable (Landeo et al. 1995). In general, genotypes with early maturity have been shown to be more susceptible to late blight than genotypes with late potato maturity (Visker et

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al. 2004). Several studies have documented late blight resistance, disease, and yield stability of potato cultivars under tropical and sub-tropical environments (Mulema et al. 2004, 2008; Olanya et al. 2006).

In the highland tropics, potatoes are grown twice a year and farmers often prefer early maturing genotypes or cultivars since there is substantial risk for tuber yield reduction by unfavourable climatic conditions and infection by pests and pathogens. In addition, early harvests of potato are preferred due to the short-term demand for food and fluctuations in market prices during critical periods of food shortages during the year. The maturity duration as a genotypic trait in potato has been defined based on either the occurrence of tuber formation or leaf senescence (Turkeensteen and Zimnoch-Gucowska 2002). The extent to which maturity duration and late blight resistance may impact tuber yield in specific production locations has not been ascertained. It has been documented that tuber formation in potato plants occurs at similar stages of plant growth, and that this process is independent of the maturity duration (Kawakami et al. 2005). Assessment of the relationships between potato maturity duration and late blight resistance in tropical environments would be beneficial for improved tuber yield.

The selection and breeding of potato cultivars for early bulking and late blight resistance may lead to improved potato production. Similarly, an assessment of disease and yield stability of resistant potato genotypes may contribute to increased potato yield. Disease and yield stability of potato clones have been previously examined in some highland tropical environments (Mulema et al. 2004, 2008). In this study, the extent to which late blight disease development can be minimized and yield stability maximized in potato genotypes free of R-genes when cultivated under early and late harvest scenarios at different locations were investigated. This research presents unique results on the agronomic performance and late blight resistance as well as disease stability that have not been previously documented. In previous studies, the cultivars utilized were either derived or developed from clones with vertical or high levels of resistance or had cultivars with quantitative resistance but with few major resistant genes. Due to the severe yield constraints imposed on cultivar performance in tropical highland environments, this research documents and characterizes disease and yield stability on new genotypes that could result in significant yield increases in the resource-constrained environments. The yield performance and disease reaction of these new potato genotypes and clones have not been previously investigated under environments in which late blight pressure is abundant all year around. Moreover, in many of the previous experiments, cultivar resistance and fungicides were utilized as synergistic or complementary management options for potato late blight. Due to the changing nature of pathogen populations (*P. infestans*) in various geographical regions, it is imperative to assess new potato genotypes and characterize resistance and tuber yield attributes so as to enhance potato productivity. Therefore, the objectives of this research were to: (1) evaluate early and late harvests in relation to potato yield and (2) quantify the stability of advanced R-gene free clones in the tropical climate environment of Kenya.

Materials and Methods

Potato genotypes and field experiments

The experiments were established at two locations: at the National Potato Research Center, Tigoni (Limuru) at 2,300 meters above sea level (masl) and Marimba (Meru) at 1,844 masl during the 2005 and 2006 cropping seasons. The average annual rainfall and mean temperatures for Tigoni are 800 mm and 18ºC, and 1,299 mm and 18.5ºC for Marimba, Meru. Major soil type for the two sites is humic nitisols (Jaetzold and Schmidt 1983).

Ten advanced late blight resistant potato clones from breeding population B3 developed by International Potato Center (CIP) breeding program and introduced to Kenya by CIP's Sub-Saharan Africa Regional Office in 2002 were utilized. They consisted of: 385524.9, 389746.2, 391696.96, 392617.54, 392637.10, 392657.8, 393280.57, 393371.58, 393385.39, and 393385.47 and two local check cultivars: Tigoni (moderately resistant to late blight) and Kerr's Pink (highly susceptible to late blight) which were evaluated in this study. Population B consists of genotypes with quantitative resistance to late blight, which is effective against a broad range of pathogen races or isolates. They were developed from a four-way hybrid cross between *Solanum acaule*, *Solanum bulbocastanum*, *Solanum phureja*, and *S. tuberosum*, genotypes with horizontal resistance free of R genes (Landeo et al. 1995, 1997). The absence of race-specific R genes in population B has been tested and confirmed (Landeo et al. 2001).

The 12 genotypes were planted in furrows in a randomized complete block design with three replicates. Each experimental plot consisted of four rows containing 10 plant shill^{-1} in each row with plant spacing of 30 × 75 cm within and between rows, respectively. In all the experimental plots, normal agronomic practices for potato production were followed. At planting, 500 kg ha^{-1} of compound fertilizer N : P : K (17:17:17) was applied for field plots. No fungicides were applied to the experimental plots. When necessary, aphids and other insects were controlled with metasystox (i.e. Oxydementonmethyl) insecticide. Weeds were controlled by hoe weeding. During both years, no artificial inoculations were made, and late blight disease was initiated from natural infections.

Assessment for late blight disease

Plants in experimental plots were assessed for late blight severity and disease development by visual rating of foliage for percent leaf area blighted when 5% leaf area was infected by the pathogen, and was observed on the most susceptible cultivar. Subsequent assessments of disease severity were recorded