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IDENTIFICATION OF ADDITIONAL GENES CONFERRING RESISTANCE TO *PUCCINIA STRIIFORMIS* WEST. IN Yr LINES OF BARLEY

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ABSTRACT

Barley cultivars, Abyssinian 14 (yr 1), I.5 (yr 3), and Cambrinus (Yr 4) were genetically analysed against the Indian pathotypes G and 57 of barley stripe rust. Two tester lines, EB 410 (Ps 1) and EB 438 (ps 4), with known single gene for resistance to the races were used in the crosses to determine relationship between the genes concerned in stripe rust resistance present in the material under study. The F_1 and F_2 seedlings were tested against both the races. It was found that Abyssinian 14 possessed two dominant genes for resistance, one each effective against races G and 57. These genes for resistance are tentatively designated as Yr Ab. 14 1 and Ab. 14 2. Cv. I.5 also possesses two dominant genes for resistance to the races and these were designated as Yr I.5 1 and Yr I.5 2. One dominant gene detected in the cultivar Cambrinus was allelic to the gene Ps 1 already identified in EB 410.

Key words: Additional genes, resistance, stripe rust, barley.

Genetic studies carried out abroad on resistance to stripe rust of barley have identified that three recessive genes control resistance to pathotype 24 [1]. These genes were designated as yr 1 (in Abyssinian 14), yr 2 (in Abed Binder), and yr 3 (in I.5) [2]. Johnson [3] reported a single dominant gene in variety Cambrinus conferring resistance to race 23. He designated this gene as Yr 4. Bakshi and Luthra [4], on the other hand, found 8 loci causing resistance to 5 races in varieties EB 410, EB 438 and EB 145. They designated these loci as Ps 1–Ps 8 *(Puccinia striiformis)*. The relationship of the Ps genes to the Yr factors of [1] has not been established.

In this paper we report genetic analysis of three resistant Yr lines, namely, Abyssinian 14 (yr 1), I.5 (yr 3), and Cambrinus (Yr 4) against the most virulent races G and 57 of Northern India. Correspondence between Ps genes and Yr factors identified by earlier workers is also reported.

MATERIALS AND METHODS

The genetic analysis for stripe rust resistance was carried out in a 4×4 diallel cross involving 3 donors (Abyssinian 14, I.5 and Cambrinus) and a susceptible variety (Fongtein Barley). The three donors of resistance are briefly described below:

Abyssinian 14. An introduction from Abyssinia is a six rowed, hulled barley. It is early in maturity and possesses resistance to stripe rust under field conditions. It is resistant to the races G, 57, 24 and 19 in seedling stage. The grains are yellow.

I.5. A selection from Dalmatinic barley. It is tall, six rowed hulled, and late in maturity. It is also resistant to stripe rust under field conditions. Resistant to the races G, 57, 24 and 19 under seedling conditions.

Cambrinus. A derivative from the cross Balder × Strengs Franken III. It is a 2–rowed hulled type. It is late maturing and possesses resistance to stripe rust under field conditions. In the seedling stage, the variety exhibits resistance to races G, 57 and 19.

Fongtein Barley. It is a 2–rowed, hulled and late variety. It is susceptile under both seedling and adult stages.

Two tester lines, EB 410 (Ps 1) and EB 438 (ps 4), with a known single gene each for resistance were used in the crosses to determine the relationship between these genes and the genes present in the materials under study. Two most virulent and predominant races, G and 57, of the stripe rust organism of Northern India were used to analyse the material under study. Seedling reactions in the glasshouse were recorded according to Gassner and Straib [5].

RESULTS

Observations on inheritance of resistance to virulences G and 57 are presented in Tables 1 and 2. The behaviour of crosses involving each resistance donor is summarised.

Abyssinian 14. The F_1 of cross Abyssinian 14 × Fongtein Barley was resistant, which indicates that resistance against both virulences is dominant. The F_2 data (Table 1) clearly show that the resistance to virulences G and 57 in Abyssinian 14 is conferred by one dominant gene each (3R : 1S).

All the recombinants were obtained in the interrelationship studies conducted between genes conferring resistance to virulences G and 57. The analysis of χ^2 for independence gave P value between 0.50–0.30, confirming that the genes are inherited independently.

The reactions of F_2 seedlings derived from the crosses of Abyssinian 14 with the two tester lines, EB 410 (Ps 1) and EB 438 (ps 4), were also studied (Table 2). The dominant genes for resistance to races G and 57 in the donor are nonallelic in the crosses when tested with appropriate virulences. We tentatively designate these genes as Yr Ab. 14 1 and Yr Ab. 14 2, respectively.

I.5. The F_1 of cross I.5 × Fongtein Barley gave 4 resistant reaction to both the virulences, suggesting that the resistance is dominant. Further, the F_2 data (Table 1) of the cross indicate that the cultivar I.5 possesses one dominant gene each against races G and 57.

Relationship studies between genes conferring resistance to virulences G and 57 revealed that the genes are inherited independently. The computation of the data for the χ^2 for independent segregation gave a P value between 0.30–0.20.

The seedling reactions of the F_2 populations from the cross of I.5 with Abyssinian

14 (Table 1) against the virulences G and 57 revealed that the dominant genes in I.5 are nonallelic to the genes in Abyssinian 14. Susceptible segregates were obtained in the cross when tested against the appropriate virulences.

