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Pyramiding of stem rust resistance genes to develop durable and multiple disease resistance wheat varieties

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Wheat (*Triticum aestivum* L.) is widely cultivated over large areas and is an important food crop worldwide.Wheat rusts (leaf, stem and stripe rust) are major foliar diseases of wheat, causing substantial yield losses. The ability of these rust pathogens to change and be dispersed over long distances pose a continual global threat. Annually, millions around the world are spent on fungicides in an attempt to control wheat rusts. Resistant cultivars have proven to be the most effective, economical and environmentally friendly form of rust control. Although many resistant cultivars have been developed and released worldwide carrying specific rust resistance genes, pyramiding of more and more race specific and race non-specific genes is the effective strategy in developing durable rust resistance varieties. The application of molecular markers and marker-assisted selection (MAS) strategies in breeding programmes can support plant breeders in accomplishing pyramiding of several rust resistant genes into new cultivars.

Of the, so far identified stem rust resistance genes, *Sr2* is the only minor adult plant gene (APR) for stem rust resistance. Presence *Sr*2 alone is not adequate under heavy disease pressure but does provide adequate resistance in combination with other major genes. Pseudo-black chaff, a dark pigmentation around the stem internodes and glumes is closely associated with *Sr2* and has been used as a useful morphological marker to fix the gene, although its expression is much influenced by genetic background and environment.

The *Thinopyron ponticum*-derived linked genes *Sr*24+*Lr*24 and *Triticum timopheevii*-derived linked genes *Sr*36+*Pm*6 which are major genes that provides effective rust resistance to leaf and stem rusts. Additionally the *Pm*6 give very effective protection against the powdery mildew. Although *Sr24* was effective for some time, race 40-1 has overcome its resistance in India. The linked gene complexes of *Lr*24+*Sr*24 and *Sr*36+*Pm*6 though individually not effective against Ug99 pathotype and its variants but together confers very effective stem rust protection against Ug99 and also the occurring stem rust races in India. Though susceptible to Ug99 pathotype there have been no reports of virulence for *Sr*36 yet in India.

The aim of this study was to pyramid three rust resistance genes in the background of five wheat varieties using three microsatellite markers. The study focused on wheat rust resistance genes effective to the Indian pathotypes and to develop durable rust resistant varieties. Marker sequences obtained from the public domain were used for precise introgression and pyramiding *Sr*2, *Sr*24/*Lr*24, *Sr*36/*Pm*6 genes into a particular wheat background using MAS. In this study five wheat varieties Lok-1, Sonalika, Raj 4083, HSB6 and WTN 0164 already carrying minor adult plant stem rust resistance gene *Sr2* were used as recurrent parents.The donor genotypes include a near isogenic line of Darf developed using TR 380-14*7/3Ag#14, as the source genotype for the major stem rust resistance gene *Sr24/Lr24.*The donor parent contributing for

the stem rust resistance gene *Sr36* was Indian hexaploid wheat stocks already introgressed with *Sr36* gene-derived from an Australian cultivar 'Cook'. The major genes *Sr24* and *Sr36* were pyramided with *Sr2* using step wise and simultaneous transfer method in the background of these varieties. Selection after each cross was done using a MAS approach with microsatellite markers linked to the major resistance genes, SRT and field response(Table-1).

