Testing of Czech cultivars and advanced selections of apples for fire blight (*Erwinia amylovora*) resistance

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ABSTRACT: Five apple cultivars from the Czech Republic and 26 selections from the same country (a majority of them were resistant to scab) were included in the present study. *M. robusta* strain (Nr. 5) was used as a control with the highest level of resistance to fire blight. Another 7 cultivars with different levels of resistance or susceptibility to the disease were also evaluated. Selena and Nabella were found to be resistant, whereas Angold, Resista and Topaz were susceptible. Two HL selections were previously identified as highly resistant, 3 selections as medium resistant and 7 others as moderately susceptible. The rest of the 14 selections ranged from very high susceptible to medium susceptible. A high level of resistance was confirmed in 3 cultivars from Dresden-Pillnitz: Reanda, Remo and Rewena. Comparison of the parentage of the tested cultivars or selections with their level of resistance to fire blight suggests that most of the resistance comes from *Malus floribunda*, which was used in the course of their breeding as a donor of scab resistance. In one case, the source of the fire blight resistance was Starking Delicious cv.

Keywords: *Erwinia amylovora*; apple; fire blight; resistance; cultivars; Czech Republic

Fire blight is a very destructive bacterial disease of the Rosaceae family, especially of pome fruits, caused by *Erwinia amylovora*. This disease appeared in Europe for the first time in 1956, in Great Britain, and since that time it invaded the rest of Europe from there, the European continent in 1961, Germany in 1971, and then more than 40 European countries (RICHTER 1999).

Growing of pome fruit species – apples, pears, quinces – is particularly threatened by this disease as currently there are no effective fungicides available for plant protection. A highly effective antibiotic chemical – Plantomycin – has been withdrawn from use in fruit orchards during the last several years. But it will be completely prohibited for use from 2004. Some other means against fire blight are known in fruit growing. One of them, which is very efficient but a long-term possibility, is the breeding of new cultivars with resistance to fire blight.

The majority of grown cultivars of the apple is very susceptible to the disease, for example Jonagold, Elstar, Fuji, Gala, Golden Delicious, Rubinette, Šampion, and also commonly spread cultivars of the pear and the quince. Breeding of new cultivars with resistance to fire blight is a long time effort on an international level. In the case of pears, success in breeding was achieved in Canada by resistant novelties Harrow Delight and Harvest Queen. In Germany, breeding for fire blight resistance has been incorporated into the apple-breeding programme since the seventies, when the first natural occurrence appeared there. A systematic breeding led to new apple cultivars with resistance to fire blight – Reanda, Rebella, Remo, Rewena and some others (FISCHER, SCHAEFER 1990; FISCHER, RICHTER 1999) that were initiated into growing in the meantime. Among new foreign apple cultivars Enterprise, Florina, Liberty, Nabella and Selena show a good level of resistance to fire blight (FISCHER, RICHTER 1999).

MATERIAL AND METHODS

Tests for fire blight resistance were conducted in the glasshouse by shoot infections and outdoors by blossom infections. Twenty to forty plants per cultivar or selection were grafted on the rootstock MM 106, and actively growing shoots were inoculated when they achieved a length between 15 and 25 cm. The bacterial suspension consisted of three highly virulent *Erwinia amylovora* strains that were determined, by previous tests for virulence, as the most virulent ones chosen each year. The concentrations of bacteria in the inoculum suspension were adjusted to 10^9 cfu/ml.

The infestation of plants was evaluated after 4 to 6 weeks following the inoculation by calculating the length of necrotic lesions to total shoot length (× 100%). These results were transformed into a score system that is presented in Table 1 (FISCHER, RICHTER 1999). Blossoms of apple cultivars were inoculated in the field by

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Table 1. Rating of resistance to fire blight after shoot infection (length of infected shoot divided by total length of shoot × 100%)

Rank value	Length of infected shoot (%)
9	0–0.9
8	1.0–16.3
7	16.4–31.0
6	31.1–44.2
5	44.3–56.1
4	56.2–66.9
3	67.0–76.5
2	76.6–85.9
1	85.3–100

spraying the local strains. After infection, the spread of the disease in the trees was noted. The results were assessed at the 5% significance level.

