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Durability of Dual Resistance of Potato Varieties to Late Blight [*Phytophthora infestans* (Mont.) de Bary] and Common Scab [*Streptomyces scabies* (Thaxt.) Waksman et Henrici]

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Horizontal (field) resistance to late blight and common scab that is controlled by numerous genes proved to be quite durable in certain potato varieties in Hungarian trials. Although it is difficult to breed for this type of resistance, it has become the preferable strategy in today's breeding programmes, providing long-lasting and less vulnerable protection. Potato breeding in Hungary has produced some promising cultivars such as White Lady, Százszorszép and Rebeka with multiple disease resistance that may play an important role in the Integrated Pest Management (IPM) of near future.

Keywords: Variety testing, breeding for resistance, late blight, common scab, durable resistance, IPM.

Although breeding for resistance of several crops, including potato, resulted in varieties with high resistance to diseases and pests, a great amount of experience has accumulated indicating that varietal resistance is broken by new races of the pathogens (Fry and Goodwin, 1997; Zarzycka and Sobkowiak, 1997; Peters et al., 1998). According to Barabás (1979) "self-breeding" of the pathogens seems to be more effective than the breeding programmes against them. Thus questions frequently arise whether it is worth working for decades for achieving disease resistance which may happen to lose its effectiveness and stability. Besides the major virus diseases such as potato leafroll and Y mosaic, late blight caused by *Phytophthora infestans* and common scab caused by *Streptomyces scabies* greatly threaten the stability and/or quality of potato crop worldwide. Due to the constraints of chemical control, resistant cultivars can play an important role in the Integrated Pest Management (IPM) with a reduced rate of fungicide application (Clayton and Shattock, 1995).

Breeding for resistance to the late blight pathogen first aimed at building-up the vertical (race-specific) resistance. This type of resistance was very effective against the old populations of *P. infestans* consisting of simple races only. New populations of *P. infestans* are composed of complex races having several virulence factors from 1 to 11 capable of overcoming previously developed vertical resistance to simple races. The growing diversity of the pathogen has made the vertical resistance vulnerable. Horizontal resistance (also called field, partial or general resistance) is controlled by numerous genes that exist in both cultivated and wild *Solanum* species. However, these genes cannot be

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identified as easily as the major R-genes. The greatest advantage of horizontal resistance is its non race-specific nature providing resistance to any races of the pathogen. This type of resistance, however, is less effective than the vertical resistance because the fungus can grow and/or sporulate on the foliage at a limited rate. But it is just the guarantee of durable protection because there is no selection pressure on the pathogen's populations.

The resistance to common scab is polygenic; there are relatively few resistant cultivars and immunity could not even be found in the wild species (Wiersema, 1975). In this paper we report resistance testing of potato varieties to late blight and common scab with special attention to the durability of resistance in the Hungarian variety trials.

Materials and Methods

Foliage resistance to late blight of potato genotypes was assessed in tests performed in walk-in plastic tunnels because field crops had been treated with fungicides. A mixture of two Hungarian isolates of *P. infestans* was used as an inoculum that have virulence factors capable of overcoming at least 7 R-genes (type of virulence: 1.2.3.4.7.(8).10.11). Inoculation was carried out by spraying a suspension of 30,000 sporangia/ml onto the foliage of plants at a 10- to 14-leaf stage. Foliar infections were assessed 12 to 16 days after inoculation using an arbitrary 10-grade scale of increasing susceptibility (infected leaf area %) (Gergely, 1999).

Resistance to common scab was symptomatically assessed in naturally infected samples of 2 × 100 tubers per variety, within 2 months after harvest. Tubers were collected from 4 to 6 locations representing Hungary's main climate zones and soil types. Severity of the disease was determined by estimating infected tuber surface on a 10-grade scale of increasing susceptibility (infection index %).

Durability of varietal disease resistance was estimated by comparing infection rates determined at distant intervals. Although varieties performed in field trials for 3 to 4 years only, there is a possibility to compare them because check (standard) varieties such as Cleopatra and Désirée have been the same during the last 30 years.

