Partial Resistance to *Phytophthora infestans* in Four *Solanum* Crosses

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**ABSTRACT**

Thirty progeny from each of four *Solanum* crosses were evaluated in the field at Mount Vernon, WA, in 1996 and 1997 for partial resistance to *Phytophthora infestans*. Of the four parents, three have high levels of partial resistance to *P. infestans*; one derived from somatic hybridization of *S. bulbocastanum*, the other two from traditional breeding efforts for multiple disease resistance. Data were collected from each cross to estimate area under the disease progress curve (AUDPC), days to 5% disease severity threshold (DT\(_5\)), and sporangia production (SP). All of these variables differed significantly among the progeny within each cross in each year. Correlation analysis indicated that DT\(_5\) was highly correlated with AUDPC for all four populations for both years. Log-transformed SP was significantly (P<0.001) correlated to AUDPC values for one population in both years, but the significance of the correlation was variable between years for the remaining three crosses. The variable DT\(_5\), which is composed of three components (infection efficiency, latent period, and lesion growth rate), was the most important in identifying progeny with partial resistance to late blight in all four crosses in this study.

**RESUMEN**

Treinta progenies de cada uno de los cuatro cruza-mientos de *Solanum* fueron evaluadas en los campos de Mount Vernon, WA en 1996 y 1997, para comprobar su resistencia parcial a *Phytophthora infestans*. De los cuatro progenitores, tres muestran altos niveles de resistencia parcial a *P. infestans*; uno, derivado de la hibridación somática de *S. bulbocastanum*; los otros dos, producto de esfuerzos tradicionales de mejoramiento para conferir resistencia a múltiples enfermedades. Los datos fueron recolectados de cada cruce, con el fin de estimar la curva de progreso de la enfermedad (AUDPC por sus siglas en inglés), los días al 5% de inicio severo de la enfermedad (DT\(_5\)) y la producción de esporangio (PE). Todas estas variables fueron significativamente diferentes entre la progenie de cada cruce, cada año. Los análisis correlativos indicaron que DT\(_5\) fue la correlación más alta con AUDPC para las cuatro poblaciones en ambos años. El registro transformado de PE fue significativamente (P<0.001) correlativo con los valores de la AUDPC para una población en los dos años, pero el significado de la correlación fue variable entre años para los tres cruces restantes. La variable DT\(_5\), que consta de tres componentes (eficacia de la infección, periodo de latencia y tasa de crecimiento de la lesión)—fue la más importante para identificar las progienes con resistencia parcial al tizón tardío en los cuatro cruces de este estudio.

**INTRODUCTION**

Late blight epidemics have occurred in the majority of North American potato production regions during the past decade due to the presence of immigrant genotypes of *Phytophthora infestans* (Mont.) de Bary coupled with environmental conditions conducive to disease development (Fry and Goodwin 1997; Goodwin *et al.* 1998). Populations of *P. infestans* that are now present in the U.S. and Canada have been shown to be more aggressive than pre-existing...
populations (Fry and Goodwin 1997; Kato et al. 1997; Lambert and Currier 1997; Miller et al. 1998). Coinciding with the migrations and introductions of new genotypes, insensitivity to the systemic fungicide metalaxyl also has been identified as a mitigating factor in these epidemics (Deahl et al. 1993). Consequently, producers are applying more fungicides to protect the potato foliage from P. infestans, thereby increasing production costs (Johnson et al. 1997).

Development of late-blight-resistant potato cultivars has been an ongoing effort in Europe since the epidemics of the 1840s (reviewed by Umaerus et al. 1983). However, in the U.S. effective fungicide programs, along with breeding efforts directed towards processing qualities rather than disease resistance, relegated the search for late blight resistance to a low priority (Pavek 1987). Due to the recent changes in populations of P. infestans and the need to reduce the amount of fungicide to produce a viable potato crop, resistance to late blight is now being sought in potatoes with desirable processing qualities (Corsini et al. 1999; Douches et al. 1997; Haynes et al. 1998; Helgeson et al. 1993; Helgeson et al. 1998).

