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Characterization of the suppressor gene of powdery mildew resistance gene Pm8 in common wheat (*Triticum aestivum* L.) cv. Regina

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Abstract. The Czech winter wheat cv. Regina which does not possess specific genes for powdery mildew resistance except Pm5 was crossed with the cvs. Florida, Tjelvar, Agra, Olymp and Sabina, all possessing T1BL·1RS and the dominant suppressor SuPm8, with Riebesel 47/51 possessing substitution 1R-1B and SuPm8 and with the T1BL·1RS cvs. Sparta, Iris, Mona without SuPm8. Powdery mildew isolates avirulent on Pm8 and virulent on other Pm genes were used in the trials. Tests for resistance were carried out either on seedlings at the first leaf stage or on detached leaves cultured on benzimidazolagar. No segregation for resistant plants in F_2 of all crosses of the cv. Regina with cultivars possessing T1BL·1RS and SuPm8 indicates that Regina has SuPm8. The segregation ratio 3 resistant : 13 susceptible in the F_2 population of crosses between the cv. Regina and cultivars possessing T1BL·1RS and no SuPm8 also confirms the presence of SuPm8 in the cv. Regina. The obtained results also indicate that expression of Pm2 and Pm4b is not affected by SuPm8 and that SuPm8 does not affect stem rust resistance gene Sr31 located on 1RS segment.

Key words: 1BL·1RS translocation, powdery mildew, resistance gene Pm8, suppressor gene SuPm8, wheat.

Introduction

Wheat cultivars carrying 1BL·1RS translocation are widely grown and used in breeding programmes all over the world (VILLAREAL et al. 1991, BARTOŠ 1993). The translocation carries closely linked genes for powdery mildew

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resistance (Pm8), leaf rust resistance (Lr26), stem rust resistance (Sr31) and yellow rust resistance (Yr9) (SINGH et al. 1990, VILLAREAL et al. 1991) as well as factors contributing to yield increase (VILLAREAL et al. 1995). However, it has a negative effect on baking quality (ZELLER et al. 1982).

FRIEBE et al. (1989) found that the gene Pm8 for powdery mildew resistance was not expressed in the cvs. Florida, Heinrich and Olymp in spite of the fact that they carry 1BL·1RS translocation. LUTZ et al. (1992) described unexpressed powdery mildew resistance conferred by Pm8 in the former Czechoslovakian cvs. Agra and Sabina. HANUŠOVÁ et al. (1996) listed 15 cultivars with 1BL·1RS translocation and one substitution line lacking expression of Pm8. Many other wheat cultivars and lines lacking Pm8 expression were found in Chinese and Mexican varieties (REN et al. 1996).

To explain the non-expression of Pm8, FRIEBE et al. (1989) suggested that either Pm8 was not located on the 1RS chromosome arm, or that the 1RS arm had been mutated, or that there was genetic suppression of Pm8. HANUŠOVÁ (1992) demonstrated that Pm8 in the cv. Agra was inhibited by a dominant suppressor gene segregating independently from Pm8, and that this gene is identical with those in Sabina, Florida, Olymp and Tjelvar (HANUŠOVÁ et al. 1996). ZELLER, HSAM (1996) and REN et al. (1996) found that the common wheat cultivar Caribo and the line WW31 possessed the suppressor of Pm8 in the absence of 1BL·1RS translocation.

This contribution presents data indicating the presence of the gene suppressing Pm8 (SuPm8) in the cv. Regina that does not posssess 1BL·1RS translocation and proving that SuPm8 acts specifically on Pm8 and does not suppress Pm2 or Pm4b.

Material and methods

The cv. Regina (Yubileynaya 50 / Zora // Tadorna) does not possess specific genes for powdery mildew resistance except Pm5 that is ineffective to the prevailing powdery mildew races. The cv. Regina was crossed to the cvs. Florida, Tjelvar, Agra, Olymp and Sabina, all possessing T1BL·1RS and SuPm8, with Riebesel 47/51 possessing substitution 1R-1B and SuPm8 and with Sparta, Iris and Mona, all T1BL·1RS without SuPm. Some of the above mentioned cultivars possessing T1BL·1RS were also crossed to the cvs. Hana and Viginta, both without T1BL·1RS and SuPm8.

