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GENETIC DIVERSITY OF LEAF RUST RESISTANCE IN INDIAN WHEATS

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Investigations were conducted on 58 Indian wheats for assessing the extent of genetic diversity for leaf rust resistnace. Seedling studies of these wheats had indicated that the genetic basis of resistnace was due to 9 *Lr* genes while the adult plant resistance studies showed as many as 18 distinct groups. Seedling testings of these genotypes displayed the maximum preponderance of *Lr*26, *Lr*34, *Lr*13 and *Lr*23 genes and all of them have become susceptible to the newly evolved pathotypes of leaf rust barring *Lr*34. Therefore there was an urgent necessity to mobilize the highly effective resistance genes *Lr*9, *Lr*19, *Lr*24 and *Lr*28 in breeding programmes. *Lr*34, partial adult plant resistance gene which is invariably associated with durable resistance, confers a high degree of adult plant resistance in combination with other seedling resistance genes in these studies. Therefore a data base of adult plant resistance sources must be characterised in terms of the number and the nature of resistance genes to breed for durable resistance.

Key words: Wheat, genetic diversity, leaf rust resistance

Leaf rust of wheat (*Triticum aestivum* L.) caused by *Puccinia recondita* Roberge ex Desmaz. f. sp. *tritici* Eriks. and E. Henn. is the most cosmopolitan and the regularly occurring of the three rusts found on wheat (Samborski, 1985) and the wheat cultivars that are susceptible to leaf rust regularly suffer yield reduction of 5-15 per cent or greater. Genetic resistance is the most economical and preferred method of reducing yield losses due to leaf rust which invariably was based on specific resistance genes. However, resistance to leaf rust in common wheat was short lived possibly because it was based on single resistance genes (Samborski, 1985). The genetic basis of most durable resistance to leaf rust has been the combination of resistance genes (Roelfs, 1988). Gene combinations exploit the gene interactions usually between, (1) the seedling resistance genes and (2) the interactions of seedling resistance genes with adult plant resistance genes, resulting in higher resistance than that conferred by individual genes (Samborski and Dyck, 1982). The present investigation was undertaken in a collection of Indian wheats possessing different combinations of resistance genes (identified in seedling stage), during 1993-94 rabi season to assess the extent of genetic variation for the adult plant resistance.

MATERIALS AND METHODS

The materials for the present investigation comprised collection of Indian wheats which were under testing in the final year of All India Coordinated Wheat Improvement Programme (AICWIP) and the respective checks of the mega environments as defined by AICWIP where wheat is cultivated. Seedling postulation of resistance genes was done at the Rust Laboratory, Directorate of Wheat Research, Flowerdale, Shimla. Seedling studies of such wheat genotypes detect the seedling genes, however, the adult plant resistance genes

remain undetected. In order to identify such resistance sources, these wheats were tested under field conditions in the isolated nurseries with leaf rust pathotypes chosen for virulence on one or more of the seedling resistance genes.

Each nursery was bordered on all sides with susceptible spreaders and test entries were planted in 1m long row spaced 30 cm apart. Artificial plant epiphytotics were initiated by inoculating the plants with a selected pathotype of leaf rust using hypodermic syringe. The avirulence and virulence formulae of leaf rust pathotypes in respect of resistance genes are as follows:

Table 1. Avirulence/virulence formulae of three leaf rust pathotypes

S. No.	Race/ Variant	Avirulence/virulence
1.	77-2	*PLr26*/p*Lr1*, *Lr2*, *Lr3*, *Lr10*, *Lr11*, *Lr12*, *lr13*, *Lr15*, *Lr16*, *Lr17*, *Lr20*, *Lr21*, *Lr23*, *Lr27+Lr31*, *Lr30*
2.	77-5	P*Lr21*/p*Lr1*, *Lr2*, *Lr3*, *Lr10*, *Lr11*, *Lr12*, *Lr13*, *Lr15*, *Lr16*, *Lr17*, *Lr20*, *Lr23*, *Lr26*, *Lr27+Lr31*, *Lr30*
3.	104-2	P*Lr2a*, *Lr3*, *Lr15*, *Lr20*, *Lr27+Lr31*/p*Lr1*, *Lr10*, *Lr11*, *Lr12*, *Lr13*, *Lr16*, *Lr17*, *Lr21*, *Lr23*, *Lr26*, *Lr30*

[a]Common avirulence : *Lr9*, *Lr18*,*Lr19*, *Lr24*,*Lr25*,*Lr28*,*Lr29*

Data on disease severity and response of adult plants were recorded according to oegering (1959) and the maximum incidence of disease infection is reported as the terminal disease severity.

