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SEEDLING AND ADULT PLANT RESISTANCE TO LEAF RUST IN WHEAT

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Forty exotic genetic stocks of bread wheat were tested in glasshouse and isolated single race nurseries against three pathotypes of race 77 and with mixture of pathotypes to observe their seedling and adult plant resistance to leaf rust. Twenty five genotypes showed adult plant resistance and significant genetic differences were detected to enable their grouping in 8 distinct classes. Fifteen genetic stocks depicted seedling resistance at the seedling and adult plant stages when tested against race 77-5 and were placed in three distinct groups. The study indicated that adequate variability for seedling and adult plant resistance to leaf rust exists in these germplasm accessions when tested against native pathotypes of leaf rust.

Key words : Plant resistance, durable resistance, leaf rust, wheat, *Puccinia recondita* f. sp. *tritici*

The food security of India depends on the increased production of wheat and rice. The stability and sustainability of wheat production is greatly influenced by biotic and abiotic stress factors. Leaf rust of wheat caused by *Puccinia recondita* Rob. ex Desm. f. sp. *tritici* Erikes and E. Henn. is important in all the wheat growing regions of the country and causes serious yield losses (Swaminathan, 1978). A number of pathotypes of race 77 have evolved with increasing virulence to a number of *Lr* genes (Kadam *et al.*, 1977; Nayar *et al.*, 1980), thereby making resistance of many bread wheat cultivars ineffective to which these genes have been deployed. In recent decade, there has been an increasing interest on adult plant leaf rust resistance (APR) genes because most of the sources of APR have been found to confer durable resistance. Knowledge of genetic diversity for APR may help in deploying novel APR sources towards breeding for durable resistance against this rust. The present investigation was, therefore, undertaken in 40 exotic genetic stocks of wheat leaf rust germplasm pool to detect variation for adult plant leaf rust resistance against the most virulent forms of race 77 (77-5), (Nayar *et al.*, 1992).

MATERIALS AND METHODS

The materials of the present study comprised of 40 genetic stocks obtained from the National Bureau of Plant Genetic Resources. The pedigree details are mentioned in Table 1. The leaf rust pathotypes 77-1, 77-2 and 77-5 whose

Table 1. Pedigree of genetic stocks in wheat leaf rust germplasm pool (WLRGP) 1993

Entry No.	Name or Cross/Pedigree
1	4777(2)//Fkn/Gb/3/Vee'S'/4/Buc'S'/Pvn'S'/5/Ald'S'/3/CC//Inia/Bb
2	67109/Frd//P101/Fw71002/3/2*Vee#6
3	Au//Kal/Bb/3/Bon/4/Bow'S'
4	Au//Kal/Bb/3/Bon/4/Bow'S'
5	Au//Kal/Bb/3/Bon/4/Kvz//Cno/Pj62
6	Bage/Hork'S'//Aldan'S'/4/Au/Kal/Bb/3/Bon
7	Bow'S'/Vee'S'//71St2959/Crow'S'
8	Buc'S'/Dga//Hpo'S'
9	CHAM2/Vee'S'
10	Carpentro/Carp/4/G11/Yr-Resel(B)/3/Au//Kal/Bb
11	Genaro.81/Snb'S'
12	Genaro.81/Vee'S'
13	Ghurab
14	Glennson.81/Kea'S'
15	G11/YrResl(B)/3/Au//Kal/Bb/4/Yr/Pam'S'
16	Gv/Adl'S'//Bow'S'
17	Gv/Adl'S'/Mji//Bow'S'
18	Hahn'S'/Mji//Lira'S'
19	Jcan/Emu'S'//Chrc'S'/4/las20//
20	KAUZ'S'
21	Kvz//Cno/Pj62/4/T.Ast//Kal/Bb/3/Sq48/A1/Cno'S'(2)//Cno(4)
22	Maya74'S'/On//1160-147/3/Bb/G11/4/Chat'S'5/Maya74-'S'/On//1160
23	Myna'S's/3/F35.70/Mo//Nac
24	Ns732/Her
25	Seri82/5/Ald'S'/4/Bb/G11//Cno67/7C/3/Kvz/Ti
26	Seri82/5/Ald'S'/4/Bb/G11//Cno67/7C/3/Kvz/Ti
27	Sn64/Hn4//Rex/3/Edch/Mex/4/Sls'S'/5/Bow'S'

