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AGROPYRON—DERIVED SPECIFIC GENES IN COMMON WHEAT AND THEIR ADULT PLANT RESPONSE TO WHEAT PATHOGENS

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ABSTRACT

Twelve wheat stocks carrying *Agropyron*-derived specific genes and two accessions each of *Agropyron elongatum* and *A. intermedium* were studied for adult plant resistance to the populations of stem and leaf rust pathogens prevalent in the Nilgiris. They were also studied for seedling resistance to *Erysiphe graminis tritici*. The genes Sr24, Sr26 and Sr Agi conferred effective adult plant resistance to stem rust, whilst genes Lr19, Lr24 and Lr29 conditioned high resistance to leaf rust. Gene Sr25 was found to be completely ineffective. All the wheat stocks were susceptible to powdery mildew. Except for the low intensity reaction of *A. intermedium* to stripe rust, both *Agropyron* species showed complete freedom to rusts and powdery mildew. With the exception of wheat variety Eagle, all the wheat stocks tested were found to be noncarriers of necrosis genes. The variety Eagle was found to be a heterogeneous population of Ne1 ne2 and ne1 ne2 genotypes.

Key words: *Agropyron elongatum, A. intermedium.*, specific genes, wheat pathogens, adult plant resistance, hybrid necrosis.

Wild progenitors of hexaploid wheat, allied genera and species constitute a vast reservoir of potentially useful genes for disease resistance and wide hybridisation has been used as valuable tool to transfer these desirable traits to common wheat. Alien genetic transfers obtained particularly for disease resistance have been generally found effective against a broad spectrum of physiological races. The present investigation has been carried out to assess the effectiveness of *Agropyron*-derived genes in common wheat stocks to the infection of rust and powdery mildew. The wheat stocks were also studied for the distribution of genes for hybrid necrosis.

MATERIALS AND METHODS

The material used in the present study comprised 12 diverse wheat stocks carrying *Agropyron*-derived specific genes conditioning resistance to stem rust and leaf rust, and two accessions each of *Agropyron elongatum* and *Agropyron intermedium*. The stocks were critically evaluated for 14 seasons under high incidence of natural infection at Wellington in the Nilgiri hills, South India. The rust reactions were

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recorded by combining severity (percentage of infection) and response (type of infection) at adult plant stage. The stocks were also studied for seedling resistance to the sample of *Erysiphe graminis tritici* prevailing in the Nilgiris. The seedling inoculations for powdery mildew were made as described [1] and the seedlings scored for resistance to powdery mildew on 0–4 scale [2]. The wheat stocks were crossed to two *Triticum aestivum* testers, C 306 (Ne1 ne2) and Sonalika (ne1 Ne2). Genotype of the stocks with respect to the necrosis genes were determined from the phenotype of the F_1 hybrids.

RESULTS AND DISCUSSION

Table 1 shows that *Agropyron*-derived specific genes confer effective adult plant resistance to the populations of stem rust (*Puccinia graminis* f. sp. *tritici* Eriks. & Henn.) and leaf rust (*Puccinia recondita* Rob. ex Desm.) pathogens prevalent in the Nilgiris. The genes Sr24, Sr26 and Sr Agi were found to be effective against the stem rust races and their biotypes, whilst genes Lr19, Lr24 and Lr29 conferred high resistance against the leaf rust races. The gene Sr25, however, was found to be completely ineffective to the stem rust flora of the Nilgiris. The physiological races and biotypes of stem rust and leaf rust recorded from India and the Nilgiris are given in Table 3. Sawhney et al. [3] and Sawhney and Goel [4, 5] reported that genes Sr24 and Sr26 conferred seedling resistance to 19 cultures of Indian stem rust races, whilst genes Lr19, Lr24 and Lr29 conditioned seedling resistance to most

Table 1. Reactions to rust and powdery mildew in *Agropyron*-derived wheat stocks and their genotypes with respect to the genes for hybrid necrosis

