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HYBRID NECROSIS AND DISEASE RESISTANCE IN WINTER WHEATS

M. KOCHUMADHAVAN, S. M. S. TOMAR,*
P. N. N. NAMBISAN AND M. V. RAO

IARI Regional Station, Wellington
Tamilnadu 643231

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ABSTRACT

One hundred and forty four semiwinter and winter varieties of breadwheat (*Triticum aestivum* L.) were screened for their reaction to powdery mildew at the seedling stage and to stem, leaf and stripe rusts at maturity, under natural and artificial epiphytotic conditions at Wellington in the Nilgiris. The stocks were also investigated for the hybrid necrosis genes. The winter wheats were found to be either Ne2–carriers or noncarriers; only one variety, Opal, was found to be Ne1–carrier.

Key words: *Triticum aestivum*, specific genes, rust resistance, hybrid necrosis, *Erysiphe graminis tritici*.

Generally the wheats are classified as of spring, winter, or intermediate growth habit. Pugsley [1] designated them as genetically spring, genetically semiwinter, and genetically winter based on the genes governing vernalization response. Thus winter and spring wheats constitute a wide reservoir of useful genes for the improvement of each other. Crossing these two ecotypes is likely to bring complementary factors together for the improvement of yield and other characteristics [2–4]. Use of winter wheats may contribute to spring wheats the resistance to drought, and additional sources of resistance to stripe rust [5], leaf rust [6], powdery mildew and *Septoria*. In addition, winter × spring wheat crosses could produce spring genotypes with a wide range of maturity suitable for cultivation in different ecological conditions. The elite Indian rainfed spring wheat variety C 306 has in its pedigree the winter wheat variety Regent. Released in 1965, C 306 has so far remained an ideal cultivar under water stress conditions. This variety carries gene Ne1 .

In India, only spring wheats are grown. The winter wheats are being currently used in the Indian wheat improvement programme to develop drought and disease resistant spring varieties. However, in several cases, hybrid necrosis is a serious hinderance. Hybrid necrosis, defined as progressive debility or death of the F_1 hybrid, is due to the interaction of two complementary dominant genes Ne1 and Ne2 [7, 8]. The present investigation has been carried out to identify the sources of resistance to rusts and powdery mildew in winter wheats and to find the distribution of necrosis genes in them.

*Address for correspondence: Division of Genetics, IARI, New Delhi 110012

MATERIALS AND METHODS

A diverse collection of 144 semiwinter and winter varieties of *Triticum aestivum* L. was critically evaluated for seedling resistance to powdery mildew and adult plant resistance to rusts. The disease reactions were recorded for 4 years under natural and artificial epiphytotic conditions at Wellington in the Nilgiri hills, which is an important hot spot for rust and powdery mildew. The rust reactions were recorded by combining severity (percentage of infection) and response (type of infection); and the varieties were classified as resistant or susceptible according to the modified Cobb's scale. The seedlings were inoculated for powdery mildew as described by Scharen et al. [9]; and resistance scored on 0–4 scale as described by Powers [10]. The stocks were also crossed to two *T. aestivum* testers, C 306 (Ne_1ne_2) and Sonalika (ne_1Ne_2) to determine the necrosis genes present in them. The genotype of varieties with respect to necrosis genes were determined from the phenotype of their F_1 hybrids.

RESULTS AND DISCUSSION

The results are presented in Tables 1 and 2. With the exception of the semiwinter variety Opal, all the winter wheat stocks studied were either Ne2-carriers or noncarriers. The study confirms that Ne1-carriers are extremely rare in winter wheats. Tsunewaki and Nakai [11] studied the distribution of Ne-genes in the wheat varieties grown in North America and found a higher frequency of Ne1 gene in spring wheats while the winter types were predominantly Ne2-carriers. Pukhal'skii [12, 13] also reported the occurrence of Ne1 in spring wheats and Ne2 in winter wheats and ascribed this difference to selection for genes for vernalization being linked to Ne1 and Ne2 genes. Zeven [14] suggested that spring and winter wheats were possibly derived from two different groups, one carrying Ne1 and the other Ne2. It has been reported that the Indian breadwheat varieties predominantly carry Ne1 gene [15, 16], while the western European and North American wheats are mainly Ne2-carriers. Widespread prevalence of Ne1-carriers among the Asiatic spring wheats and Ne2-carriers in the European and American spring wheats [17, 18] has also been reported. Thus the clear differentiation of spring wheats into Ne1 carrying Asian populations and Ne2 carrying western populations is not reflected in winter wheats. The results of the present study indicate that there has been little or no gene exchange between the winter and spring ecotypes.