28	TALLO 3
29	Tsi/Vee#5#'S'
30	Ures.81/Genaro.81
31	Ures/Bow'S'
32	Ures/Bow'S'
33	VCee#5'S'Bow'S'
34	Vee'S'//GV/Ald'S'
35	Vee'S'//Sannine/Ald'S'
36	Vee'S'//Sannine/Adl'S'
37	Vee'S'/3/Tast/Mo//Nac
38	Vee'S'/5/Gv/4/D6301/Nai/Wrm/3/Cno*3/Chr
39	Vee'S'/5/Skh8/4/Rrv/Ww15/3/Bj'S'//On*/Bon
40	Vee'S'/5/kh8/4/Rrv/Ww15/3/Bj'S'//On*3/Bon

avirulence and virulence formulae are given below, were obtained from the Directorate of Wheat Research Station, Shimla

77-1	=	Lr21, Lr23/Lr1, Lr2, Lr3, Lr10, Lr11, Lr12, Lr13, Lr15, Lr16, Lr17, Lr20, Lt26, Lr27+31, Lr30
77-2	=	Lr26/Lr1, Lr2, Lr3, Lr10, Lr11, Lr12, Lr13, Lr15, Lr16, Lr17, Lr20, Lr21, Lr23, Lr27+31, Lr30
77-5	=	Lr21/Lr1, Lr2, Lr3, Lr10, Lr11, Lr12, Lr13, Lr15, Lr16, Lr17, Lr20, Lr23, Lr26, Lr27+31, Lr30
Common avirulence	=	Lr9, Lr18, Lr19, Lr24, Lr25, Lr28 and Lr29
Common virulence	=	Lr14, Lr22, Lr33, Lr34

Seedling studies

Six to eight wheat seedlings of genetic stocks were planted as hill and raised in trays in triplicate. Ten days old seedlings were inoculated with uredospores suspended in Tween 20. The inoculated plants were placed in humidity chambers overnight at 10° to 15°C and transferred to glasshouse chamber. The infection types (ITs) were recorded after 12-14 days on 0-4 scale (Stakman 1962). Infection type data from only one replicate are reported because there was no significant variations in ITs of the other two replicates.

Adult plant resistance studies

The adult plant resistance was monitored for 3 years (1995., 1996 and 1997) against 77-1, 77-2 and 77-5 chosen for virulence on seedling resistance genes and also with the mixture of prevalent races of leaf rust. Forty genetic stocks alongwith susceptible check (Agra-Local) were planted in isolated

nurseries at IARI farms in 1.25 m long rows 23 cm apart and inoculated with individual pathotypes. Spreader rows were planted periodically between the rows. The nursery was bordered on all sides with two rows of mixture of Agra Local and Lal Bahadur, followed by two rows of oats spaced 23 cm apart to trap foreign spores if any.

Artificial leaf rust epiphytotic was initiated by injecting urediospore-water-Tween 20 suspension in leaf sheaths of spreader plants 60 days old with hypodermic syringe. Rust severity and response were measured at the terminal stage of plant growth for individual pathotype (Loegering, 1959), while disease ratings were made thrice at fortnight intervals when tested with mixture of pathotypes in 1995 and 1996.

RESULTS AND DISCUSSION

Adult plant resistance

Out of 40 genotypes under study 25 genotypes were susceptible at the seedling stage with the seedling infection type (IT) 33+ to 4 while 15 genotypes were resistant 0 to 2 when tested with leaf rust race 77-5, which is the most aggressive race and covers most of the virulences available in the country. The genetic stocks were tested at the adult plant stage with the same race (77-5) besides other pathotypes of race 77 (77-1 and 77-2). Based on the identical response pattern for each pathotype, 25 genotypes can be classified in 9 distinct groups (Table 2).