The F_2 populations derived from the crosses of cv. I.5 with the tester lines, EB 410 (Ps 1) and EB 438 (ps 4), were studied (Table 2). The dominant genes for resistance in I.5 to virulences G and 57 appear to be nonallelic to Ps 1 of EB 410 and ps 4 of EB 438. The two genes are tentatively designated as Yr I.5 1 and Yr I.5 2 for resistance to virulences G and 57, respectively.

Cambrinus. The F_1 of cross Cambrinus × Fongtein Barley gave resistant reaction to both the virulences, suggesting that the resistance is dominant in nature. Further, the F_2 data (Table 1) show that the dominant gene in Cambrinus imparts resistance against both virulences.

Table 1. Inheritance in F_2 of 4×4 diallel set of crosses for resistance against races G and 57 of barley stripe rust

Cross	Race	No. of seedlings			Expected ratio	P
		R	S	total		
Abyssinian 14 × Fongtein Barley	G	301	110	411	3R:IS	0.50–0.30
—Do—	57	243	90	333	3R:IS	0.50–0.30
I.5 × Fongtein Barley	G	368	131	499	3R:IS	0.70–0.50
—Do—	57	310	112	422	3R:IS	0.50–0.30
Cambrinus × Fongtein Barley	G	383	121	404	3R:IS	0.70–0.50
—Do—	57	337	101	438	3R:IS	0.50–0.30
Abyssinian 14 × I.5	G	453	34	487	15R:IS	0.70–0.50
—Do—	57	240	14	254	15R:IS	0.70–0.50
Abyssinian 14 × Cambrinus	G	227	14	231	15R:IS	0.80–0.70
—Do—	57	240	14	254	15R:IS	0.70–0.50
I.5 × Cambrinus	G	142	9	151	15R:IS	0.90–0.80
—Do—	57	290	22	312	15R:IS	0.70–0.50

Relationship studies between the genes conferring resistance to virulences G and 57 revealed that the genes for resistance are allelic to each other. The F_2 seedlings were either resistant or susceptible to both virulences. This strongly suggests that a single dominant or two closely linked genes govern resistance of Cambrinus to both the virulences.

The reactions of F_2 seedlings from the crosses of Cambrinus with the other two resistant cultivars were also studied (Table 1). The segregation ratio of 15 R : 1 S was observed in the crosses Abyssinian 14 × Cambrinus and I.5 × Cambrinus in relation to G and 57. One dominant gene in Cambrinus appears to be nonallelic to Yr Ab. 14 1 and Yr Ab. 14 2 in Abyssinian 14 and Yr I.5 1 and Yr I.5 2 in I.5.

The seedling reactions in F_2 of the crosses of Cambrinus with the tester lines, EB 410 (Ps 1) and EB 438 (ps 4) presented in Table 2 show that one dominant gene detected in this variety is allelic to gene Ps 1 already identified in EB 410.

However, it is nonallelic to ps 4 in EB 438. Consequently, Cambrinus carries Ps 1 gene for resistance to virulences G and 57.

Table 2. Segregation of seedlings of the crosses involving Abyssinian 14, I.5 and Cambrinus with tester lines EB 410 (Ps 1) and EB 438 (ps 4)

Cross	Race	No. of seedlings			Expected ratio	P
		R	S	total		
EB 410 (Ps 1) × Abyssinian 14	G	177	11	188	15R:1S	0.70–0.50
—Do—	57	147	8	155	15R:1S	0.70–0.50
EB 410 (Ps 1) × I.5	G	185	13	198	15R:1S	0.90–0.80
—Do—	57	148	8	156	15R:1S	0.70–0.50
EB 410 (Ps 1) × Cambrinus	G	226	—	226	N.S.	
—D0—	57	198	—	198	N.S	
EB 438 (ps 4) × Abyssinian 14	G	—	—	—	—	
—Do—	57	175	41	216	13R:3S	0.95–0.50
EB 438 (ps 4) × I.5	G	—	—	—	—	
—Do—	57	179	38	217	13R:3S	0.70–0.50
EB 438 (ps 4) × Cambrinus	G	—	—	—	—	
—Do—	57	176	42	218	13R:3S	0.90–0.80

DISCUSSION

In the present investigation, four additional genes have been identified, two each in the cultivars Abyssinian 14 and I.5, besides the known recessive genes Yr 1 and Yr 3 reported earlier [1]. Upadhyay and Prakash [6] from the relative analysis of seedling reaction postulated the presence of additional genes to the known Yr gene in Abyssinian 14. It has also been established from the present study that Yr 4 reported in Cambrinus [3] is allelic to Ps 1 of EB 410 [4].

Luthra and Chopra (unpublished) found four recessive genes in EB 1556 and EB 1626 against the virulences G and 57. It is, therefore, evident that the four recessive genes are different from the four dominant genes identified in the present investigations.

The additional genes identified in this study have been given temporary gene symbols as suggested by [7]. A summary of genes for resistance in the five barley accessions is given below:

Cultivar	*Genes operative against races*	
	G	57
Abyssinian 14	Yr Ab. 14 1	Yr Ab. 14 2
I.5	Yr I.5 1	Yr I.5 2
Cambrinus	Ps 1 (Yr 4)	Ps 1 (Yr 4)
EB 410 (tester)	Ps 1 (Yr 4)	Ps 1 (Yr 4)
EB 438 (tester)	Susceptible	ps 4

Isogenic lines are being developed in variety Fongtein Barley for the genes identified in the above cultivars. The genes Ps 1 (Yr 4) and Ps 4 have already been transferred and the seed of the near-isogenic lines is available for distribution to the breeders. However, only first backcross dose has been administered in respect of Abyssinian 14 and I.5.

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