RESULTS AND DISCUSSION

Genetic constitution of wheat genotypes in respect of an array of named resistance genes based on seedling testing in glass house is presented in Table 1. The seeding resistance of wheat genotype was based on the following 9 Lr genes: *Lr1*, *Lr3*, *Lr10*, *Lr13*, *Lr14a*, *Lr23*, *Lr24*, *Lr26* and *Lr34* wherein *Lr26* appeared to be the most preponderant (28 times) followed by *Lr34* (20 times), *Lr13* (18 times) and *Lr23* (17 times). The genes were present either singly or in two or three gene combinations (Table 2).

Table 2. Genetic constitution of wheat genotypes in respect of named leaf rust (*Lr*) genes

Lr genes	Genotypes
One gene	
Lr 3+	Vl616
Lr 13 +	Ska,Lok1,K9305,K9329,K9362,K9367, HUW452,HUW453,K3027
*Lr*14a +	Sujata,HUW234
*Lr*24 +	HW2004,HP1776,DL788-2
*Lr*26 +	VL719,UL751,PBW383,PBW396,Wh601,Raj 3856,HD2667
Lr 34 +	C306,HP1731
Two gene combinations	
Lr 10 + *Lr* 13	K9351,K9361,K8962
*Lr*10 + *Lr*23	HD2380,K9334
*Lr*13 + *Lr* 34	UP2338,PBW299,PBW343,PBW373,HS361,HS277
*Lr*23 + *Lr*34	HS295,PBW175,GW173
*Lr*3 + *Lr* 26	Vl755,DT46
*Lr*3 + *Lr* 26	K9321
*Lr*23 + *Lr* 26	HUW206,K8804,HUW318,GW190,MACS2496,DL1014-2
Three gene combinations	
*Lr*1 + *Lr*10 + *Lr* 13	HS364
*Lr*1 + *Lr*26 + *Lr*34	HS240,HPW42
*Lr*10 + *Lr* 13 + *Lr* 34	HD2329
*Lr*23 + *Lr* 26 + *Lr* 34 +	HS317,VL739,Wh542

The genotypes viz., HW2004, HP1776 and DL788-2 gave a very high level of resistance to all the three races of leaf rust employed in this study at the adult plant stage obviously due to the highly effective seedling leaf rust resistance gene *Lr24* (Table 3).

Very high levels of resistance were recorded in K9362, HUW452 and K8027, carrying *Lr*13. Obviously, some adult plant resistance components interacted with seedling resistance (APR). Other seedling resistance genes *Lr*23, *Lr*26 and *Lr*34 interacted with APR components to confer high level of resistance (Table 3). Two gene comminations of *Lr*13 + *Lr* 34, *Lr*23 + *Lr* 34 and *Lr* 26 + *Lr* 34 as postulated in NIAW34,

MS295 and UP2338 respectively display high order of resistance. The interactive role of Lr34 in conferring high resistance levels is now well documented (Dyck and Samiborski, 1982; German and Kolmer, 1992; Sawhney, 1992). Three gene combination of *Lr*1 + *Lr*26 + *Lr*34 and *Lr*23 + *Lr* 26 + *Lr*34 observed in HPW42, HS317 and WH542 also fall in this category (Table 3).

Table 3. Adult plant resistance response patterns of 58 wheat genotypes with different degrees of resistance to selected leaf rust pathotypes

Response Patterns	Lr genes	Genotypes	Interaction phenotypes to leaf rust pathotypes		
	Gene		77-2	77-5	104-2
1. LLL One gene combination	*Lr*24	HW2004	TR	TR	TR
		HP1776	TR	TR	TR
		DL788-2	TR	TR	TR
	*Lr*13	K9362	5MR	10S	TR
		HUW452	TR	TR	TR
		K8027	10MS	5MS	TR
	*Lr*23 +	HI1418	10MR	TMR	TR
		K93223	10MR	TR	TR
	LR 26 +	Raj3856	TR	TMR	5MR
	Lr 34 +	HP1731	TR	10MR	TR
	Lr 10 + *Lr* 13 +	K9351	5R	TR	TR
Two gene combinations	*Lr*10 + *Lr* 23 +	K9334	TR	TR	TR
	*Lr*13 + *Lr* 34 +	NIAW34	TR	TMS	TR
	*Lr*26 + *Lr*34 +	UP2338	TMR	10MR	TMR
	*Lr*23 + *Lr*24 + HS295	TR	10 MR	TR	
	*Lr*1 + *Lr* 26 + *Lr* 34	HPW 42	TMR	5MS	5MR
Three gene combinations	*Lr*23 + *Lr*26 + *Lr*34	HS317	TR	10R	TMR
		Wh542	TMR	10S	TMR