Group I	:	It comprises of 12 stocks with very low (VL) response to 77-5,77-1,77-2 and mixture of pathotypes of leaf rust.
Group II	:	The second group comprises of 4 stocks,wherein very low (VL) disease ratings were obtained for 77-1 and 77-2 and comparatively high (L) for 77-5.
Group III	:	It comprised of one stock Entry 12 which gave very low responses to 77-1 and 77-2 but high (H) to 77-5.
Group IV	:	Entry 2 and 16 constituting this group in which APR factors are effective against 77-1 and 77-2 but ineffective against 77-5.
Group V	:	The APR source is effective against 77-1 and 77-5 (Ent 35) but ineffective against 77-2.
Group VI	:	It embodies unique APR of race specific type which is effective to race 77-1 only (Ent. 33).
Group VII	:	This APR source (Entry 25 and 26) showed race specific adult plant resistance to 77-1 like group 6, however, the entries in this group gave high response to mixture of races during 1995 and 1996.
Group VIII	:	Low reaction to 77-2 is the characteristic of this APR source (Entry 10).
Group IX	:	It involves Entry 1 with susceptible check Agra local which lack any APR component.

Table 2. Categorising adult plant resistance to leaf rust : Seedling infection type with leaf rust race 77-5 in glasshouse and adult plant response patterns of 25 genotypes of WLRGP-93, with specific leaf rust pathotypes and mixture of leaf rust pathotypes in isolated field nurseries.

			77-1	77-2		77-5			Mixture 1995			Mixture 1996		
	Entry	SIT	1995	1995	1996	1996	1997[a]	1997[b]	I	II	III	I	II	III
Group I			(VL)	(VL)				(L)						
	6	3+	10MR	5MR	TR	TR	-	-	5MR	10MR	20MS	TR	TR	TR
	7	4	-	5MR	TR	TR	5MR	5MR	5RMR	10MR	5MRMS	5MR	10MR	10MR
	9	4	5RMR	5MR	TMS	-	5MR	5MR	10RMR	20MR	40MRMS	-	-	-
	13	3+	TR	TR	TR	10S	10MR	5MR	10R	10RMR	20MR	5R	10RMR	10MR
	14	3+	5R	10MSS	TS	10S	10MS	10MS	5MR	5MR	10MRMS	5MR	10MR	10MR
	15	4	10MR	5MR	10MSS	TS	10S	10MS	10MS	5MR	5MR	10MRMS	5MR	10MR
	20	3+	10MRMS	TR	TR	TMR	TMR	20MR	10MR	20MR	30MRMS	-	-	-
	23	4	TR	TMR	TR	TR	TR	5MR	TMR	5RMR	5R	-	-	-
	28	3c	5R	5MR	TR	5MS	TR	10MR	5RMR	5MR	20MRMS	5MR	10MR	10MRMS
	36	3+	TMR	TR	TR TMR	TR	TR	TMR	TR	TR	TR	5R	5R	
	39	33+	5R	10MR	TMR	20MR	TR	TR	5MR	10MR	10MRMS	-	-	-
	40	33+	30MS	TR	-	20MS	-	-	10MR	20MRMS	30MRMS	10MS	30MS	40MSS
Group II			(VL)	(VL)			(L)							
	3	3+4	5RMR	10MR	TR	10S	20MSS	30S	10MR	20MSS	50MS	20MS	30MS	40MSS
	4	33+	20MR	20MR	TR	30S	10MSS	30S	10MRMS	10MS	40MS	20MS	30MSS	40MSS

(Table Contd. on next page)

Table 2 contd.

			77-1	77-2		77-5			Mixture 1995			Mixture 1996	
	5	4	10MR	20MRMS	TR	TR	10MSS	20MSS	10MSS	20MSS	50MS	-	-	-
	29	3	10MR	20MRMS	TR	10MSS	10MS	20S	5MR	10MR	30MS	5MS	19MRMS	20MS
Group III		(VL)	(VL)			(H)								
	12	3+	10MR	10S	TR	-	40S	40S	10MRMS	10MSS	20MSS	-	-	-
Group IV			(L)	(L)			(H)							
	2	3	40MS	30MS	TMR	40S	-	-	20MR	40S	60S	30MS	40S	50S
	16	3+.	20MR	30MR	-	-	60S	60S	10MR	-	20MSS	20MS	20MSS	30MSS
Group V			(L)	(H)			(L)							
	35	3+	40MSS	50S	-	-	20S	30S	10MS	20MSS	50S	20MSS	50S	60s
Group VI			(L)	(H)			(H)							
	33	3+	40MSS	50S	-	40-S	10MSS	-	10MR	10MRMS	30MSS	-	-	-
Group VII			(L)	(H)			(H)							
	25	4	60MS	80S	-	20S	-	-	30MS	50S	70S	40S	50S	70S
	26	4	-	80S	-	20S	20MSS	60S	30MS	60S	80S	50S	60S	80S
Group VIII			(L)	(L)			(H)							
	10	4	60S	30S	-	-	10MS	60S	20MS	40S	60S	40S	50S	60S
Group IX			(H)	(H)			(H)							
	1	33+	50S	60S	40S	-	-	60S	60MRMS	40S	60S	40S	60S	60S
	AL	4	70S	80S	70S	60S	70S	100S	70S	70	80S	70S	80S	30S

