Frequency of Powdery Mildew Resistances in Spring Barley Cultivars in Czech Variety Trials

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Abstract

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In 2006–2010, resistance to the powdery mildew pathogen was studied in 277 spring barley cultivars. They were represented by 54 cultivars in Czech official variety trials, of which 42 were foreign, and 223 cultivars in variety trials conducted by domestic breeding companies in that period. Sixty-eight domestic cultivars (28.8%) exhibited heterogeneity in the examined trait, i.e. they were composed of lines with different resistances to powdery mildew. Thirteen known resistances were identified (Ab, Ar, HH, La, Ly, Mlo, Ri, Ro, Ru, Sp, St, Tu2 and We). The most frequent resistance was Mlo detected in 160 homogeneous cultivars (= 76.6%). The newly described resistance Ro was found in 13 cultivars. Frequency of other resistances was low (maximally 2.4%). Unknown resistances were found in 16 cultivars, in five of which they were effective to all used pathotypes of the pathogen. Research on cultivars possessing unknown resistances and registered heterogeneous cultivars continues.

Keywords: *Blumeria graminis* f.sp. *hordei*; *Hordeum vulgare*

Spring barley (*Hordeum vulgare* L.) is a crop that has undergone important changes in the Czech Republic over the last five decades. On average of 1960–1968 the areas of spring barley were 365,000 ha, then they enlarged up to 624 000 ha on average of 1975–1982, and in 2007–2010 they were on average of 327 000 ha. Only domestic (including Slovak) cultivars were grown till 1996, when the first foreign cultivars Ditta, Krona and Signal were registered. In 2001–2010, 53 cultivars were registered, among which there were only 12 Czech and three Slovak cultivars. At the end of the 20th century, spring barley was bred at seven breeding stations in comparison with three present places.

Long-term disease severity data on barley evaluated in Czech official variety trials were analysed (Dreiseitl 2011a). It was found out that 50% of all detected epidemics on spring barley was caused by the fungus *Blumeria graminis* (DC.) E. O. Speer f.sp. *hordei* emend. É. J. Marchal (anamorph *Oidium monilioides* Link) (= *Bgh*). The results revealed that on average 33% of the spring barley area was heavily infected by this pathogen every year and the disease was found on spring barley in all years of the period 1971–2005.

The objective of the present contribution was to summarise data on the postulation of resistance to the powdery mildew pathogen in spring barley cultivars tested in domestic variety trials that were conducted in 2006–2010 and to compare results with previous data in a similar way like in winter barley cultivars (Dreiseitl 2011b).

MATERIAL AND METHODS

Resistances were identified using the postulation method based on scoring phenotypes of host-pathogen interactions.

Barley germplasm. Two hundred and seventy-seven spring barley cultivars tested in 2006–2010 were studied. They were represented by 54 European cultivars evaluated in Czech official variety trials, and 223 domestic cultivars evaluated in

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variety trials conducted by breeding companies. Seed of all cultivars was provided by respective breeders.

Pathogen isolates. Thirty-two (40 in 2009) pathotypes of *Bgh* held in the genebank at the Agricultural Research Institute Kromeriz Ltd. (Czech Republic) were used for resistance tests. Between the tests in individual years, several pathotypes were always replaced by the new ones with greater resolving power. Before inoculation, each pathotype was purified, verified for the correct virulence phenotype on differential hosts and increased on susceptible cultivars.

Testing procedure. In 2006–2008, young plants were used for resistance tests (Dreiseitl 2007). In 2009 and 2010, the resistance tests were conducted on leaf segments as follows. About 20 seeds of each barley cultivar were sown into each of two pots (80mm diameter) filled with a gardening peat substrate and placed in a mildew-proof greenhouse under natural daylight. Leaf segments 20 mm long were cut from the central part of healthy fully-expanded primary leaves. Three leaf segments of each accession were placed in a Petri dish on water agar (0.8% and 40 ppm benzimidazole) for testing with an isolate. For each isolate, a Petri dish with leaf segments was placed at the bottom of a metal inoculation tower and inoculated with inoculum density ca. 8 conidia per mm^2. The dishes with inoculated leaf segments were incubated at 18 ± 3°C under artificial light (cool white fluorescent lamps providing 12 h light at 30 ± 5 $\mu mol/m^2/s$).

Evaluation. Eight to ten days after inoculation, reaction types (RTs) on the upper part of the adaxial side of leaf segments were scored. The nine RTs scale (0–4 including intertypes) was used for scoring (Torp *et al*. 1978). Each cultivar was tested in two replications. If there were significant differences between replications in RTs, additional tests were carried out. A set of 32 or 40 RTs developed after inoculation with selected pathogen isolates provided the basis for a resistance spectrum (RS) of each cultivar. The resistance in each cultivar was postulated by comparing its RS with previously determined RSs of standard barley lines possessing known resistance genes. In some heterogeneous cultivars some resistances were determined and they are shown in brackets behind the symbol H. The resistance spectra of the tested cultivars are included in protocols provided to individual breeders or to the Czech official variety trials authority, and they are available at the author of this contribution. The found resistances were designated using European codes (Boesen *et al*. 1996). Four missing codes [H, HH, Ro and U(E)] were added (H = heterogeneous cultivars in terms of the trait studied, when after inoculation with one *Bgh* pathotype at least plants exhibited different reaction types and thus they were composed of two or more lines possessing different resistances; HH and Ro are designated after Heils Hanna and Roxana respectively, and U(E) means unknown resistance effective to all isolates of the pathogen used).