Resistance to P. infestans such as specific resistance (Thurston 1971; Toxopeus 1956; Umaerus et al. 1983) as described by Flor (1955), partial resistance (Colon and Budding 1988; Colon et al. 1995a; Umaerus 1970; Umaerus et al. 1983), and non-host resistance (Kamoun et al. 1998) has been utilized and explored from many sources. The term partial resistance, also referred to as rate-limiting, field, general, or horizontal resistance, is believed to be controlled by several genes and is thought by some to be both effective at all stages of the pathogen and durable (Colon and Budding 1988; James and Fry 1983; Parlevliet 1979; Umaerus et al. 1983). Partial resistance can be identified by the specific components which limit the infection process. Components that have been identified in Solanum germplasm include lower infection efficiency, slower lesion growth rate, and longer generation time or latent period, shorter infectious period, and/or slower sporulation rate (Colon and Budding 1988; Colon et al. 1995a; Guzmán 1964; River-Peña 1990; Tooley 1990; Umaerus 1970).

Analysis of the components of partial resistance that are present in wild Solanum spp. and in progeny from crosses with wild Solanum and cultivated potato have been completed using both laboratory and field assessments (Cañizares and Forbes 1995; Colon et al. 1995a; Guzmán 1964; Umaerus 1970). Specific components that contribute most towards reduced disease severity varied among species (Colon et al. 1995a) and within a species (Cañizares and Forbes 1995). Infection efficiency, latent period, and lesion growth rate were important in S. microdontum whereas infection efficiency, lesion growth rate and sporulation capacity were important in S. tuberosum. No association was identified in seven other Solanum spp. (Colon et al. 1995a). Cañizares and Forbes (1995) reported that the log number of lesions was the best indicator for overall resistance. They also identified plants that had high numbers of lesions even though the latent period was long. Although levels of partial resistance can be transferred to progeny when Solanum spp. are crossed with S. tuberosum, repeated backcrossing with regular intercrossing may be necessary to place donor genes in a commercially acceptable genetic background (Colon et al. 1995b). An understanding of which components of partial resistance are present in potato lines used as parents and their genetic controls is necessary to efficiently transfer these kinds of traits into the cultivated gene pool.

Potential sources of partial resistance include S. tuberosum ssp. andigena, S. aranezei x S. hondelmannii, S. berthaultitii, S. brachycarpum, S. bulbocastanum, S. chacoense, S. ciriacifolium, S. demissum; S. iochetalum, S. leptophyes, S. microdontum, S. phureja, S. stoloniferum, S. sucrens, S. tuberosum, S. venturii, S. vernei, and S. verrucosum (Cañizares and Forbes 1995; Colon and Budding 1988; Colon et al. 1995a; Guzmán 1964; River-Peña 1990; Tooley 1990; Umaerus 1970). In several cases, barriers to sexual hybridization have prevented utilization of several wild Solanum spp. as a source of resistance until recently. Due to successful application of somatic hybridization (Helgeson et al. 1993, 1998) and long-term potato germplasm development programs (Corsini et al. 1999; Goth and Haynes 1997), some of these sources of resistance may now be exploited.

Advanced potato selections have recently been identified which have some level of partial resistance to late blight (Corsini et al. 1999; Douches et al. 1997; Goth and Haynes 1997; Helgeson et al. 1998). One such advanced potato selection, AWN86514-2, has been widely used as a parent in Pacific Northwest potato breeding programs (Corsini et al. 1999). It is resistant to Verticillium spp., Alternaria solani, and PVY, and also may have components of partial resistance to late blight from sources such as S. stoloniferum, S. phureja, and S. demissum. The advanced potato selection B0718-3, developed at the USDA, Beltsville potato-breeding program, has resistance to P. infestans derived from PI 383470B (Goth and Haynes 1997). The selection J103-K7 is from the somatic hybridization of S. bulbocastanum (PI