Short Communication

Susceptibility of Potato (*Solanum tuberosum* L.) Foliage and Tubers to the US8 Genotype of *Phytophthora infestans*

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ABSTRACT

Late blight is an important disease of potato (*Solanum tuberosum* L.) worldwide, and therefore, many potato-breeding programs have prioritized the development of late blight-resistant potato cultivars. Although the emphasis has been to enhance foliar resistance, it is also necessary to evaluate tuber late blight resistance in new breeding lines and new sources of late blight resistance. We report here on the assessment of foliar and tuber resistance and the correlation between these aspects of resistance in a sample of Michigan State University potato breeding lines. Two MSU breeding lines had significantly less infected foliage than the susceptible check cultivars. Tuber susceptibility was significantly different ($P < 0.05$) only between the most susceptible and the least susceptible breeding lines/cultivars. Foliar and tuber susceptibility to potato late blight were not correlated as low tuber susceptibility was associated both with extremely low (e.g., MSG274-3) and high (e.g., MSE202-3Rus) foliar susceptibility.

INTRODUCTION

Potato late blight [*Phytophthora infestans* (Mont.) de Bary] has re-emerged as a significant threat to potato (*Solanum tuberosum* L.) production worldwide in recent years (Andviron 1995; Fry and Goodwin 1995). Although the production of late blight-resistant varieties is a priority for potato-breeding programs, no commercial varieties adapted to North American growing conditions with good foliar resistance to modern genotypes of *P. infestans* are currently available (Douches *et al.* 1997). Economic losses due to late blight result from foliar susceptibility (defoliation) as well as tuber infection, and severe storage losses can occur after tubers infected with *P. infestans* are held for processing at temperatures in excess of 7° C (Kirk *et al.* 2001). Despite this, potato-breeding efforts have emphasized foliar late blight resistance with less attention given to tuber resistance. Additionally, studies of tuber and foliar resistance are inconclusive regarding the strength of association between these characteristics (Stewart *et al.* 1992, 1994; Platt and Tai 1998). The objective of this study was to evaluate commercial potato cultivars and advanced breeding lines from Michigan State University (MSU) for their susceptibility to foliar and tuber late blight and to determine the strength of association between these traits.

MATERIALS AND METHODS

Tubers of the commercial potato cultivars Atlantic, Onaway, Snowden, and Yukon Gold and advanced breeding lines obtained from the MSU potato breeding program MSA091-1, MSB040-3, MSB073-2, MSB076-2, MSC103-2, MSE018-1, MSE202-3Rus, MSE221-1, MSE228-11, MSE230-6, MSE246-5, MSF099-3, MSF373-8, MSG007-1, MSG050-2, MSG227-2, and MSG274-3 were produced in field plots in 1997. Parental details and maturity characteristics of the advanced breeding lines were described in a separate publication (Douches *et al.* 2000). A chlorothalonil-based fungicide program was implemented to prevent infection

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of foliage and tubers by *P. infestans*. Tubers were harvested by hand on 15 October 1997. Tubers of test cultivars and breeding lines were visually inspected for disease symptoms at harvest. Disease-free tubers were then stored at 8° C, 90% relative humidity for three months prior to late blight testing. The experiment was repeated 15 days after the first run of the experiment.

For studies on tuber response to late blight, ten tubers from each cultivar and breeding line were selected for each of the two runs of the experiment, and a further ten tubers were selected as a control group for each run. Selected tubers ranged between 200 and 250 g. Tubers were surface sterilized by soaking in a 10% Clorox solution for 30 min and rinsed five times with distilled water. Tubers were inoculated with *P. infestans* isolate MSU97-5 (US8, A2 mating type). Axenic cultures of this isolate were grown on rye agar plates for 14 days at 18° C in the dark (Dhingra and Sinclair 1985). Each plate had 25 ml molten rye agar poured to ensure production of even colonies using an electronic pipette meter (Pipet-aid, Drummond Scientific Company, Broomall, PA, 19008, USA). Each plate produced 1.6 (±) 0.22 x 10^5 spores 25 ml^{-1} rye agar. A mycelial homogenate was prepared from the mature culture (Schmitthenner and Bhat 1994) and approximately 0.1 ml of the mycelial homogenate was injected into the apical end of each tuber. The homogenate was injected 3-5 mm into the tuber periderm, 1-2 cm from the apical meristem. Ten tubers per cultivar and advanced breeding line were inoculated with sterilized distilled water (0.1 ml $tuber^{-1}$). Tubers were transferred to controlled environment chambers (12° C, 95% relative humidity) and stored in the dark for 40 days. Inoculated tubers were removed from storage and surface development of late blight was visually rated on a 1-9 scale (Niemira *et al.* 1999).