Table 1. Frequency of resistances to the powdery mildew pathogen found in 277 spring barley cultivars in Czech variety trials in 2006–2010

Resistance[1]	No. of cultivars		Resistance[1]	No. of cultivars	
	total	domestic		total	domestic
Ab	1	1	Ru	4	3
Ar	4	2	Sp	4	4
HH	4	4	St	2	2
La	1	0	Tu2	3	3
Ly	1	0	U	16	12
Mlo	160	131	– of them U(E)	5	5
None	0	0	We	5	4
Ri	5	5	Heterogeneous	68	68
Ro	13	5			

[1]according to Boesen *et al*. (1996); additional resistance codes used: HH – designated after Heils Hanna; Ro – designated after Roxana; U(E) = unknown resistance (effective to all isolates of the pathogen used)

RESULTS

Two hundred and nine homogeneous cultivars and 68 heterogeneous cultivars were found. A specific resistance was found in each of the tested cultivars. Thirteen known resistances were identified (Ab, Ar, HH, La, Ly, Mlo, Ri, Ro, Ru, Sp, St, Tu2, and We) and their numbers are given in Table 1. The most frequent resistance was Mlo detected in 160 homogeneous cultivars (= 76.6%) and also in a line of 28 heterogeneous cultivars. The resistance Ro was found in 13 cultivars (6.2%). Frequency of other resistances was low (maximally 2.4%). Unknown resistances were found in 16 cultivars, in five of which they were effective to all used pathotypes of the pathogen.

A set of 54 cultivars in Czech official variety trials comprised 42 foreign and 12 domestic cultivars. Four domestic cultivars were heterogeneous and 35 out of 50 homogeneous cultivars (70%) contained the Mlo resistance.

DISCUSSION

The resistance of all cultivars tested in Czech Official Variety Trials was examined every year till 2005. However, since 2006 it was studied only in selected cultivars, generally those tested for the second and third year.

In 2006–2010, 235 domestic cultivars were tested in both trials. This number did not differ from preceding 5-year periods (Dreiseitl 2005) although the number of barley breeding stations decreased. The proportion of heterogeneous cultivars (29%) was identical to that in the previous 5-year period and sets of domestic cultivars greatly differed right in this parameter because among 42 foreign cultivars tested within this paper there were no heterogeneous cultivars and only seven heterogeneous cultivars were found among 168 foreign cultivars tested earlier (Dreiseitl 2006).

In terms of increased knowledge of the given pathosystem, detection of new and unknown resistances belongs to the most significant findings. Subsequent experiments are focused especially on these resistances as well as on resistances of registered heterogeneous cultivars. Since 1991, hundreds of advanced barley lines developed in the Czech and Slovak Republics and elsewhere have been tested. Among them many possessed the Mlo resistance. Some other cultivars were also resistant to all isolates used, but they did not express a reaction type typical of the Mlo resistance (Jensen *et al*. 1992) and were considered to have unknown resistance(s). Such cultivars were lodged in our working barley genebank, among them also Cebeco 0421 registered as cv. Kangoo in 2008.

In 2008, the powdery mildew pathogen population was studied (Dreiseitl 2008) and the virulence frequency on resistance genes carried by winter barley cultivars was assessed. Furthermore, some spring barley genotypes were used, including cv. Kangoo (Dreiseitl unpublished), whose resistance was at that time effective against all isolates in the pathogen genebank at Kromeriz. Out of the 160 isolates examined, eight (5%) were virulent on cv. Kangoo. Five out of the 160 isolates, including two isolates that were virulent on cv. Kangoo, were added to the pathogen genebank. Subsequently, 22 cultivars with previously detected unknown resistance(s) were tested with 40 reference isolates of the powdery mildew pathogen, including two isolates virulent on cv. Kangoo. Cv. Kangoo and 17 other cultivars including cvs Havanna, Marnie and Roxana expressed a similar resistance spectrum. Cv. Roxana derives its resistance from wild barley accession 1B–86B, and was the first cultivar registered with this resistance, therefore it was recommended that this resistance would be designated Ro (Dreiseitl 2011c). In this paper, the newly described resistance Ro was found in 13 cultivars, five of which were domestic.

It can be assumed that some of the present, and also of the formerly examined cultivars with unknown resistances, possess resistances derived from wild barley (*Hordeum vulgare* subsp. *spontaneum*), e.g. those detected by Jahoor and Fischbeck (1987, 1993). However, to trace original sources of these resistances in commercial cultivars is often an uphill job and to communicate, if necessary, with foreign breeding companies is not mostly successful. Therefore, it is probable that some new resistances will be characterised using only original resistance spectra obtained by the postulation method, without knowing a relevant source and other data on genetics of this important varietal trait.

Among 45 cultivars registered in 1995–2005, the Mlo resistance was detected in 49% (Dreiseitl & Jørgensen 2000; Dreiseitl 2005, 2006). During the period 2006–2010, 31 cultivars were registered in the Czech Republic and the Mlo resistance was found in 19 (61%). In comparison with the previ-

ous period (2001–2005), the proportion of tested homogeneous cultivars carrying the Mlo resistance also increased – from 71% (Dreiseitl 2005) to 77% at present. Thus, a further increase in the proportion of registered cultivars possessing this durable resistance can be supposed.

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