Relevant results of the testing could be completed after 3 years as the performance of symptoms is more or less influenced by environmental conditions. The advanced selections from Holovousy, however, were tested only in 2002 as the trees in the previous year were too small and shoots in the necessary number of plants were not obtained.

RESULTS AND DISCUSSION

From the beginning of the research, foreign cultivars of the apple were tested for their resistance or susceptibility to fire blight with the aim to identify new suitable parental material for subsequent breeding. Czech apple cultivars were also tested since 1996.

For comparison, the standard cultivars Idared (susceptible), Prima (moderately resistant to moderately sus-

Table 3. Results of testing of advanced selections from Holovousy for fire blight resistance (2002)

Category of the response	Selection number	Mean value of rating
Highly resistant	HL 999	8.2
	HL 1047	8.1
Medium resistant	HL 799	7.9
	HL 354	7.4
	HL 184	7.1
Moderately susceptible	HL 178	6.7
	HL 337	6.6
	HL 2218 A	6.6
	HL 2219	6.4
	HL 782	6.4
	HL 183	6.2
	HL 759	6.2
Medium susceptible	HL 2163	5.9
	HL 1196	5.7
	HL 2280	5.5
	HL 151	5.4
	HL 1356	5.2
	HL 659	5.1
	HL 13	4.6
Highly susceptible	HL 447	4.5
	HL 649	4.3
	HL 1381	4.1
	HL 1529	3.8
Very highly susceptible	HL196	1.8
	HL 514	1.7
	HL 722	1.7

Table 2. Results of evaluation (1–9) of selected cultivars for fire blight resistance after shoot infection in 1996–2002

Cultivar	1996	1997	1998	1999	2000	2001	2002
Idared	1.4	4.2	2.8	3.9	1.9	3.1	3.7
Golden Delicious		5.2				3.3	4.4
Prima	2.9	7.2*	4.2	7.1*	5.6*	6.8*	7.6*
M. robusta Nr. 5	9.0*	9.0*	9.0*	9.0*	8.1*	9.0*	8.3*
Liberty			7.8*		6.9*	8.5*	7.8*
Angold	1.8		3.0		2.3		
Nabella	4.4*	8.3*	6.6*	7.9*	5.9*		7.8*
Resista	2.5		5.1		3.5		
Selena	5.8*	8.4*	8.2*	8.7*	7.9*		8.4*
Topaz			2.8		1.1	5.0	3.9
Reanda	8.4*	8.8*		8.3*	7.8*	7.9*	8.3*
Remo	7.1*	8.4*	8.3*	7.9*	5.8*	8.5*	7.9*
Rewena	8.2*	8.0*	8.3*	7.9*	7.3*	8.4*	8.5*

*Significantly different from Idared for $\alpha = 5\%$

Table 4. Breeder's status, response to scab and origin of genotypes in this study

Name or designation	Breeder's status	Response to scab (in contemporary conditions of CZ)	Parents or pedigree	
			female	male
Angold	cultivar	moderately resistant (tolerant)	HL A 28/39 (Antonovka o.p.)	Golden Delicious
Liberty	cultivar	resistant	PRI 54-12*	Macoun
Nabella	cultivar	moderately resistant (tolerant)	Mother	Starking Delicious
Prima	cultivar	resistant	PRI 14-510*	NJ 123249
Reanda	cultivar	resistant	Clivia	Hybrid of V_f donor*
Remo	cultivar	resistant	James Grieve	Hybrid of V_f donor*
Resista	cultivar	resistant	Prima*	NJ 56
Rewena	cultivar	resistant	(Cox Orange × Oldenburg)	Hybrid of V_f donor*
Selena	cultivar	resistant	Britemac	Prima*
Topaz	cultivar	resistant	Rubín	Vanda*
HL 13	candidate for a cultivar	moderately resistant (tolerant)	HL 324 [HL A 28/39 (Antonovka o.p.) × Golden Delicious]	Idared
HL 151	donor of scab resistance	moderately resistant (tolerant)	HL 200 (Golden Delicious × Purdue R7T41)*	Zuzana
HL 178	donor of scab resistance	resistant	HL 18 (Golden Spur × Granny Smith)	HL 261 (Golden Delicious × Purdue R7T41)*
HL 183	candidate for a cultivar	resistant	HL 18 (Golden Spur × Granny Smith)	HL 261 (Golden Delicious × Purdue R7T41)*
HL 184	candidate for a cultivar	resistant	NJ 55 (NJ 303955 × Golden Delicious)	DI 292*
HL 196	donor of scab resistance	resistant	D 21-213 (Spartan × M2439)	Coop 18*
HL 354	candidate for a cultivar	resistant	Gloster	Prima*
HL 337	donor of scab resistance	resistant	Prima*	HL 200 (Golden Delicious × Purdue R7T41)*
HL 447	donor of fruit quality	susceptible	Lord Lambourne	Šampion
HL 514	candidate for a cultivar	susceptible	HL III 12/30 (Jonathan × Ontario)	Rubín
HL 649	candidate for a cultivar	susceptible	Mio	Quinte
HL 659	donor of scab resistance	resistant	Florina	Liberty
HL 722	donor of fruit quality	moderately resistant (tolerant)	Rubín	HL II 9/18 (Landsberger Renette × Marbrée de Watervliet)
HL 759	donor of fruit quality	moderately resistant (tolerant)	Rubín	Oldenburg
HL 782	candidate for a cultivar	moderately resistant (tolerant)	Rubín	Priscilla*
HL 799	candidate for a cultivar	resistant	HL 75-26-8 (Britemac × Prima)*	HL 128A (mutant of McIntosh)

