

Pre-selection of apple seedlings for partial powdery mildew (*Podosphaera leucotricha* Ell. et Ev. /Salm./) resistance

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ABSTRACT

Incidences of powdery mildew were repeatedly evaluated for two years on 1 420 young seedlings of 20 progenies (of different levels of mildew susceptibility) in a green house, and then for 10 years on 642 seedlings in an orchard. Part of the seedlings in the orchard were pre-selected for the characteristic and others not. Except for the first scoring done in the first year, there was no correlation between mildew incidence on individual seedlings in the green house and their mean performance in the orchard. The seedlings with scores above 6 (resistant or tolerant) at the first stage of evaluation in the green house, however, yielded four times more desirable seedlings after final selection in the orchard than the mean of the total. The progenies that had a better healthy state as a whole yielded more partially resistant genotypes than those with low mean scores. Therefore, the progenies that most rapidly develop infestation on the whole lot should be discarded, whereas those that retain a healthy state longer should be subjected to individual selection according to the previous item.

Keywords: apple trees; *Malus × domestica*; powdery mildew; *Podosphaera leucotricha*; resistance; early selection

After scab, powdery mildew (*Podosphaera leucotricha* Ell. et Ev. /Salm./) is the second most important disease of apples under climatic conditions of the Czech Republic. Grown cultivars differ largely in their reactions to this pathogen from very susceptible to nearly completely resistant (Blažek et al. 1979). This disease, which attacks the foliage and young shoots, has, in the case of susceptible cultivars, a very marked effect on the quantity and the quality of the fruit produced. In new orchards of recent scab-resistant cultivars where the chemical control of fungal diseases has been essentially reduced, however, there is more demand for a higher level of tolerance also to mildew. Therefore, the present main aim in the apple breeding program at Holovousy is to develop apple cultivars resistant to scab and only very slightly susceptible (tolerant) to mildew (Blažek 1999).

Segregation of partially resistant (or rather tolerant) seedlings to mildew, which only rarely produce any infected shoots, is under polygenic control if traditional cultivars are used in a breeding program, and usually only a very small portion of such seedlings can be selected (Blažek and Syrovátko 1991, Ognjanov et al. 1999). Therefore, rather large progenies (at least of several hundred seedlings) should be screened for the disease to ensure desirable progress.

Monogenic sources of mildew resistance that had been derived from some wild species of *Malus* with higher levels of resistance or even immunity (Alston 1983) have been used at Holovousy only for a few years, which is too short of a time for any experience. It seems, however, that fruit quality will be a crucial problem in progenies of the present donors of these major genes, despite significant progress, which has been reported recently (Krüger 1994, Schmidt 1994). Therefore, more generations of backcrossing are expected using this material before real commercial cultivars involving this resistance could be obtained (Blazek 2000).

Compared with scab resistance mildew resistance is difficult to evaluate, partly because the extent of infection varies substantially from year to year and partly because seedlings react differently according to age. The level of mildew resistance of a particular genotype can be demonstrated only by making a sufficient number of observations over several years (Mihatsch and Mildenerger 1966, Pitera and Bogdanowicz 1992).

Young seedlings of tender age are extremely susceptible to the disease, and the opinion prevails that the differences in resistance are not clear until the seedlings are 2 years old. Greenhouse or plastic-house conditions regarding mildew usually so favour infection that degrees of host susceptibil-

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ity are obscured (Dayton 1977, Janick et al. 1996). For this reason, pre-selection for partial mildew resistance is being done upon results of outdoor evaluations for two successive years in a nursery or on beds. Still, a comparison of scoring between nursery (or beds) and in the orchard is not very satisfactory (Blažek and Srovátko 1991, Janse et al. 1994).

This study was initiated to verify utilising mildew infection scoring made upon young apple seedlings in a plastic-house for early selection of seedlings with partial resistance to powdery mildew.

