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# Terminal shoot susceptibility of new Polish apple cultigens to fire blight

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ABSTRACT

In 2000 – 2001 the following apple cultivars and clones, bred at Research Institute of Pomology and Floriculture in Skierniewice, Poland (grafted on M.9 and P 22 rootstocks), were evaluated: 'Early Freegold', 'Egeria', 'Free Redstar', 'Ligol', 'Ligolina', 'Medea', 'Melfree', 'Odra', D-13, and J-79. 'Freedom' and 'Florina' were included as standards. Tips of terminal shoots of young trees growing in pots in a greenhouse, were inoculated with a highly virulent strain (Ea 691) of *E. amylovora* ($10^7$ cfu $ml^{-1}$). Observations and measurements of the development and severity of fire blight, performed 6 weeks after inoculation, showed that 'Free Redstar' and J-79 on the P 22 rootstock appeared to be the most resistant, while 'Egeria', 'Ligol', and 'Ligolina' were the most susceptible. Also on M.9 'Free Redstar' and J-79 showed the lowest susceptibility among the evaluated cultigens while 'Ligolina' was the most susceptible. These findings corresponded to the distribution of the tested trees amongst 5 susceptibility classes. 40-46.7% of the individuals of 'Free Redstar' on both rootstocks and 80% of J-79 on P 22 were

classified as susceptibility class 1 (the most resistant). On the other hand, none of ‘Ligol’ on P 22 and ‘Ligolina’ on M.9 and only 6.7% of ‘Ligolina’ on P 22 trees belonged to that class.

## INTRODUCTION

Fire blight (*Erwinia amylovora*) is one of the most serious diseases affecting apple and pear trees as well as many other *Rosaceae* plants (van der Zwet and Keil 1979, van der Zwet and Beer 1995, Sobiczewski et al. 1997, Bonn and van der Zwet 2000). It attacks all organs of the aboveground part of host plants, often leading to their death. To date, fire blight has occurred in over 40 countries of the world, including Poland (van der Zwet 2002). The control of the disease is difficult and involves integrating various activities such as sanitation, chemical treatments, soil and tree management, as well as selection and breeding for resistance. Fire blight resistance, which is coded by numerous genes, has usually been included in programs in which resistance to scab and mildew are investigated (Lespinasse and Aldwinckle 2000). However, Korban et al. (1988) found that there is no evidence of close link between the *Vf* gene from *Malus floribunda* 821 coding for scab resistance and the genes for fire blight resistance. One of the aims of the apple breeding program conducted at the Research Institute of Pomology and Floriculture in Skierniewice is to obtain genotypes which combine high fruit quality with resistance to fire blight.

The purpose of this study was to evaluate the susceptibility of 10 new apple cultivars and selections to fire blight under greenhouse conditions.

## MATERIAL AND METHODS

The study was performed in 2000 – 2001 on apple trees growing on M.9 an P 22 rootstocks (P 22 is very draft rootstock bred in Poland). The trees were produced each year during winter by hand grafting, planted in pots and placed in spring in a greenhouse with uncontrolled temperature. The following cultivars and clones originating from the breeding program conducted at the Research Institute of Pomology and Floriculture in Skierniewice were evaluated: ‘Early Freegold’, ‘Egeria’, ‘Free Redstar’, ‘Ligol’, ‘Ligolina’, ‘Medea’, ‘Melfree’, ‘Odra’, D-13, and J-79. The cultivars ‘Freedom’ and ‘Florina’ were included for comparison (Table 1).

Table 1. Origin of studied cultivars and clones

| Cultivar or clone | Parentage |
|---|---|
| 'Early Freegold' | Unknown |
| 'Egeria' | 'Lobo' × 'Redspur Delicious' |
| 'Free Redstar' | Unknown |
| 'Ligol' | 'Linda' × 'Golden Delicious' |
| 'Ligolina' | 'Linda' × 'Golden Delicious' |
| 'Medea' | 'Lobo' × 'Redspur Delicious' |
| 'Melfree' | 'Melrose' × 'Freedom' |
| 'Odra' | 'Primula' × 'Bankroft' |
| D-13 | Unknown |
| J-79 | Unknown |
| 'Florina' | PRI 612-1 × 'Jonathan' |
| 'Freedom' | NY 18492 × NY 4921-46 |