H : High M : Medium L : Low

Table 4. Adult plant response patterns of wheat genotypes with different degrees of resistance to selected leaf rust pathotypes

Response Patterns	Genotypes	Interaction phenotypes to leaf rust pathotypes		
		77-2	77-5	104-2
1. MMM	Sujata	30S	40S	40S
	HD2380	20S	30S	20S
2. HHH	Sonalika	70S (H)	60S(H)	40S(H)
3. HHM	Lok1	60S(H)	80S(H)	20S(H)
	HUW234	90S(H)	80S(H)	20MS(H)
	WH147	90S(H)	90S(H)	30S(H)
4. HHL	J8962	50S(H)	60S(H)	TR(L)
	HD2329	80S(H)	50S(H)	5MR(L)
5. HLL	GW173	50S(H)	10MR(L)	5MR(L)
6. HML	PBW175	60X(H)	40X(M)	5MR(L)
7. MHM	C306	40S(M)	50S(H)	30S(M)
8. MHL	PBW382	40S(M)	70S(H)	TR(L)
9. MMH	GW190	20S(M)	20MR(M)	80S(H)
10. MML	K9329	20MR(M)	30MS(M)	TR(L)
	K9367	20MS(M)	20M(M)	TR(L)
	K9330	40MS(M)	20MS(M)	TR(L)
	K9361	20S(M)	20MS(M)	TR(L)
	HD2189	30MS(M)	20MS(M)	TMR(L)
11. MLH	K9305	20MR(M)	5MR(L)	50S(H)
12. MLL	HUW453	30S(M)	TR(L)	TR(L)
	HD2501	20MR(M)	5MR(L)	TR(L)
13. LHL	PBR343	TR(L)	50S(H)	5S(L)
	PBW373	TR(L)	50S(H)	5R(L)
14. LMH	HUW206	10S(L)	20MR(M)	80S(H)
	HUW318	10MS(L)	40MS(M)	70S(H)
15. LMM	Dt46	TR(L)	20S(M)	305(M)
16. LML	PBW299	TMR(L)	20S(M)	TMR(L)
	HS361	TS(L)	40MR(M)	TR(L)
	HS277	TR(L)	20S(M)	5MR(L)
	HS363	5R(L)	20MR(M)	TMR(L)
	HS240	TS(L)	305(M)	10MR(L)
17. LLH	K8804	TR(L)	10MR(L)	60MS(H)
	MACS2496	5MS(L)	10MR(L)	70MS(H)
	DL1014-2	5MS(L)	10MR(L)	70S(H)
	VL738	TS(L)	10MR(L)	50MSS(H)
	VL719	10S(L)	5S(L)	70S(H)
	VL751	5MS(L)	10MR(L)	50S(H)

Besides this group, the adult plant response patterns of wheat genotypes to individual races of leaf rust could be classified in 17 distinct groups (Table 4) suggesting the different genes were involved. Of the 19 groups, wheat in some group were susceptible, their APR being race specific. In similar studies of adult plant resistance Sawhney (1992) also detected race specific APR.

Studies indicated that while the seedling testing of resistance genes could detect only 9 *Lr* genes in Indian wheat, there was substantial variation for adult plant resistance genes for as many as 19 diverse groups were detected through APR tests. Besides, the diversification of seedling resistance genes other than the most preponderant genes floating in Indian wheat (*Lr*26, *Lr*23, *Lrd*13 and *Lr* 10) must be resorted to, mobilizing the highly effective alien genes like *Lr*9, *Lr*19, and *Lr*24. It calls for launching of an aggressive national breeding effect to mobilise such genes. This can prove to be an effective strategy to checkmate the possible buildup of leaf rust epidemic of wheat in near future. The results reveal that :

1. The genetic basis of leaf rust resistance based on adult plant resistance studies is not so narrow as revealed by seedling resistance studies.

2. Adult plant resistance gene *Lr*34 is associated with enhanced resistance to different leaf rust pathotypes in association with different seedling leaf rust resistance genes.

3. Highly effective, alien, seedling resistance genes viz. *Lr*9, *Lr*19 and *Lr* 24 should be mobilised in future breeding programmes.

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