Stock	Gene(s) present	Range of reaction to stem rust	Range of reaction to leaf rust	Range of reaction to stripe rust	powdery mildew	Genotype of the variety tested
Agropyron elongatum-derivatives						
Agatha	Sr25Lr19	60S-70S	F-TMR	20S-80S	3	ne1ne2
Sears' traslocation 7D/Ag	Sr25Lr19	70S-80S	F-TR	20MS-50MS	3	ne1ne2
Agent	Sr24Lr24	10MR-30MS	F-TMS	40S-80S	4	ne1ne2
Sears' translocation 3Ag 3	Sr24Lr24	10MR-20MR	F-TR	F	3	ne1ne2
Sears' translocation 3Ag 14	Sr24Lr24	10MR-20MR	F-TR	F	3	ne1ne2
*TR 380-16 7/3 Ag3	Sr24Lr24	10MR-20MR	F-TMR	F-5S	3	ne1ne2
*TR 380-14 7/3 Ag14	Sr24Lr24	10MR-20MR	F-TMR	F-TMR	3	ne1ne2
*TR 548 7/3 Ag3	Sr24Lr24	F-10R	F-TMR	F-15S	3	ne1ne2
Sears' 7D/Ag 11	Lr29	80S-90S	F-10MR	5S-15S	3	ne1ne2
Eagle	Sr26	5MR-20MR	60S-70S	30S-60S	3	ne1ne2 * Ne1ne2
Kite	Sr26	10MR-20MS	60S-70S	5MS-10MS	3	ne1ne2
Agropyron intermedium-derivative						
TAF 2d	Sr Agi	F-20MR	20MR-30MS	F-5S	3	ne1ne2

* Early, dwarf white seeded recombinants, tested for six seasons only.

of the prevalent and virulent leaf rust races and biotypes from India. The desirable resistance genes Sr24 and Lr24 have profitably been exploited and utilized in developing commercial cultivars like Agent, Blueboy II, Cloud, Fox, Osage, Parker 76, Payne, Sage, Teewon Sib and KS 79 H 69 in U.S.A.; and Gamka, SST 23, SST 44 and SST 102 in South Africa. These genes have, however, been knocked down by new virulence(s) in North America and South Africa [6, 7], but in India they are still very effective. A programme of incorporating these genes in Indian cultivars is under progress at this centre.

Knott [8] transferred the wheat stem rust resistance gene Sr26 from *Agropyron elongatum* (Host) Beauv. to chromosome 6A of wheat, and this gene has been found very effective in several countries. In Australia, all the strains of stem rust have been found to be avirulent on Sr26 and this major gene continues to be an effective source of resistance [9]. The gene Sr26 has been bred into several Australian elite cultivars, viz., Eagle, Gaberic, Kite, Hybrid Titan, Terre, Jabiru and Avocet. The spectacular and lasting resistance provided by this alien gene [10] shows that certain genes for avirulence in *Puccinia graminis tritici* rarely mutate to virulence and strongly advocated the use of major vertical genes like Sr26, contrary to the common belief that vertical genes, when used singly, are of only limited value. The present study indicates that the known prevalent races and biotypes of stem rust in the Nilgiris are avirulent on Sr26 at adult plant stage.

The transfer of specific genes for resistance from alien sources may be associated with other undesirable genes located in the alien chromosome segment restricting the utilization of alien genes in breeding commercial cultivars. Gene Lr19 (Agatha) confers resistance to a wide spectrum of races prevailing in U.S.A., Canada, Australia and India [11], but its undesirable linkage with a gene for yellow flour colour has restricted its utility in wheat improvement. Agatha equals the parent variety Thatcher, an excellent cultivar in Canada, in yield, milling and baking quality except that it produced yellow flour. Knott [12] suggested the mutation of the gene governing yellow flour colour. Gene Lr19 is also linked to the stem rust res-gene Sr25. Sawhney and Goel [4] reported that gene Sr25 conferred seedling resistance to 19 cultures of Indian stem rust races. However, this gene does not confer mature plant resistance to stem rust at Wellington.