The winter wheats studied have been found to possess several desirable diseased resistances. Varieties carrying diverse specific res genes [19] conditioning adult plant resistance to rusts and seedling resistance to powdery mildew are listed in Table 2. Genes Sr31, Lr26, Yr9 and Pm8 present in varieties Aurora, Burgas 2, Clement, Kavkaz and Skorospelka 35 have been derived from Petkus rye (*Secale cereale*). They were found to condition a high degree of resistance to stem rust, leaf rust, stripe rust and powdery mildew races prevalent in the Nilgiris. The German wheat cultivar Weique, a 1R (1B) substitution line or 1RS/1BL translocation line, carries the rye res genes Sr31 and Lr26 conferring resistance to both stem and leaf rust. The line, however, has been found susceptible to stripe rust and powdery mildew. With the appearance of leaf rust virulences 12-1 and 77-1 [20] in the Nilgiris, gene Lr26 has been rendered ineffective for Indian conditions. The semiwinter line Transec carries Lr25 and Pm7 derived from Rosen rye [21]

Table 1. Classification of winter wheats according to their genotypes for necrosis and resistance to rusts and powdery mildew

Resistance reaction	Class	
	Ne2-carriers	noncarriers
Resistant to:		
Stem, leaf and stripe rust	Skorospelka 35	Aurora*, Burgas 2, Clement, Kavkaz*, Lovrin 24, Ploughman, Purdue 4930, TJB 72/2
Stem and leaf	—	Agent, Weique
Stem and stripe	—	Elite Lepeuple, Purdue 6922-A-1-16
Leaf and stripe	Cappelle-Desprez, Era, La Prevision, Lancota, Mardler, Maris Freeman, Moldova, N S 440, Roussalka, Selpek, TJB 989/4, TJB 989/7, V 1287, Kinsman	Backa, Centurk, Favorit, F 26–70, G K Protein, Jubile, Maris Ranger, Nap Hal, N E 7060, N S 111–64, Odessa-4, Pastizauka, PI 185408, Transec Carifen 12, ZG 4364
Stem rust	— —	Festiguay, Webster
Leaf rust	Flatcher, Lilifen, Maris Butler,	Agatha, Asosan, Conte Marzotto, Heines Kolben, N S 732 Transfer
Stripe rust	Barleta Benvenuto, Bezostaya 1, Bon Fermier, Caribo, Democrat, Doina Envoy, Heines VII, Hyb 46, Joss Cambier, Maris Dove, Maris Widgeon, Ridit, Rio, R P Barbee, Sadoval, Sava, Starke 1, Tadoma, TJB 916/26, Turkey	Absolvant, Adam, Albit, Ariana, Atle, Axminster x Cc[8], Blueboy, Bolal, Bouquet, Budifen, Champlein, Chancellor, Compair, Demar 4, Desprez 80, Flanders, Flinor, Hackiman, Hussar, Hybride de bersee, Inversable Bordeaux, Iulia, Jyva, Khapli/Cc[8], Libellula, Liberator Little Joss, Lokrin, Malakoff, Martonvasar, Newton, NS 32, NS 322-1, NS 439, Sicco, Slabyanka, Vilmoria 23, Yeoman, Yorkwin
Powdery mildew	Atles 66, Kinsman, Mardler, Selpek, Skorospelka 35, TJB 916/26, TJB 989/4, TJB 989/7	Asosan Aurora, Axminster xCc[8], Burgas 2. Centurk, Clement, Compair, Flinor, Kavkaz, Libellula, Little Joss, Odessa-4, Ploughman, Pardue 4930, Purdue 6922–A–1–16, Sicco, Transec, Yeoman
None of the diseases studied	Klein Cometa, Manitou, Mediterranean, Naguay, Nap Hal/Atlas 66, Neepawa, NS 475	Apollo, Brevit, Chinese 166, CI 13449/Centurk, ELS, Etoile de Choisy, Golden Vaalley, Hope, Lee, Loros, Marquis, Mv 575, NS 500 NS 602, NSR 1, Richer Berg, Stepova, Thatcher, Oasis