VL = 0-20mR; L = 20MS-30MSS; H = 40S-100S; SIT = Seedling Infection type; A = Agra local

Table 3. Seedling resistance : Seedling infection type with leaf rust race 77-5 in glasshouse and adult plant response patterns of 15 genotypes of WLRGP-93, with specific leaf rust pathotypes and mixture of leaf rust pathotypes in isolated field nurseries.

			77-1		77-2		77-5		Mixture 1995			Mixture 1996		
	Entry	SIT	1995	1995	1996	1996	1997[a]	1997[b]	I	II	III	I	II	III
Group I			(VL)	(VL)			(VL)							
	8	2+	TR	TR	TR	5MS	TR	TR	5R	5R	5R	TMR	5MR	5MR
	18	2+	TR	TR	TR	-	TR	TR	TMR	TR	TR	-	-	-
	19	1-2-	TR	10MR	TR	-	TMR	10MR	TMR	10MR	20MR	5MR	10MR	10MR
	21	22+	5R	TR	TR	-	TR	TMR	5R	5R	10MRMS	-	-	-
	22	22+	5MR	20MR	TMR	TR	TMR	5MR	5RMR	20MS	30MS	10MR	20MRMS	20MS
	24	2-	TR	TR	TR	TR	TR	TR	TR	0	TR	TR	-	-
	27	2+	10MR	20MR	TMR	5MS	10MS	20MS	10MR	30MRMS	-	10MR	30MR	30MR
	30	2	20MRMS	20MR	TMR	5MRMS	10MS	10S	10MR	10MSS	-	5MS	10MS	20MS
	31	1+2-	TR	10MR	TR	5MR	10MR	10MS	5RMR	10MR	10MR	5MR	10MS	20MRMS
	32	22+	10R	5RMR	TR	TMR	5MS	10MS	5MR	10RMR	10MRMS	10MR	10MR	20MRMS
	34	2+	10MR	-	TMR	TR	TMR	5MR	10MR	10MR	20MS	10MR	10MS	20MSS
	38	1+2	TR	TR	TR	TR	TMR	TR	TR	5R	5RMR	10MR	5MR	5MR
Group II			(VL)	(VL)			(L)							
	11	2+	10MR	5MR	TR	20S	30S	30S	10MRMS	20MSS	50S	30S	40S	60S
Group III			(H)	(H)			(H)							
	17	2+	50S	40MSS	-	-	10MSS	50S	20MS	40S	60S	30S	40S	60S
	37	2+	90S	80S	-	60S	60S	70S	20MSS	60S	70S	30MSS	40S	60S

Seedling resistance

Group I embodies 12 genotypes possessing high seedling resistance to all the pathotypes which remains effective throughout the life of plant (Table 3). Entry 11 (Group 2) was distinct in the sense that it gave low resistance response to race 77-5. Genotypes 17 and 37 showed seedling resistance in glasshouse but were susceptible to 77-1, 77-2 and 77-5 races of leaf rust at adult plant stage. Similar cases were also reported by Bahadur *et al.*, 1993.

Studies have indicated that the genetic stocks are available with seedling resistance as well as adult plant resistance to the most virulent forms of leaf rust (77 group). Both types of resistances are valuable, since the interaction of major seedling resistance genes with adult plant resistance genes has been suggested as one of the means to achieve durable resistance (Sawhney *et al.*, 1992, Sawhney and Joshi, 1996). Pyramiding of seedling resistance genes with adult plant resistance genes can be an effective strategy to breed for durable resistance to leaf rust in wheat.

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