The line TAF 2d carrying the gene Sr Agi from *Agropyron intermedium* was found to possess high degree of resistance to stem rust. In addition, this line also carries considerable mature plant resistance to leaf rust and stripe rust. The gene Sr Agi has been found to confer seedling resistance to nine cultures of Indian stem rust races [4].

The study on powdery mildew revealed that all the 12 wheat stocks tested were susceptible to the sample of *Erysiphe graminis* f. sp. *tritici* em. Marchal occurring in the Nilgiris. Currently these stocks are being screened critically throughout the year to monitor new rust virulence, if any, arising in nature at Wellington, an important 'hot spot' for wheat pathogens.

Table 2. Resistance to wheat rust and powdery mildew in *Agropyron elongatum* and *A. intermedium*

Accession number	Species	Reaction to stem rust	leaf rust	stripe rust	powdery mildew
EC 162439	*Agropyron intermedium* (Host.) Beauv. (Iran)	F	F	5S-10S	0
EC 162440	*A. intermedium* var. *trichophorum*	F	F	5S-10S	0
EC 162478	*Agropyron elongatum*	F	F	F	0
SWAN 202	*A. elongatum*	F	F	F	0

The authors observed two accessions each of the perennial grasses, *Agropyron elongatum* and *A. intermedium* (Table 2) over a period of six seasons. The strains of *Agropyron elongatum* exhibited complete freedom from the infection of wheat rusts. Both the accessions of *Agropyron intermedium* were also found to be resistant to the known stem rust and leaf rust races (Table 3) but showed low reaction to stripe rust infection. All the four strains of *Agropyron elongatum* and *A. intermedium* were resistant to powdery mildew. The authors also evaluated 54 different species of *Agropyron* and found more species of *Agropyron* resistant to leaf rust (89%) than to stem rust (66%) and stripe rust (44%). With regards to the wheat powdery mildew fungus, all the 54 species of *Agropyron* were found to carry seedling resistance.

Table 3. Physiological races and their biotypes of stem rust and leaf rust recorded from India and the Nilgiris

Stem rust: India	Stem rust: Nilgiris	Leaf rust: India	Leaf rust: Nilgiris
11, 11A, 14, 15, 15C, 17, 21, 21A, 21A-1, 21A-2, 24, 24A, 34, 34A, 40, 40A, 40A-1, 42, 42A, 42B, 42B-1, 42B-2, 42B-3, 53, 72, 75, 117, 117A, 117A-1, 122, 184, 194, 222, 295, X and Y	11, 14, 15, 15C, 17, 21, 21A-1, 24, 34, 34A, 40, 40A, 42, 42A, 42B, 72, 117, 117A, 117A-1, 122, 184, 194, 222 and 295	10, 11, 12, 12A, 12B, 16, 17, 20, 26, 61, 63, 70, 77, 77A, 77B, 77A-1, 104, 104A, 104A-1, 104B, 106, 107, 107A, 108, 131, 162, 162A, 162B and 213	10, 11, 12, 12A, 12B, 16, 17, 26, 77, 77A, 77A-1, 77B, 104, 104A, 104B, 131, 162 and 162A

Source: Dr. S. D. Singh (personal communication).

STUDY OF HYBRID NECROSIS

Inter- and intraspecific wheat crosses frequently produce necrotic F_1 hybrids exhibiting progressive death or debility. Hybrid necrosis is caused by the interaction of two dominant complementary genes Ne1 and Ne2. The study reveals that with the exception of the variety Eagle, the wheat stocks tested were found to be noncarriers for necrosis genes. The variety Eagle, however, produced normal hybrids as well as necrotic hybrids when crossed to Sonalika. The variety Eagle thus appear to be a heterogeneous population consisting of noncarriers and carriers of gene Ne1.

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