Inoculations of green, vigorously growing shoots were made by cutting-off their tips under the first undeveloped leaf using scissors previously immersed in a water suspension of a highly virulent strain of *E. amylovora* (No 691 from own collection, concentration of bacteria in suspension: $10^7$ cfu $ml^{-1}$), (Lespinasse and Paulin 1990). One or two shoots were inoculated on each tree. After inoculation the shoot tips were covered with plastic bags for 48 hours to protect desiccation of inoculum and to establish favorable conditions for infection. After 6 weeks in 2000 and after 2, 4, and 6 weeks in 2001, the total length of shoots and the length of their necrotized parts were measured. The diseased part of each shoot was expressed as a percentage of the shoot's total length. Each cultivar and selection was represented by 15 trees in 2000 and by 30 trees in 2001 which constituted 4 replications with uneven number of objects. The results were subjected to an analysis of variance. For the separation of means the Duncan's multiple t-test at the 5% level of significance was used. The calculated disease severity values (percentages of necrosis) were also presented as disease susceptibility classes (in order of increasing susceptibility) according to Le Lezec et al. (1997), where: 1 – very low (0 - 20%); 2 – low (>20 - 40%), 3 – moderate (>40 - 60%), 4 – high (>60 - 80%), and 5 – very high (80 - 100%).

## RESULTS AND DISCUSSION

The inoculated apple shoots showed a wide range of susceptibility to fire blight. The percentage values expressing damaged length of shoots determined 6 weeks after inoculation ranged from 6.7 to 71.8 on P 22 and from 24.6 to 65.1 on M.9. Out of the evaluated cultivars and clones 'Free Redstar' and J-79 showed the highest degree of resistance to fire blight, while 'Egeria', 'Ligol', 'Ligolina', and 'Melfree' appeared to be the most susceptible (Table 2). It should be pointed out that 'Medea' and 'Odra' on P 22 also showed relatively low susceptibility. The standard cultivar 'Florina' on both rootstocks was classified as having low susceptibility, however, on M.9 it was less affected by the disease than on P 22. Travis at al. (1999) suggest that there is some interaction between cultivars and rootstock which affects susceptibility to fire blight. Preliminary results of the present study showed that P 22 is moderately resistant (unpublished data) but M.9 is highly susceptible to this disease (van der Zwet and Beer 1995). 'Freedom' showed moderate susceptibility on both rootstocks but, like 'Florina', a tendency to lower disease severity on M.9. These results are in accordance with those obtained by Le Lezec et al. (1997). Fischer and Richter (1999) similarly classified 'Florina' as not very susceptible, but 'Freedom' was evaluated as susceptible. Also Aldwinckle et al. (1999) determined 'Florina' as very low susceptible but in other trials the blossoms and shoots of this cultivar appeared to be susceptible (Forsline and Aldwinckle 2002). Several pome-fruit breeding programs currently conducted both in Europe and the USA, evaluate breeding material for susceptibility to fire blight in greenhouse conditions (Aldwinckle et al. 1999, Fischer and Richter 1999, Kasa et al. 2001, Norelli et al. 2002). Using various artificial inoculation techniques it is possible to avoid the effect of the large variations in inoculum levels that occurs under natural conditions. These methods appear to be especially efficient in eliminating highly susceptible individuals (Aldwinckle and van der Zwet 1979).

The index for fire blight susceptibility which was applied in the present study is commonly used for this purpose in various apple breeding programs. It was found that the percentage value presenting the extent of necrosis development on shoots was strongly correlated with the field susceptibility of apple cultivars in several independent observations (Lespinasse and Aldwinckle 2000).

An analysis of disease development during the entire period of the present investigation on cultivars and clones grafted on M.9 indicated that shoots of 'Medea' showed the lowest degree of disease presence 2 weeks after inoculation. However, with time the shoots became more and more susceptible and after 6 weeks this cultivar was classified as moderately susceptible.