*Recorded low infection of leaf rust at adult plant stage in 1986.
Variety Opal is resistant to leaf and stripe rusts.

and imparts excellent resistance to leaf rust and moderate resistance to powdery mildew. Varieties Festiguay and Webster carry Sr30 gene which confers moderate resistance to stem rust. The linked genes Sr24 and Lr24 transferred from *Agropyron elongatum* and present in var. Agent have been consistently found to confer resistance to stem and leaf rust. In recent years, pathogen(s) capable of overcoming Lr24 have been encountered in South Africa and North America [22]. However, so far this res gene remains quite useful in India. Similarly, the *Agropyron elongatum* gene Lr19 present in var. Agatha [23] conditions excellent resistance to leaf rust. Variety Transfer carries the gene Lr9 from *Aegilops umbellulata* [24] and has been found to confer resistance to the leaf rust flora prevailing in the Nilgiris. The line Compair produced through homoeologous recombination on chromosome 2D carries gene Yr8 of *Aegilops comosa* [25] and imparts effective resistance to stripe rust. High resistance to stripe rust was also observed in varieties Cappelle-Desprez (Yr3a, Yr4a), Bon Fermier (Yr3a), Heines VII (Yr2), Hyb 46 (Yr3b, Yr4b), Liberator (Yr2, Yr3c), Opal (Yr4b), Tadorna (Yr1, Yr2), and Vilmorin 23 (Yr3a), while Heines Kolben (Yr6) showed moderate resistance. Genes Yr2, Yr3a and Yr4b are reported to be effective both in seedling and adult plant stages [26]. The powdery mildew resistance genes Pm3a (Asosan) and Pm1 (Axminster × Cc^8 impart excellent resistance to the *Erysiphe graminis tritici* population occurrring in the Nilgiris.

Table 2. Winter wheats carrying specific resistance genes conditioning adult plant resistance to rusts and seedling resistance to powdery mildew races prevalent in the Nilgiris

Effective genes	Cultivar	Effective genes	Cultivar
Stem rust		Stripe rust	
Sr24*	Agent	Yr2	Heines VII, Liberator, Selpek, Tadorna
Sr31*	Aurora, Bezostaya 1, Burgas 2, Clement, Kavkaz, Skorospelka 35, Weique	Yr3a	Bon Fermier, Cappelle-Desprez, Vilmorin 23
Leaf rust		Yr3b	Hyb 46
Lr9*	Transfer	Yr3c	Liberator
Lr19*	Agatha	Yr4a	Cappelle-Desprez
Lr24*	Agent	Yr4b	Opal, Hyb 46
Lr25*	Transec	Yr8*	Compair
Lr26*	See under Sr31	Yr9*	See under Sr31
Powdery mildew			
Pm1	Axminster × Cc^8		
Pm3a	Asosan		
Pm8*	See under Sr31		
Ineffective genes:			
Stem rust	: Sr1, Sr2, Sr5, Sr6, Sr7a, Sr7b, Sr9g, Sr11, Sr12, Sr15, Sr16, Sr17, Sr18, Sr19, Sr20, Sr23, Sr25*, Sr29, Sr34*, Sr Bb		
Leaf rust	: Lr1, Lr2a, Lr2c, Lr3, Lr10, Lr11, Lr13, Lr14a, Lr16, Lr22b, Lr23		
Stripe rust	: Yr1, Yr7		
Powdery mildew	: Pm2, Pm4, Pm4b, Pm5		

* Alien genes.

Opal, the only Ne1-carrier identified in this study, and the noncarriers can be exploited in crosses with indigenous varieties. Similarly Ne2-carriers among the recent semidwarf, spring wheats in India can be crossed with the selected stocks of Ne2 carrying winter wheats. It is presumed the Ne2 gene in the semidwarf wheats may have come along with Rht gene (s) from the Norin 10 variety Brevor which is a winter type.

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