MATERIAL AND METHODS

The seedling material of apples was obtained at Holovously by crosses made between 1974 and 1978. After stratification in the period of November–February, seeds were sown on trays in the greenhouse. Young seedlings in the stage of 2 or 4 true leaves were inoculated by *Venturia inaequalis* conidia in a growth chamber using a mixture of domestic pathotypes. The seedlings after this screening for scab resistance (on average more than 50% of them were discarded) were transplanted during the late days of April or early days of May into a plastic-house on ground beds where they were grown for two subsequent seasons under natural infection by mildew.

The first scorings of the seedlings for mildew incidence were done during June at a stage when a majority of the seedlings was infested. The second screening was done about six weeks later (usually in mid August) at the time of maximum spread of the infestation. In the next year, the whole process of double scoring was again repeated. After the second scoring of the second year of the evaluation, budwood was taken from the seedlings for

budding on M9 rootstock. From larger progenies usually 30 to 50 seedlings with the best health state were selected for budding, whereas in small progenies all seedlings available were propagated. In the second group only those seedlings were discarded that had developed no healthy budwood suitable for budding.

The seedlings budded on M9 were grown for two subsequent years in the nursery and then were planted into hybrid orchards in the spacing 4 × 1 m. There they were grown for 8–10 years without any chemical sprays against fungal diseases, and also every year they were evaluated for mildew infestation.

For the final classification of the seedlings regarding their susceptibility or resistance to mildew in the orchard, the means of three or four years with the highest infestation scores were used. For the assessment of the seedlings and their final classification the rating scale 1–9 was used. The grades of the scale correspond to the following classes: 1 and 2 = very susceptible, 3 and 4 = susceptible, 5 and 6 = moderately susceptible, 7 and 8 = tolerant, and 9 = resistant (no visible sign of infection). Correlation analyses in this study were based on data of 217 seedlings (of nine different progenies) completely evaluated both in the plastic house and in the orchard without selection application, and 11 progenies in which 1 203 seedlings were scored in the plastic house and 425 (pre-selected) in the orchard.

RESULTS AND DISCUSSION

Except for the first scoring done in the first year, there was no correlation between mildew incidence of individual seedlings in the plastic house and their final classification regarding

Table 1. Ranking correlation coefficients between parameters from plastic house scoring and final classification of seedlings in the orchard regarding mildew resistance without selection

No.	Parameter	1	2	3	4	5	6	7
1	first scoring of the first year	1						
2	second scoring of the first year	0.40**	1					
3	mean scoring of the first year	0.71**	0.93**	1				
4	first scoring of the second year	0.14	0.19*	0.20*	1			
5	second scoring of the second year	0.31**	0.36**	0.40**	0.51**	1		
6	mean scoring of the second year	0.28**	0.34**	0.37**	0.77**	0.94**	1	
7	mean of both the first scorings	0.75**	0.39**	0.60**	0.76**	0.54**	0.70**	1
8	final classification in the orchard	0.23*	0.12	0.19*	-0.08	-0.18	-0.16	0.10

*significant at $P < 0.05$, **significant at $P < 0.01$

Table 2. Shares of partially resistant seedlings in the orchard in relation to their performance in the plastic house

Characteristics	Number of seedlings in the plastic house	Number of seedlings with partial resistance in the orchard	Percentage of partially resistant seedlings
Total number	217	24	11
Seedlings with scoring 7 or more during the first scoring of the first year	25	9*	36
Seedlings with scoring equal to 6 during the first scoring of the first year	48	8	17
Seedlings with mean scoring 7 or more in the first scorings of both the years	15	6	40

*significantly different according to χ^2 test at $P < 0.01$

susceptibility or resistance to the disease based on long-term evaluation in the orchard (Table 1). With one exception significant correlations of different values were calculated, however, between all scoring sessions (or their means) that took place in the plastic house.

The correlations were higher between evaluations of the same year and smaller between the sessions of the different years. It is obvious that the extent of mildew incidence of an individual seedling strongly influences the incidence of the disease on seedlings growing in its neighbourhood within the dense planting and, in this way, modifies their expressions based on a genetically determined nature.