For studies on foliar response to late blight, seed tubers of the test cultivars and advanced breeding lines were cut 7 days prior to planting in field plots as part of larger cultivar and advanced breeding line trials at the MSU Muck Soils Research Station in 1997 and 1998. Plots consisted of five cut seed tubers planted 0.25 m apart at 1m spacing in May of each year. Within rows, varieties were separated by 0.5 m to facilitate disease ratings. The cultivars and advanced breeding lines were arranged in a complete randomized block design with five plants per plot and three replicated plots spread over three blocks. The three blocks were separated by a 5-m unplanted buffer zone. Plants were hilled immediately after emergence and no foliar fungicides were applied. Immediately prior to row closure, the foliage was inoculated by injecting a zoospore suspension of the previously described US8 genotype of *P. infestans* into the irrigation system (~100 ml per row) at 10^3 zoospores ml^{-1}. The volume of inoculum applied was calibrated to deliver approximately 1000 zoospores per plant based on the canopy density of a typical cultivar, e.g., Snowden. Plots were irrigated as necessary to maintain high canopy humidity and soil moisture conditions conducive for development of foliar late blight (Wallin 1953) with turbine rotary garden sprinklers (Gilmour Group, Somerset, PA, USA) sprinklers at 1055 l ha^{-1} hr^{-1}. The plots were managed using standard potato agronomic practices.

Visual foliar disease ratings were taken every 5 to 7 days beginning immediately following inoculation until approximately 30 days after inoculation (DAI). The area under the disease progress curve (AUDPC) was calculated as described by Shaner and Finney (1977) and divided by the maximum AUDPC (DAI at last evaluation x 100) converting the value to relative AUDPC (RAUDPC). Data were analyzed with ANOVA for differences between entries of potato varieties and advanced breeding lines. The relation between tuber and foliar infection were analyzed with Pearson's product moment correlation test to determine the strength of correlation between these characteristics.

RESULTS AND DISCUSSION

The range in susceptibility of the varieties and advanced breeding lines to late blight was homogeneous over the two runs of the experiments and data were therefore combined. Tuber susceptibility of the varieties examined was significantly different ($P<0.05$) only between the most susceptible (MSE246-5) and least susceptible (MSG274-3) breeding lines (Figure 1). Late blight did not develop in tuber controls of any variety or advanced breeding line inoculated with sterile distilled water in either run of the trial, and the data were therefore not included in Figure 1. The breeding line MSG274-3 had a foliar susceptibility (RAUDPC) rating significantly lower ($P<0.05$) than most other breeding lines, while MSE192-8 RUS was the most susceptible, but not significantly different from other varieties or advanced breeding lines except MSG274-3 (Figure 1). All other cultivars and advanced breeding lines did not differ from each other. Foliar susceptibility ratings were not correlated with tuber susceptibility ($r^2 = 0.02$, $n = 68$). The association between tuber and foliar susceptibility to late blight is a matter of ongoing research.

Dorrance and Inglis (1998) concluded that foliar and tuber susceptibility were not correlated, while a separate report indicated that a strong correlation exists (Platt and Tai 1998). In their research, Platt and Tai (1998) used the older US1 genotype of *P.*