Results and Discussion

Foliage resistance to late blight

The early cultivar Cleopatra was consequently highly susceptible (> 80% infected leaf area), whereas the mid-late cultivar Désirée performed as an intermediate type. Cultivars Kondor, Agria and Százszorszép maintained their medium level resistance during a long period of time. Two other cultivars of mid-late maturity, Bakonyi sárga and Signal were considered to be moderately resistant. Although cultivars White Lady, Raja and Cicero lost their vertical (HR-type) resistance in 2001, showing limited sporulation on the foliage, their rates of infection were much less than those of susceptible cultivars like Cleopatra and Russet Burbank *(Table 1).* The Hungarian cultivar White Lady has been performing in breeding experiments in the field since 1979 and retained its HR-type

Table 1

Foliage infections of potatoes caused by late bligth *(Phytophthora infestans)* in Hungarian variety trials at distant intervals

Variety maturity group	Infected leaf area %			
	1990	1995	1997	2001
Very early and early				
Cleopatra	90.0	77.6	72.6	82.5
Réka	75.0	47.6	–	–
Rebeka	–	45.0	–	–
Luna	5.0	–	–	–
Galant	2.5	–	–	–
Mid-early and mid-late				
Désirée	70.0	42.6	57.6	57.5
Kondor	70.0	40.0	55.5	–
Agria	70.0	47.6	52.6	60.0
Bakonyi sárga	20.0	12.6	–	–
Százszorszép	60.0	45.0	47.6	55.0
Santé	–	40.0	–	65.0
Signal	–	27.6	15.0	–
Solara	–	12.6	–	–
White Lady	–	0	0	3.0
Raja	–	0	0	3.0
Cicero	–	–	0	17.5
Kastia	2.5	–	–	–
Russet Burbank	95.0	–	–	–

resistance until the introduction of more complex races of *P. infestans* in the late 1990s (M. Lönhárd, unpublished data). The most resistant variety candidates such as Galant, Kastia and Luna performed only in the 1990 test because they were not given state registration because of some undesirable traits.

The exclusive use of *Solanum demissum* and *Solanum tuberosum* as genetic bases is unlikely to result in significant progress in breeding for resistance to late blight. Therefore, other wild species such as *Solanum bulbocastanum, S. berthaultii, S. verrucosum* etc., which are known to have high level of horizontal resistance need to be involved in practical breeding (Soest et al., 1984). On the basis of Hungarian breeding experiences *Solanum hougasii* (syn. *S. spectabilae*) is also considered to be a usable source of resistance to both *PVY* and *Phytophthora infestans* (M. Lönhárd, unpublished data). Recently Gundersen et al. (2000) reported that *S. hougasii* expressed its high late blight resistance at a relatively good rate in crosses with *S. tuberosum.* The extremely high level of resistance of the earlier Hungarian variety candidates Kastia and Galant may also be attributed to the presence of *S. hougasii* in their pedigree *(Table 1).* Decreasing vertical resistance to late blight is not always accompanied by significant increase in susceptibility because certain genotypes may also possess another type of resistance. In the case of the Hungarian cultivar White Lady, for example, in addition to R-genes, genes for horizontal resistance might have also been transferred from the wild species *S. demissum* and *S. stoloniferum*

during interspecific hybridizations. The latter two species and *S. tuberosum* spp. *andigena* are considered to be good sources of relative (horizontal) resistance (Darsow et al., 1993). The two prevalent cultivars in Hungary, Désirée and Kondor carrying no R-genes, also have some horizontal blight-resistance contributing to their leading role in commercial production. It is to be noted that these cultivars of mid-late maturity showed a medium-level field resistance based on their AUDPC- (Area Under the Disease Progress Curve) values in a 2-year preliminary trial (L. Gergely, unpublished data). Evidently, there is a positive correlation between the level of field resistance to late blight and the late maturity (Colon et al., 1995).