Under the present arrangement of conditions for screening in the plastic house, it is useless to prolong evaluation of the disease beyond the first scoring. To obtain additional information about an individual seedling, which would be useful for selection decisions, the seedling should be replanted or grafted for evaluation in the following year under a changed position arrangement. A procedure proposed by Janse et al. (1999) based on using a special device in the greenhouse seems to be ideal for this purpose, except for its economic feasibility in a bulk screening.

A comparison between groups of seedlings with different mildew incidence ranking during the first scoring of the first year in the plastic house and

Table 3. Relationship between the first scoring in the first year and share of partially resistant seedlings in the orchard

Progeny	Progeny mean of the first scoring in the first year	Share of partially resistant seedling in the orchard (%)
Britemac × Prima	5.4	18.8
Britemac × Purdue 1983	6.0	14.0
HL A 28/39 (Antonovka o.p.) × Alkmene	4.7	12.8
HL A 28/39 (Antonovka o.p.) × Golden Delicious	4.9	1.5
HL B 14/11 (Spätblühender Tafettapfel × Court Pendu Plat) × Canada 0-531	6.3	29.2
Florina × Jarka	3.2	0
Liberty × HL 166C	4.5	0
Prima × Red Spur Delicious	5.8	15.3
Priscilla × Holovouské malinové	4.8	14.9
Priscilla × Lord Lambourne	5.3	17.9
Quinte × Discovery	4.7	12.9
Correlation coefficient between both the characteristics	$r = 0.77^{**}$	

their final scores in the orchard revealed some possibilities for effective pre-selection of the seedlings with partial resistance to mildew, despite the fact that the correlation for the whole lot was very small (Table 2). The seedlings with scores above 6 (resistant or tolerant) in this stage subsequently yielded four times more desirable seedlings after final selection than the mean of the whole number. The same comparison using seedlings with the score equal to 6, however, did not differ much from the mean rate. On the other hand, a consideration of seedlings that were quite healthy in both years would not significantly improve the final result of such a hypothetical selection.

Another possibility for the improvement of pre-selection of desirable seedlings, under the present handling of breeding stock, considers the mean scoring of all the progenies (Table 3). The progenies that had shown a better healthy state regarding mildew as a whole (with highest mean scores) produced more partially resistant genotypes than those with low mean scores. In such progenies usually the infestation of a majority of the seedlings start later than in very susceptible ones. Therefore, the progenies that most rapidly develop infestation of the whole lot should be discarded, whereas those that retain a healthy state longer should be subjected to individual selection according to the previous item.

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ABSTRAKT

Předběžná selekce jabloňových semenáčků na částečnou odolnost proti padlí jabloňovému (*Podosphaera leucotricha* Ell. et Ev. /Salm./)

Výskyt padlí jabloňového byl opakovaně hodnocen po dobu dvou let u 1420 mladých semenáčků pocházejících z 20 potomstev (lišících se citlivostí k padlí) ve fóliovníku a potom po dobu 10 let u 642 semenáčků v hybridním sadu. Část těchto semenáčků byla předselektována, ostatní předselektovány nebyly. Kromě prvního hodnocení v prvním roce věku semenáčků nebyl zjištěn žádný vztah mezi výskyty padlí na semenáčcích ve fóliovníku a pozdějším průměrným výskytem této choroby u těchto hybridů hodnocených na trvalém stanovišti. Přesto semenáče, které měly nejlepší zdravotní stav při prvním hodnocení ve fóliovníku, poskytly čtyřikrát více hybridů s částečnou odolností proti padlí, než byl průměr celé populace. Potomstva, která měla nejlepší zdravotní stav jako celek, poskytla mno-

hem více odolných hybridů než potomstva, která měla průměrně vyšší napadení. Potomstva, která bývají nejdříve a nejsilněji napadena, by měla být z další selekce vyřazena, protože se u nich hybridy s požadovanou odolností zpravidla nevyskytují. U potomstev s pozdějším výskytem napadení by měla být uplatněna individuální selekce podle předchozího bodu.

Klíčová slova: jabloně; *Malus × domestica*; padlí jabloňové; *Podosphaera leucotricha*; rezistence; selekce

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