Table 2. Apple shoot susceptibility to fire blight evaluated under greenhouse conditions after artificial inoculation with *Erwinia amylovora*

| Cultivar or clone | 2000/P 22* | | | 2001/M.9* | | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean length of shoots on day of inoculation (cm) | Disease severity (%)** (after 6 weeks) | Susceptibility class*** | Mean length of shoots on day of inoculation (cm) | Disease severity (%)** after | | | Susceptibility class*** (after 6 weeks) |
| | | | | | 2 weeks | 4 weeks | 6 weeks | |
| 'Early Freegold' | 60.2 | 49.1 bc | 3 | 62.5 | 21.5 de | 46.8 e | 49.5 de | 3 |
| 'Egeria' | 57.8 | 60.6 de | 4 | 71.9 | 18.8 cd | 49.0 ef | 52.8 ef | 3 |
| 'Free Redstar' | 49.6 | 27.4 b | 2 | 75.1 | 12.8 b | 22.8 a | 24.6 a | 2 |
| 'Ligol' | 58.0 | 68.3 e | 4 | nt | nt | nt | nt | nt |
| 'Ligolina' | 57.0 | 71.8 e | 4 | 62.6 | 15.9 bc | 55.0 fg | 65.1 g | 4 |
| 'Medea' | 51.8 | 31.8 b | 2 | 68.3 | 8.3 a | 37.0 cd | 44.2 cd | 3 |
| 'Melfree' | 74.5 | 58.5 de | 3 | 80.2 | 24.2 e | 57.7 g | 57.0 f | 3 |
| 'Odra' | 63.2 | 31.1 b | 2 | 78.1 | 17.8 cd | 51.9 efg | 55.0 ef | 3 |
| D-13 | nt | nt | nt | 66.2 | 20.1 cde | 44.1 de | 45.5 cd | 3 |
| J-79 | 70.1 | 6.7 a | 1 | 75.9 | 20.8 cd | 32.2 bc | 36.0 b | 2 |
| 'Florina' | 86.9 | 34.3 bc | 2 | 79.3 | 16.4 bc | 19.2 a | 20.3 a | 2 |
| 'Freedom' | 78.8 | 59.8 de | 3 | 65.4 | 23.4 e | 37.8 cd | 41.6 bc | 3 |

*Year of study and rootstock; **Disease severity determined 6 weeks after inoculation: Length of shoot lesion (cm)/Total shoot length (cm) × 100%; ***Susceptibility classes: 1 – very low (0 - 20%); 2 – low (>20 - 40%), 3 – moderate (>40 - 60%), 4 – high (>60 - 80%), 5 – very high (80 - 100%); nt – not tested; values in each column followed by the same letter are not significantly different (p = 0.05)

Table 3. Distribution of individuals of apple cultivars and clones grafted on M.9 and P22 rootstocks amongst susceptibility classes (%)

| Cultivar or clone | Susceptibility classes* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| | P 22/2000** | | | | | M.9/2001** | | | | |
| 'Early Freegold' | 13.3 | 6.7 | 46.7 | 33.3 | 0.0 | 0.0 | 6.7 | 86.6 | 6.7 | 0.0 |
| 'Egeria' | 0.0 | 0.0 | 40.0 | 46.7 | 13.3 | 0.0 | 3.3 | 76.7 | 20.0 | 0.0 |
| 'Free Redstar' | 46.7 | 20.0 | 33.3 | 0.0 | 0.0 | 40.0 | 50.0 | 10.0 | 0.0 | 0.0 |
| 'Ligol' | 0.0 | 0.0 | 33.3 | 46.7 | 20.0 | nt | nt | nt | nt | nt |
| 'Ligolina' | 6.7 | 0.0 | 6.7 | 60.0 | 26.6 | 0.0 | 0.0 | 26.7 | 66.6 | 6.7 |
| 'Medea' | 46.7 | 0.0 | 40.0 | 13.3 | 0.0 | 10.0 | 16.7 | 63.3 | 10.0 | 0.0 |
| 'Melfree' | 6.7 | 6.7 | 20.0 | 60.0 | 6.6 | 0.0 | 0.0 | 73.3 | 26.7 | 0.0 |
| 'Odra' | 18.8 | 56.2 | 18.8 | 0.0 | 6.2 | 0.0 | 6.7 | 60.0 | 33.3 | 0.0 |
| D-13 | nt | nt | nt | nt | nt | 3.3 | 16.7 | 80.0 | 0.0 | 0.0 |
| J-79 | 80.0 | 6.7 | 6.7 | 6.6 | 0.0 | 20.0 | 36.7 | 40.0 | 3.3 | 0.0 |
| 'Florina' | 33.3 | 6.7 | 53.3 | 6.7 | 0.0 | 53.3 | 43.3 | 3.4 | 0.0 | 0.0 |
| 'Freedom' | 6.7 | 13.3 | 33.3 | 40.0 | 6.7 | 0.0 | 41.4 | 58.6 | 0.0 | 0.0 |