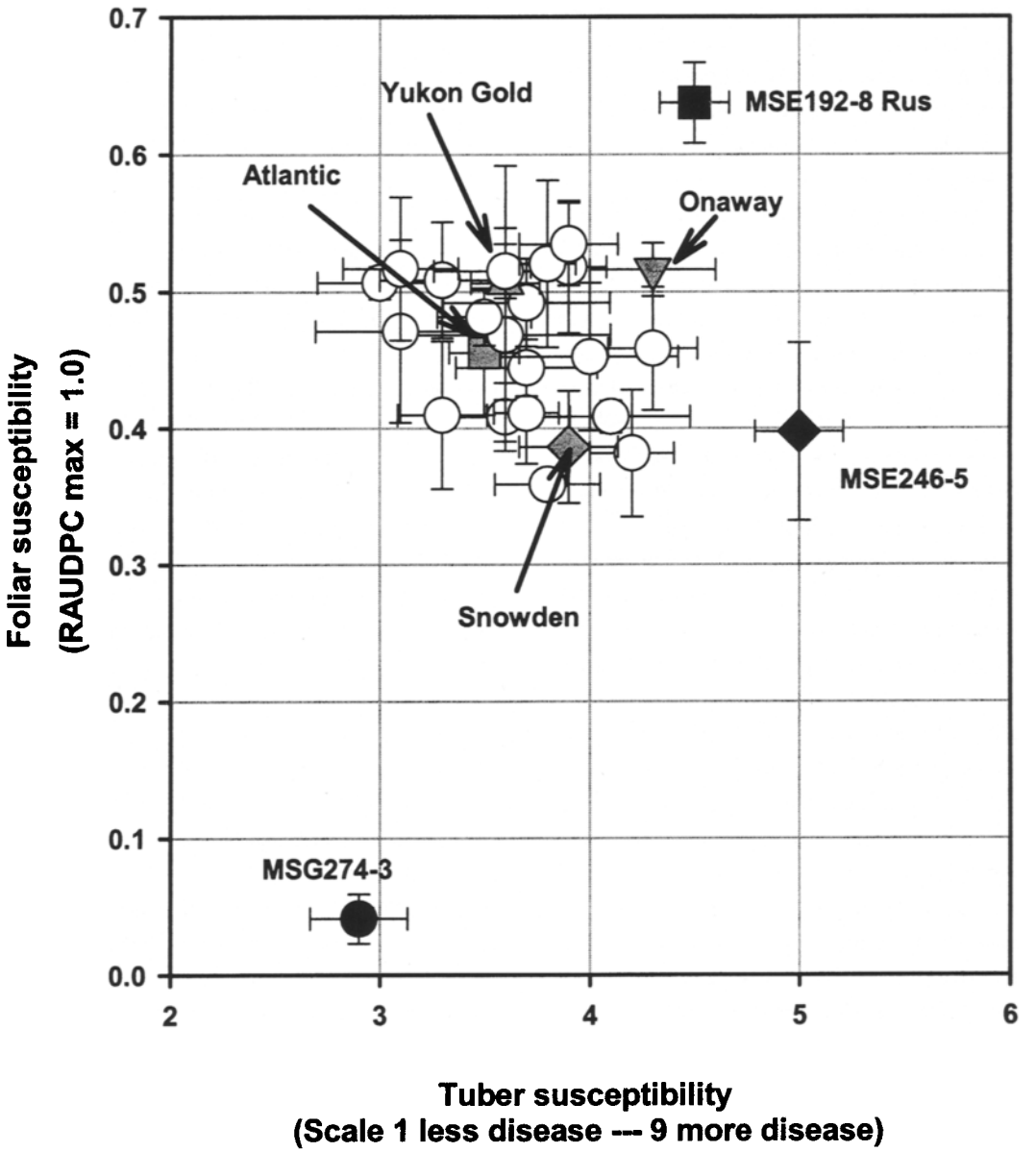

FIGURE 1.
The relation between foliar and tuber susceptibility to the US8 biotype of *P. infestans* in some commercial cultivars of potato and advanced breeding lines from the Michigan State University potato-breeding program. The bars represent 95% confidence limits of the estimate of the mean. Circles represent advanced breeding lines and gray symbols are commercial cultivars, some advanced breeding lines are labeled for clarity.

infestans whereas Dorrance and Inglis (1998) used modern genotypes such as US8. This suggests that the pathogen response to resistance mechanisms may be genotype specific. Gees and Hohl (1987) also suggested that the mechanisms by which late blight development is slowed are different between tubers and foliage. These mechanisms may be related to histological and/or cytological variations in the tuber or canopy, biochemical defense responses or a combination of these and other factors (Gees and Hohl 1987). In addition, the interactions of these underlying mechanisms may change with changes in plant maturity related to canopy development, tuber development and maturation of tubers in storage (Plissey 1993; Rowe and Secor 1993).

In our study, foliar and tuber susceptibility were not correlated supporting the conclusions of Dorrance and Inglis (1998). The rank of a given cultivar or advanced breeding line with regard to one type of susceptibility allowed no reliable inference

to be drawn regarding the other type of susceptibility. The narrow range in response and poor relation (low r^2 value) calculated from the extensive range of varieties and advanced breeding lines tested shows clearly that the two characteristics are poorly related. Although the relation is strong in perhaps two to three entries, it was not justification for predicting strong tuber resistance from strong foliar resistance and vice versa. The fact that the responses are clustered around mid-range values is an indication that the relationship is tenuous. Difference in susceptibility may occur in field situations where direct inoculations do not occur and may be due more to morphological adaptations such as rate of periderm maturity than inherent tuber tissue susceptibility to late blight. Less intrusive challenges to determine the response of tubers of varieties and advanced breeding lines should therefore be developed. Foliar and tuber resistance should therefore be evaluated separately and care should be taken when reporting on the resistance of a breeding line/cultivar to specify whether the description is based on foliar or tuber susceptibility. Of the varieties and advanced breeding lines tested, advanced breeding line MSG274-3 was the most promising due to its low foliar and tuber susceptibility. The parentage, maturity and agronomic traits and of MSG274-3 will be the subject of a variety description submission to the American Journal of Potato Research in 2001.

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