



Non-hypersensitive stripe rust resistance in some Indian and exotic bread wheat (*Triticum aestivum* L.)

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Stripe rust of wheat (*Triticum aestivum* L.) caused by *Puccinia striiformis* West, is a major threat to cultivation of wheat in North Western Plain Zone of India. The disease often appears in the second week of February and continues to increase till the end of March, when the plants are at maximum tillering stage to early boot stage. At this particular phase of the plant, adult plant resistance becomes operative, which may either be due to qualitatively inherited major hypersensitive resistance gene (s) or due to collective effect of minor genes or one or more of the genes not able to evoke hypersensitive response. The emphasis at present for the management of rusts worldwide is to develop varieties with partial resistance which is often of non-hypersensitive type [1]. Such resistance is the most useful as it subtends very little or no selection pressure on the pathogen, thus remaining effective for long duration [2]. The present communication reports wheats with such partial resistance to stripe rust based on diverse genes.

Thirty five Indian and exotic bread wheats were tested for seedling infection types, percent disease severity and leaf tip necrosis (Ltn), a trait linked to the gene *Yr18* known to be associated with durable resistance, from 1999-2000 to 2003-04. Susceptible cultivars WL711 and Agra Local were also included as checks. For study of infection types, first leaf of ten day old seedlings were hand inoculated with uredinospore-talc mixture of each of the races 46S102, 46S103, 47S102 and 46S119, separately and incubated for 48 hr at 16°C in a humidity chamber. These were then placed in separate glass houses maintained at 18°-20°C. Observations on infection types were recorded, 14 days after inoculation following Stakman *et al.* [3]. The avirulence/virulence formulae of the races used are given below:

46S102 = *PYr1, Yr2, Yr5, Yr9, Yr10, Yr15, Yr17, Yr24, Yr25, Yr26, Yr27/pYr3, Yr4, Yr6, Yr7, Yr8, Yr11, Yr12, Yr18*
46S103 = *PYr5, Yr9, Yr10, Yr15, Yr24, Yr25, Yr26/pYr1, Yr2, Yr3, Yr4, Yr6, Yr7, Yr8, Yr11, Yr12, Yr17, Yr18, Yr27*

47S102 = *PYr5, Yr9, Yr10, Yr15, Yr17, Yr24, Yr25, Yr26/pYr1, Yr2, Yr3, Yr4, Yr6, Yr7, Yr8, Yr11, Yr12, Yr18, Yr27*
46S119 = *PYr1, Yr5, Yr10, Yr15, Yr24, Yr25, Yr26/pYr2, Yr3, Yr4, Yr6, Yr7, Yr8, Yr9, Yr11, Yr12, Yr17, Yr18, Yr27*

For scoring percent disease severity and Ltn, the wheats were grown as 2 m long paired rows planted 50 cm apart. The experimental plots were surrounded by two rows each of the susceptible cultivars Agra Local and WL711. The susceptible cultivars and the experimental material was spray inoculated with aqueous urediospore suspension of each of the four races separately in isolated plots on alternate days to create epiphytotic of stripe rust during the years 1999 to 2004. The inoculations started from last week of December and continued till the last week of January of next year. The observations on disease severity were recorded according to modified Cobb scale as described by Peterson *et al.* [4]. The leaf tip necrosis was observed visually as creamy white streak, which started from the tip and progressed along the margins of the flag leaf blade down wards [5, 7].

The seedlings of all the 35 wheats displayed high infection types against all the 4 races, thus these wheats did not possess any race specific seedling resistance gene(s) effective against the four races (data not given). The list of the 35 wheats tested, their pedigree and disease severity against four stripe rust races is given in Table 1. The disease severity on these wheats against race 47S102 varied from 10S to 40S except for Blue silver, CIM52, Parula'S' and Tobar 66 where the severity varied from Trace resistant (TR) to 10R. This observations suggests that these four wheats may have hypersensitive adult plant resistance gene(s) effective against race 47S102. Similar hypersensitive resistance was also observed in 9 wheats against race 46S102 and against race 46S103 in 8 wheats. All the 35 wheats tested showed susceptible (MS) type of reaction with disease severity varying from

Table 1. List of the wheats ^atested, their pedigree, status of leaf tip necrosis and disease severity against four stripe rust races