Table 4 to be continued

Name or designation	Breeder's status	Response to scab (in contemporary conditions of CZ)	Parents or pedigree	
			female	male
HL 999	candidate for a cultivar	resistant	Selena*	Florina*
HL 1047	candidate for a cultivar	moderately resistant (tolerant)	Britemac	Dir 101T 192*
HL 1196	donor of scab resistance	resistant	HL A 33/74 (Spätblühender Taffetapfel × Court Pendu Plat)	Trent*
HL 1356	donor of scab resistance	resistant	Mcfree*	HL 10157 (Mother × James Grieve)
HL 1381	donor of scab resistance	resistant	Gala	HL 1347 [HL B 14/11 (Spätblühender Taffetapfel × Court Pendu Plat) × Trent]*
HL 1529	candidate for a cultivar	resistant	Primula*	HL 237 (Starkrimson Delicious × Glockenapfel)
HL 2163	candidate for a cultivar	resistant	HL 237 (Starkrimson Delicious × Glockenapfel)	Priscilla*
HL 2218A	candidate for a cultivar	resistant	HL 223 (Starkrimson Delicious × Glockenapfel)	26TRS-29T-26*
HL 2219	candidate for a cultivar	resistant	HL 223 (Starkrimson Delicious × Glockenapfel)	26TRS-29T-26*
HL 2280	candidate for a cultivar	resistant	HL 223 (Starkrimson Delicious × Glockenapfel)	24TRS-19T-2*

**Malus floribunda* in ancestors

ceptible) and *Malus robusta* Nr. 5 (very resistant) were used. A very high level of resistance of *Malus robusta* Nr. 5 to fire blight was reported previously (JANICK et al. 1996).

The results of evaluation of shoot infections for 1996–2002 are shown in Table 2. Idared, as a susceptible standard, proved to be very susceptible in all years; *Malus robusta* Nr. 5 was very resistant, but Prima gave a very variable response. Golden Delicious was susceptible; Liberty was from moderate to highly resistant.

Among the studied Czech cultivars, Angold, Resista and Topaz were susceptible whereas Nabella and Selena were resistant. As for the apple cultivars of Dresden-Pillnitz origin that were included in Table 2, Reanda, Remo and Rewena showed a high level of stable resistance (RICHTER, FISCHER 2002).

Advanced selections from Holovousy (HL selections) that were included in Table 3 displayed very variable grades of resistance. The advanced selections with average levels between 8.0 and 9.0 can be considered as highly resistant (HL 999, HL 1047), those with the range between 7.0 and 7.9 as medium resistant (HL 799, HL 354 and HL 184), 6.0 and 6.9 moderately susceptible, 4.6 and 5.9 medium susceptible, 3.6 and 4.5 highly susceptible and 1.0 and 3.5 extremely susceptible.

Within the studied series, five of the HL advanced selections were previously identified as resistant to fire blight. Their grades of resistance should be, however, confirmed by another two years of testing.