*Susceptibility classes: see Table 2, evaluation was made 6 weeks after inoculation with *Erwinia amylovora;***Rootstock and year of study; nt – not tested

While the intensity of fire blight on shoots of ‘Free Redstar’ and J-79 increased about two times during the entire 6-week-period, the intensity of the disease on ‘Medea’, ‘Ligolina’, and ‘Odra’ increased about five times. The distribution of individuals amongst the susceptibility classes corresponded to the disease severity determined for the cultivars studied (Table 3). Out of the trees grafted on P 22 the highest number classified as class 1 (the lowest susceptibility) originated from J-79, ‘Free Redstar’, and ‘Medea’: 80, 46.7, and 46.7%, respectively. On the other hand, the highest number of trees belonging to class 5 (the lowest resistance) was found amongst ‘Ligol’ and ‘Ligolina’: 20 and 26.6%, respectively. Also, out of the listed accessions grafted on M.9 the highest number of individuals from the class 1 of susceptibility originated from ‘Free Redstar’, J-79, and ‘Medea’.

The study presented here showed the susceptibility of terminal shoots of apple trees to fire blight. In breeding programs conducted in various countries less attention has been usually devoted to blossom susceptibility in both apple and pear cultivars. However, Thibault and Le Lezec (1990) stated that the correlation between the susceptibility of shoots and that of flowers is weak ($0.25 < r < 0.44$). On the other hand, the study by Aldwinckle et al. (1999) showed that such a correlation could exist. Therefore, full evaluation of the susceptibility of the studied cultivars and clones to the disease should be continued, both on shoots and blossoms.

## CONCLUSIONS

1. Of the accessions included in this study ‘Free Redstar’ and J-79 on M.9 and P 22 rootstocks appeared to be the most resistant to fire blight, whereas the highest susceptibility was shown by: ‘Egeria’, ‘Ligol’, ‘Ligolina’, and ‘Melfree’.
2. ‘Medea’, ‘Odra’, and J-79 were more susceptible on M.9 than on P 22 rootstocks.
3. The susceptibility of ‘Florina’ and ‘Freedom’ corresponded to the results obtained by other authors.

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## OCENA PODATNOŚCI NOWYCH POLSKICH ODMIAN I KLONÓW JABŁONI NA ZARAZĘ OGNIOWĄ

Streszczenie: W latach 2000 – 2001 przeprowadzono badania nad oceną podatności na zarazę ogniową następujących odmian i klonów jabłoni (szczepionych na P 22 i M.9), wyhodowanych w Instytucie Sadownictwa i Kwiaciarstwa w Skierniewicach: ‘Early Freegold’, ‘Egeria’, ‘Free Redstar’, ‘Ligol’, ‘Ligolina’, ‘Medea’, ‘Melfree’, ‘Odra’, D-13 i J-79. Dla porównania do badań włączono odmiany ‘Freedom’ i ‘Florina’. Młode aktywnie rosnące pędy jednorocznych drzewek, rosnących w pojemnikach w szklarni, zakażano bakteriami wysoko wirulentnego szczepu *E. amylovora* (Ea 691; koncentracja $10^7$ jtk $ml^{-1}$). Obserwacje i pomiary dotyczące rozwoju zarazy ogniowej, wykonane 6 tygodni po inokulacji, wykazały, że na podkładce P 22 najbardziej odporne okazały się ‘Free Redstar’ i J-79, podczas gdy ‘Egeria’, ‘Ligol’ i ‘Ligolina’ zaliczono do najbardziej podatnych. Również na M.9 ‘Free Redstar’ i J-79 wykazały najniższą podatność spośród badanych genotypów, a ‘Ligolina’ – najwyższą. Uzyskane wyniki korespondują z dystrybucją testowanego materiału w 5 klasach podatności. Spośród drzewek ‘Free Redstar’ (na obu podkładkach) oraz J-79 na P 22, odpowiednio 40-46,7% oraz 80% zostało zaklasyfikowanych do klasy 1 (najbardziej odpornej). Natomiast żadnego drzewka ‘Ligol’ i tylko 6,7% drzewek ‘Ligolina’ na P 22 oraz żadnego drzewka ‘Ligolina’ na M.9 nie zaliczono do tej klasy.

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