Powdery mildew isolates (Egt) avirulent on Pm8 (isolates 2, 53), on Pm2 and Pm8 (isolate 203), on Pm4b and Pm8 (isolates 9, 35) and virulent on other Pm genes were used in the trials.

Tests for resistance were carried out on seedlings at the first leaf stage or on segments of primary leaves of host plants at Prague-Ruzyně or in Weihenstephan. The leaf detachment method employed was described previously by ZELLER et al. (1993). Leaf segments were cultured in Petri dishes on 6 g/L agar and 35 mg/L benzimidazole.

Results with stem rust including crosses with Regina were extracted from previous experiments (BARTOŠ et al. 1990).

Table I. Reactions of F_1 and F_2 generations of crosses involving wheat cultivars with Pm8, SuPm8 and without Pm8 after inoculation with Egt isolates 2, 35 and 53

Cross	Generation	Egt isolate	Number of plants			Expected ratio	χ^2	P
			sistant	susceptible	total			
a)								
Agra × Regina	F_1	2	–	6	6	–	–	–
	F_2	2	–	168	168	–	–	–
Sabina × Regina	F_1	2	–	2	2	–	–	–
	F_2	2	–	180	180	–	–	–
Florida × Regina	F_1	2	–	3	3	–	–	–
	F_2	2	–	162	162	–	–	–
Tjelvar × Regina	F_1	2	–	1	1	–	–	–
	F_2	2	–	165	165	–	–	–
Rieb.47/51× Regina	F_1	2	–	2	2	–	–	–
	F_2	2	–	151	151	–	–	–
Olymp × Regina	F_1	2	–	4	4	–	–	–
	F_2	2	–	208	208	–	–	–
b)								
Mona × Regina	F_1	2	–	6	6	–	–	–
	F_2	2	28	140	168	3 : 13	0.4703	0.50-0.20
Sparta × Regina	F_1	53	–	3	3	–	–	–
	F_2	53	37	173	210	3 : 13	0.1762	0.80-0.50
Iris × Regina	F_1	35	–	6	6	–	–	–
	F_2	35	33	120	153	3 : 13	0.7979	0.50-0.20
c)								
Florida × Hana	F_1	2	–	6	6	–	–	–
	F_2	2	17	79	96	3 : 13	0.683	0.80-0.50
Tjelvar × Hana	F_2	2	43	205	248	3 : 13	0.3231	0.80-0.50

Results

Results summarized in Table 1 show no segregation for resistant plants in F_2 population of all crosses of the cv. Regina to the cultivars possessing T1BL·1RS or 1B-1R and SuPm8 (Table 1a). This indicates that the cv. Regina has SuPm8. In crosses of the cv. Regina with cultivars possessing T1BL·1RS and no SuPm8, the segregation ratio 3 resistant : 13 susceptible (Table 1b) in the F_2 population also confirms the presence of SuPm8 in the cv. Regina. The same ratio was obtained when the cultivars possessing T1BL·1RS and SuPm8 were crossed with susceptible cultivars without T1BL·1RS and SuPm8 (Table 1c).

Table 2. Reactions in F_1 and segregation in F_2 populations of crosses of T1BL·1RS cultivars with wheat cultivars without Pm8 after inoculation with Egt isolates 9, 35 and 203

Cross	Generation	Isolate	Number of plants			Expected ratio	χ^2	P
			resistant	susceptible	total			
Sabina × Hana	F_1	9	5	–	5	–	–	–
	F_2	9	241	63	304	51:13	0.0316	0.99-0.95
Olymp × Viginta	F_2	9	131	34	165	51:13	0.0087	0.99-0.95
Tjelvar × Hana	F_1	203	8	–	8		–	–
	F_2	203	153	48	201	51:13	1.5809	0.50-0.20
Sparta × Regina	F_2	35	90	20	110	51:13	0.3084	0.80-0.50

When more genes for powdery mildew resistance were involved in the crosses (the cvs. Sabina and Olymp possess Pm8 and Pm4b, while the cv. Tjelvar possesses Pm8 and Pm2 and the cv. Sparta – Pm8, Pm2, Pm4b), only Pm8 was suppressed and other Pm genes segregated as expected (Table 2). Results indicate that expression of Pm2 and Pm4b is not affected by SuPm8.