A survey of the tested cultivars and advanced selections regarding their scab resistance or scab susceptibility and their parents is given in Table 4. Some relations between fire blight resistance and pedigree background of the genotypes can be traced from the data. With one exception, all the cultivars and selections that were found resistant to fire blight in this study possess the *M. floribunda* ancestor in their pedigree. This is in agreement with the statement by JANICK et al. (1996) and FISCHER and RICHTER (1996), who claimed that fire blight resistance was likely transmitted from *M. floribunda* 821 along with scab resistance. Several scab resistant cultivars or selections carrying V_f gene, however, were susceptible to fire blight and Vanda seems to be even more susceptible.

It is obvious from the presented data that this character is not under simple genetic control, and several modifying factors might be involved. For example, Prima was identified in this study as medium susceptible but Selena and HL 354, which were selected within its progenies, were classified as resistant.

The cultivar Nabella is the only one in this study that was not related to *M. floribunda*. In this case, fire blight resistance probably comes from Starking Delicious, which was also reported as another source of resistance (JANICK et al. 1996). In a previous study conducted in domestic environmental conditions, Starking Delicious, however, was classified as medium susceptible (FISCHER, SCHAFFER 1990). The different classification of resistance could be derived from the different virulent *Erwinia amylovora*-strains in the resistance evaluation (FISCHER, RICHTER 1996).

References

FISCHER C., RICHTER K., 1996. Breeding for fire blight resistance within multiple resistance breeding programme in apples. Acta Hort., *411*: 375–381.

FISCHER C., RICHTER K., 1999. Ergebnisse der Resistenzzüchtung gegenüber Feuerbrand im Pillnitzer Apfelzüchtungsprogramm. Erwerbsobstbau, *41*: 56–60.

FISCHER C., SCHAFFER H.J., 1990. Vergleichende Untersuchungen der Resistenz von Apfelsorten gegenüber Feuerbrand im Gewächshaus und im Freiland. Gartenbau, *37*: 299–300.

JANICK J., CUMMINS J.N., BROWN S.K., HEMMAT M., 1996. Apples. In: JANICK J., MOORE J.N. (eds.), Fruit Breeding, Vol. 1, Tree and Tropical Fruits. New York, John Wiley & Sons, Inc.: 1–77.

RICHTER K., 1999. Der Feuerbrand des Kernobstes (*Erwinia amylovora*) und Möglichkeiten seiner Bekämpfung. Erwerbsobstbau, *41*: 202–212.

RICHTER K., FISCHER C., 2002. Stability of Fire Blight Resistance in Apple. Acta Hort., *590*: 381–384.

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Testování českých odrůd a novošlechtění jabloní na odolnost proti spále růžokvětých (*Erwinia amylovora*)

ABSTRAKT: Do studia bylo zařazeno 5 odrůd a 26 novošlechtění jabloní vyšlechtěných v České republice (z nichž většina byla rezistentních proti strupovitosti). Jako kontrola s nejvyšším stupněm odolnosti proti spále růžokvětých byl použit klon botanického druhu jabloně *M. robusta* (č. 5). V rámci studia bylo hodnoceno dalších sedm odrůd, které se vyznačovaly různým stupněm odolnosti nebo citlivosti k této chorobě. Odrůdy Selena a Nabella byly vyhodnoceny jako odolné, zatímco Angold, Resista a Topaz se ukázaly být jako citlivé. Podle předběžných výsledků byla dvě novošlechtění série HL vyhodnocena jako vysoce odolná, tři jako středně odolná a sedm dalších jako slabě citlivých. Ostatních 14 novošlechtění bylo vyhodnoceno v rozmezí od vysoce citlivých do středně citlivých. Potvrdil se rovněž vysoký stupeň odolnosti u tří odrůd vyšlechtěných v Dresden-Pillnitz: Reanda, Remo a Rewena. Porovnání původu testovaných odrůd a novošlechtění s jejich úrovní odolnosti proti spále růžokvětých ukazuje na to, že tato odolnost většinou pochází z botanického druhu *Malus floribunda*, který byl použit v procesu jejich šlechtění jako donor rezistence proti strupovitosti. V jednom případě však byla zdrojem odolnosti odrůda Starking Delicious.

Klíčová slova: *Erwinia amylovora*; jabloň; spála růžokvětých; odolnost; odrůdy; Česká republika

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