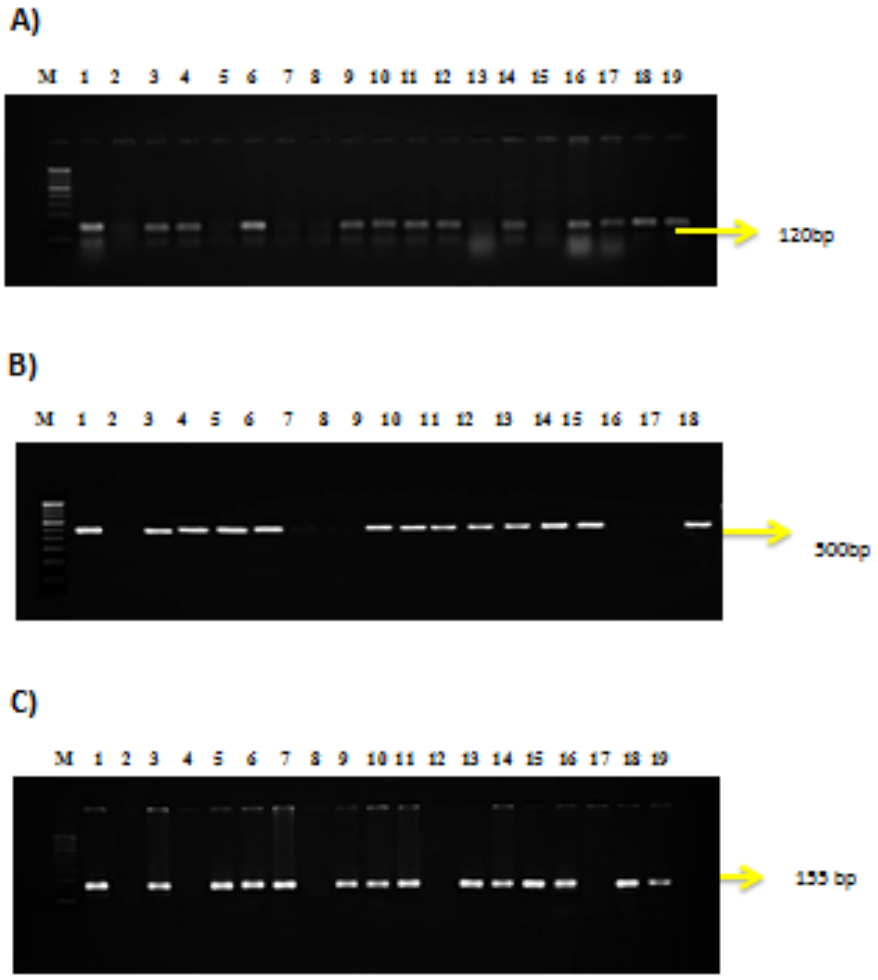
Before crosses were made, the presence of the expected rust resistance genes was confirmed in the parentaldonor lines using specific markers *gwm*533, *stm*733-2 and *Sr*24#12 linked to *Sr2*, *Sr36* and *Sr24* respectively. The presence of the minor APR gene *Sr2* was also confirmed by the presence of the morphological marker pseudo black chaff (*Pbc*) on the glumes and lower internodes in addition to the. microsatellite marker *gwm*533 Most of the F1 plants were identified with *Pbc*. The F_1 plants were top crossed and then backcrossed with the respective recurrent parent. The resulting BC_1F_1s were screened with molecular markers *gwm*533, *Sr*24#12 and *stm*733-2 specific to *Sr2, Sr24* and *Sr36* respectively to confirm the presence of the rust resistance genes. Marker assisted selection was practiced in the subsequent F_2 and F_3 filial stages to identify the plants pyramided with resistance genes. The marker results showed that each plant segregated for the presence of the resistance gene combination.

Of the three markers used in the present study for the identification of plants carrying the resistance genes *Sr*24#12 linked to the major gene *Sr24* is a dominant marker. The other two microsatellite markers *gwm*533 and *stm*733-2 linked to *Sr2* and *Sr36* were co – dominant markers and thus homozygous and heterozygous plants could be distinguished. The microsatellite marker gwm533 amplified a 120bp PCR product pertaining to the presence of the gene *Sr2* in the pyramided genotypes. A 500 bp allele was amplified by the dominant marker *Sr*24#12 linked to the major gene *Sr24* while the marker stm733-2 amplified a 155bp product in the genotypes carrying the gene *Sr36*(Figure1-3). In each population of the five varieties, plants pyramided with all the three genes *Sr2+Sr24+Sr36* and plants with two gene combinations *Sr2+Sr24* and *Sr2+Sr36* were also obtained.