The suppressor gene present in the cv. Regina does not affect Sr31, located on 1RS segment (Table 3). In the F_2 generation of crosses between cultivars Danubia, Selekta and Iris possessing T1BL·1RS with the cv. Regina as well as in the progeny of the cross Danubia × Zdar a segregation close to 3 resistant : 1 susceptible, characteristic for one dominant resistance gene, was observed. A similar segregation was also found in the F_2 generation of the cross between the cvs. Regina and Sabina, both possessing SuPm8. The cv. Sabina itself shows stem rust resistance conditioned by Sr31, thus ruling out the effect of SuPm8 on Sr31.

Table 3. Segregation of stem rust reactions in F_2 populations of crosses of T1BL·1RS cultivars with wheat cv. Regina and a control cross with cv. Zdar

Cross	Rust isolate	Number of plants			χ^2	P 3 : 1
		resistant	susceptible	total		
Danubia × Regina	G 425	118	56	174	4.76	0.50-0.01
Selekta × Regina	G 425	35	16	51	1.10	0.50-0.20
Iris × Regina	G 2030	159	65	224	1,39	0.50-0.20
Regina × Sabina	G 69	193	87	280	5.50	0.05-0.01
Danubia × Zdar	G 425	115	53	168	3.84	0.05

Discussion

The cultivar Regina registered in former Czechoslovakia in 1982, belonged to the leading winter wheat cultivars in the eighties and was also registered and grown in the former German Democratic Republic. It was also frequently used in breeding programmes and is in the pedigree of the Czech cvs. Ina, Samara and Siria. However, none of the mentioned cultivars possesses T1BL·1RS which could lead to detection of partial ineffectiveness of Pm8 already in the breeding material. Another reason why inhibition of Pm8 was not observed in other crossess that contained T1BL·1RS was the prevalence of virulence on Pm8 in the powdery mildew population.

ZELLER, HSAM (1996) located a suppressor of Pm8 on chromosome 7D in the common wheat cv. Caribo. KERBER, GREEN (1980) located a suppressor of stem rust resistance on the same chromosome. Monosomic analyses of rust resistance of the cv. Slavia carried out by KOŠNER, BARTOŠ (1983a, b) revealed suppression of stem rust resistance by the chromosomes 7D and 2D. Our experiments carried out with the cv. Regina revealed no suppression of Sr31 located on the same 1RS segment as Pm8 (Table 3). Futhermore, in the crosses where Pm8 was present together with Pm2 or Pm4b, only Pm8 was suppressed which indicates specificity of SuPm8.

Results summarized in Table 1 indicate that the suppressor in the cv. Regina is identical to that in Riebesel 47/51 and in the cvs. Olymp, Florida, Tjelvar, Agra and Sabina.

The presence of inhibitors of resistance genes seems to be more frequent than expected as was already pointed out by BAI, KNOTT (1992), ZELLER,

HSAM (1996) and REN et al. (1996). Suppressors can also be created by induced mutagenesis (JORGENSEN 1996). Monosomic analyses often reveal partial suppression of resistance in one or several monosomic lines (e.g. KOŠNER, BARTOŠ 1983a, b). Results of monosomic analyses can also be affected by suppressors of stem rust resistance present in the cv. Chinese Spring (KERBER 1983) if a CS monosomic series is used.

It cannot be excluded that some cases described in the literature as recessive resistance (susceptibility in F_1, segregation 1 resistant : 3 susceptible in F_2) might actually reflect segregation of one dominant gene for resistance and one dominant suppressor gene, because F_1 is also susceptible and segregation ratio of 3 : 13 can be confused with segregation 1 : 3.

In resistance breeding, suppressors of resistance genes pose problems particularly in the transfer of resistance genes from alien species to hexaploid wheat. However, the possibility to mutate suppressors (KERBER, AUNG 1995) or to select plants or lines in the segregating population without suppressors (unless they are closely linked with resistance genes) still offers a possibility to solve the problem of suppressors in selection though it may cause a considerable drawback in breeding efficiency.

As SuPm8 is not linked with Pm8, separation of the suppressor from the corresponding resistance gene in the segregating population is easy. Unfortunately, the value of Pm8 for the resistance breeding in Europe is rather limited at present because of the widespread virulence to this resistance gene in the powdery mildew population.

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