Wheat	Pedigree	Race and disease severity			
		47S102	46S102	46S103	46S119
Anza*	Lerma Rojo 64//Norin 10/Brevor/4/Yaktana 54//Norin 10/Brevor/3/3* Andes	10S	10R	10S	30S
Apache 81	Penjamo 62/Gabo 55/3/II12350 's'/Olesen//Roque 73/4/SF2,20S	20S	20S	20S	
Bajio 67*	Tezanos Pintos Precoz/Sonora 64A	20S	10R	10R	20S
Blue Silver*	1154-388/Andes/3/Pitic 62 sib/3/Lerma Rojo 64	10R	10R	20S	30S
Cocoraque 75*	II 12300//Lerma Rojo 64/Penjamo 'S'/Gabo 55/3/Norteno 67	30S	10MR	10MR	30S
Chris*	Frontana/3* Thatcher/3/Kenya 58/Newthatch//2* Thatcher	20S	20S	30S	20S
Chiroca	SD648.5/8156/3/Chris//Sonara 64/Klein rendidor/4/Bluebird/Calidad/5/Zambezi	20S	20S	20MR	20S
CIM32*	laasul63/Aldan 'S'	20S	30S	20MR	30S
CIM42*	Not known	20S	20S	TR	20S
CIM52*	Not known	10R	10R	20S	30S
CPAN1676*	Bonanza//Ciano/Sonora,64/3/Kalayansona/Bluebird	30S	10MR	30S	30S
Era*	11-50-10/4/Pembina/II-52-329/3/II-53-3R/III-58-4//11-53-546	30S	20S	30S	30S
Erget*	Heron/4/2* Lerma Rojo 64//Norin10/Brevor 14/3/3* Andes	20S	10R	TR	30S
Exchange	Warden/Hybrid English	20S	20S	40S-50S	30S
FKN*	Frontana/Kenya 58//Newthatch	30S	20S	20S	20MS
Flinders*	PWRH/Condor sib//2* Condor	20S	30S	20S	30S
HS86	Thatcher/Mida//McMurachy/Exchange/3/S227/4/S308	20S	TR	TR	30S
HUW37	Kalayansona/S331//HD1982	20S	20S	20S	30S
Jupateco 73 'R'	II12300//Lerma Rojo 64/8156/3/Norteno 67	20S	20S	20S	20S
Kalayansona	Frontana/Kenya 58//Newthatch/3/Norin10/Brevor/3/Gabo55	40S	30S	30S	30S
Lerma Rojo 64	Yaqui 50//Norin 10/Brevor/3 /Lerma 52/4/2*Lerma Rojo	20S	20S	20S	30S
Noreosta 66	Lerma Rojo 64/Sonora 64	20S	20S	20S	30S
Nuri 70*	Ciano 67 sib//Sonora 64/Klein Rendidor/3/Penjamo sib/Gabo	20S	20S	10MR	20S
Parula 'S'	Frontana/Kenya 58//Newthatch/3/2* Frocor//Kenya,A.D/Gabo/4/Bluebird/Chanate	10R	20S	20S	30S
Pavon 76	Vicam 71//Ciano sib/Siete Cerros//3/Kalayansona/Bluebird	20S	10R	20S	20S
Pitic 62	Yaktana 54//Norin 10/Brevor 126.IC	30-40S	20S	30S	20S
Potam 70	Inia sib/Napo 63	20S	20S	20S	30S
RL6050*	6*Thatcher/Terenzio	20S	20S	20S	20S
RL6058*	6*Thatcher/PI58548	20S	20S	20S	20S
RL6059*	6*Thatcher/PI58548	20S	20S	20S	20S
RL6061*	6*Thatcher/PI208316	20S	20S	20S	30S
RL6077*	6*Thatcher/PI250413 Terenzio	20S	20S	20S	30S
RN902491*	6*Thatcher/PI58548//6*Thatcher/PI250 413Terenzio	20S	20S	20S	20S
Shailaja	Penjamo 62 sib/P14//Kentana 54B/3/Sonalika	20S	20S	20S	30S
Tobari 66*	Tezanos Pintos Precoz/Sonora 64A	TR	30S	20S	30S
WL711	S308/Chris//Kalayansona	60S	60S	60S	80S
Agra Local	A land race from Uttar Pradesh	40S	40S	60S	70S

^a= Seedlings from all wheats are susceptible to race 46S119; [†] Ltn present

20S/MS to 30S against race 46S119. Because race 46S119 was able to overcome the hypersensitive adult plant resistance effective against the other three races identified from few wheats, this resistance is of not much consequence in breeding programmes. The low disease severity scores of these 35 wheats against race 46S119 as compared to the susceptible cultivars WL711 and Agra Local despite high infection types against race 46S119 on seedlings suggest presence of non-hypersensitive type of resistance factors in these

wheats. Of the 35 wheats tested, 23 showed leaf tip necrosis. Therefore, the partial resistance in these wheats can be ascribed to the Ltn linked non-hypersensitive adult plant resistance gene *Yr18*. This gene was earlier reported from many wheat cultivars based on its linkage with a leaf rust resistance gene *Lr34* [6], and the heritable morphological marker Ltn [7]. The Thatcher derivatives carrying the linked genes *Lr34-Yr18*, namely RL6050, RL6058 (reference line for the gene *Lr34*) RL6059, RL6061, RL6077 and 90RN2491

also showed leaf tip necrosis and have shown stripe rust severity comparable to other wheats showing this trait. Twelve wheats namely Apache 81, Chiroca, Exchange, HS86, HUW37, Kalyansona, Lerma Rojo, Noroesta 66, Pavon 76, Pitic 62, Potam 'S' 70, and Shailja did not show Ltn, but their disease severity was also comparable to the wheats carrying *Yr18*. Therefore, the non-hypersensitive adult plant resistance in these wheats may be ascribed to gene(s) different than *Yr18*. The stripe rust resistance gene *Yr18* alone has been reported to be ineffective under high inoculum pressure [8]. Since the non-hypersensitive resistance genes are additive in nature [9] identification and pyramiding of gene(s) different than *Yr18* into cultivars having *Yr18* alone should be useful for breeding durable resistance against stripe rust disease. Incidentally these twelve wheats identified as diverse source of non-hypersensitive stripe rust resistance, barring Exchange, HS86 and Kalyansona also possess partial resistance against leaf rust disease thus these wheats are good sources of resistance against both these rusts.

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