The data on the various quantitative traits characters related to field resistance showed that the in the present study showed high degree of field resistance against leaf, stem and powdery mildew resistance with maximum recurrent parent genome recovery. Further studies on the effect of these genes on the end use quality is on.The varieties pyramided with the three gene combinations were in comparison to the respective recurrent parent for all the agronomic traits so far studied. Slight increase in the number of tillers per plant and 1000 grain weight were also observed.

The wheat lines developed in the present study, by virtue of possessing resistance to one or more type of rusts and powdery mildew have definite advantage over their susceptible recurrent parents. The combination of rust resistance genes *Sr2*, *Sr24* and *Sr36* in the genetic background of commercial wheat varieties is likely to provide durability of resistance which can be strategically deployed after testing for the yield potential. The pyramided lines may also serve as good genetic stock or donor in breeding program since there in the background of well adapted Indian commercial cultivars.

Figure 1: Screening of BC_1F_3 population for the presence of rust resistance genes



Screening of BC1F3 generation of Sonalika population for rust resistance genes *Sr2, Sr24* and *Sr36* with A) STM marker gwm 533 linked to *Sr2* B) STS marker Sr24#12 linked to *Sr24/Lr24* and C)STM marker stm733-2 linked to *Sr36*

Table-1: Seedling and adult plant response (under natural conditions with high disease pressure) of recurrent and constituted lines with pyramided genes

Varieties	Adult Plant response to rust diseases under natural epiphytotic conditions			Seedling response to brown rust races					Seedling Response to Black rust races		Powdery Mildew
	Black	Brown	Yellow	17	77A	77-5	77-7	77-8	40A	40-1	Mixed Race (0-9 scale)
Lok-1	70S	80S	80S	3+	3	3	0	3	2+	3	6
Lines with *S2/Yr30, Sr24/Lr24, Sr36/Pm6*	F	F	60S	;,1	;1,1	;1	;1	1	0	0;	1
Raj 4083	30S	80S	40S	2	2	3+	2	2	2	1	4
Lines with *S2/Yr30, Sr24/Lr24, Sr36/Pm6*	F	F	40S	;,1	;1,1	;1	;1	1	0	0;	0
HSB6	30S	40S	20S	2	2	3+	1	2	2	1	5
Lines with *S2/Yr30, Sr24/Lr24, Sr36/Pm6*	F	F	20S	;,1	;1,1	;1	;1	1	0	0;	1
WTN0164	F	F	F	;,1	;1,1	;1	;1	1	;1	;1	4
Lines with *S2/Yr30, Sr24/Lr24, Sr36/Pm6*	F	F	F	;,1	;1,1	;1	;1	1	0	0;	0
Sonalika	60S	80S	60S	2	2	3	1	2	2	2	4
Lines with *S2/Yr30, Sr24/Lr24, Sr36/Pm6*	F	F	60s	;,1	;1,1	;1	;1	1	0	0;	0

Results of *AICW&BIP* trials and problems in their conduct in Southern Hill Zone, 2013-14

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Inroduction:

Southern Hill Zone (Comprising hill areas and adjoining hills) although area wise a small zone but strategically very important with respect to rust control programme since it is the focus area for leaf and stem rust in India(hot spot). Because of changing food habit and regular efforts in popularizing wheat cultivation in this zone the demand for wheat has gone up which is reflected in the increased seed demand for recently released rust resistant wheat varieties. Over the last six years sizable area has come under wheat cultivation under this zone during Rabi. In Southern hill zone the AICW&BIP yield trials viz., AVT, IVT (*Aestivum*), Spl.trial - *dicocccum* and agronomy trials for both *dicoccum* and aestivum are regularly conducted. Although area wise this zone is a small zone, this zone acts as source for spread of rust diseases to other parts of the country and while considering the rust control program in India it is strategically very important one.