Field resistance to common scab

Comparing infection indices from different years, cultivars Cleopatra, Désirée, Kondor and Agria proved to be consequently susceptible. In contrast, most domestic cultivars (e.g. Rebeka, Kánkán, White Lady, Százszorszép) and some foreign ones (e.g. Rosara, Karlena, Santé) retained their high field resistance for a long period of time *(Table 2).*

Table 2

Common scab *(Streptomyces scabies)* infection index of potatoes in Hungarian variety trials at distant intervals

Variety	Infection index (infected tuber surface %)					
	1979	1987	1990	1994	1997	2000
Cleopatra	–	23.5	6.6	15.8	14.4	10.3
Désirée	6.3	20.8	12.1	16.0	14.3	14.2
Nyírségi 501	2.6	–	–	–	–	–
Ke.9	3.7	–	–	–	–	–
Somogy gyöngye	1.2	–	–	–	–	–
Murillo	7.4	–	–	–	–	–
Romano	–	16.0	7.1	–	5.9	–
Kondor	–	17.1	4.9	–	7.9	14.5
Gülbaba	–	9.8	6.8	–	–	–
Rebeka	–	0	1.2	2.2	3.5	–
Bakonyi sárga	–	6.3	0.9	–	–	–
Kánkán	–	3.9	1.2	–	3.4	2.6
Százszorszép	–	–	2.2	1.7	2.9	3.7
Agria	–	–	5.8	8.6	10.3	10.1
Raja	–	–	–	3.2	3.2	3.9
Santé	–	–	–	2.2	3.6	3.3
White Lady	–	–	–	1.3	1.6	1.8
Hópehely	–	–	–	2.6	3.0	2.9
Góliát	–	–	–	1.6	1.7	4.3
Rosara	–	–	–	1.4	4.4	1.7
Karlena	–	–	–	2.3	2.0	3.4
Roko	–	–	–	–	4.3	2.2
Laura	–	–	–	–	–	2.4
Innovator	–	–	–	–	–	10.0
Lilla	–	–	–	–	–	10.1

Cultivars with an average infection index less than 5 % are considered to be scab-resistant. Domestic cultivars generally have lower infection indices than the foreign cultivars. This, and that Hungary's climatic conditions with extended hot and dry periods are favourable for scab development, resulted in greater efficacy in clone selection *(Table 3).*

Table 3

Common scab *(Streptomyces scabies)* infection rate of potatoes in Hungarian variety trials

Year	No. of varieties	Infection index			No. of varieties		Average infection index of varieties	
		minimum	maximum	mean	domestic	foreign	domestic	foreign
1979	27	0.1	12.1	3.5	11	16	3.4	3.9
1987	16	3.6	21.6	10.2	12	4	8.0	14.6
1990	21	0.1	13.1	4.0	12	9	2.0	6.5
1994	47	0.4	18.6	4.7	5	42	1.9	4.5
1997	33	1.5	20.1	7.0	1	32	3.5	7.1
2000	42	2.1	15.9	6.0	1	41	10.0	6.0

Tubers of susceptible cultivars Cleopatra, Désirée and Agria have consistently become severely infected under hot and dry weather conditions. In contrast, infection indices of cultivars with high field resistance are usually less than 5% even in growing seasons favourable for scab development, not affecting the marketing of their tuber lots. At one of the test sites in Keszthely (Hungary) where a number of *Streptomyces* species and an extremely high inoculum density of *S. scabies* occurred in the soil, the field resistance of cultivars White Lady and Rebeka was not broken despite the high infection pressure (Elesawy and Szabó, 1981). In general, the European and also the American potato cultivars appear to have a stable field resistance to common scab (McKee, 1958). Cultivars Bismarck and Jubel, and the wild species *Solanum chacoense* are considered to be good sources of resistance to common scab (Rudorf, 1958). Of domestic cultivars bred by interspecific hybridization for example, the high field resistance of cultivar Rebeka is likely originated from *S. chacoense* (J. Bukai 2000, personal communication).

In summary, several domestic cultivars such as White Lady, Százszorszép and Rebeka, and foreign cultivars such as Raja and Santé showed high level of field resistance to both diseases. These cultivars therefore may play an important role in the IPM of near future.

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