Conduct of AICW&BIP trials 2013-14

The AICW&BIP yield trails under Southern Hill zone, AVT(TS/LS), IVT(TS/LS), Spl. trial on dicoccum and agronomy trials were proposed and conducted. The trial locations proposed were AVT-7/IVT-7/Spl.dicoccum-2 which include the locations viz.Wellington(TS), Wellington(LS), CSWRI, Mannavanur, Kodaikanal, CSWC&RI, Ooty, Yercaud and Paiyur (TNAU) in Tamilnadu and Mandya in Karnataka and the trials were conducted in all locations except at Yercaud. The Special trial on dicoccum was proposed and conducted Wellington and Mandyacentres. Agronomy trials for final year entries of dicoccum were conducted only at Wellington location.

Table-1: Conduct of IVT/AVT/agronomy/special trials in SHZ : 2013-14

Trial	No. trials proposed in workshop	No. trials conducted	Trials rejected/Not conducted/Not reported	Reasons / Remarks
AVT-MF-RIR	(Wellington-TS, Wellington-LS, Kodaikanal, Paiyur, Yercaud & Mandya) **No. of Trials Proposed = 07**	6	Not conducted (Yercaud)	Sowings couldn't be taken since wild animal protection was not provided
IVT-MF-RIR	(Wellington-TS, Wellington-LS, Kodaikanal, Paiyur, Yercaud& Mandya) **No. of Trials Proposed = 07**	6	Rejected-1 (Paiyur) Not conducted (Yercaud)	ID(Incomplete data)
Spl.trial - *Dicoccum*	2 (Wellington, and Mandya)	2	Nil	Nil
Agronomy-*Dicoccum-Irrigation levels*	1(Wellington)	1	Nil	Nil

Advance Varietal Trials

Table-2: Mean Grain Yield (q/ha): Rabi 2013-14

AVT-RI-TS/LS-TAS-SHZ, 2013-14 State and Zonal Mean Yield (q/ha)

S.No	Variety	Code	Tamilnadu			Karnataka			ZONAL		
			Yield	Rk	G	Yield	Rk	G	Yield	Rk	G
1.	UAS 358	AVT-SHZ-3	49.6	1	1	57.7	2	1	51.0	1	1
2.	MACS 6507	AVT-SHZ-4	47.1	2	0	59.6	1	1	49.2	2	1
3.	COW(W) 1 (C)	AVT-SHZ-1	45.9	4	0	56.9	3	1	47.8	4	0
4.	HW 5216 (C)	AVT-SHZ-2	46.7	3	0	56.2	4	0	48.3	3	0
5.	HW 2044 (C)	AVT-SHZ-5	40.8	5	0	46.6	5	0	41.8	5	0
S.E.(M)			0.748			1.139			0.651		
C.D.			2.1			3.4			1.8		

No. of Trials: Proposed = 07, Conducted = 06, Trials not Conducted (01):Yercaud

Table-3Adult plant response of AVT material against wheat rusts under field conditions (artificial inoculations) during 2013-14

SOUTHERN HILLS ZONE		RUST RESPONSE (HIGHEST SCORE AND ACI)							
		South				North			
		STEM		LEAF.		LEAF		STRIPE	
Sr. No.	Variety	HS	ACI	HS	ACI	HS	ACI	HS	ACI
1	MACS 6507	30S	9.2	40S	12.3	40S	21.0	80S	47.8
2	UAS 358	20S	8.2	60S	15.6	20S	5.6	60S	35.7
3	COW(W) 1 (C)	40S*	5.2	5MS	0.6	30MS	8.0	80S	62.9
4	HW 5216 (C)	20MS	2.2	10MS	2.9	10MR	1.4	100S	50.6
5	HW 2044 (C)	10S	2.3	5S	1.3	20S	12.2	100S	56.1

The AVT trials were conducted with 2 test entries including three checks (Table 2). Both the test entries were in first non-significant group out yielding over the checks. However the test entry MACS 6507 can't be promoted further because of high ACI for brown rust.

Table -4: Promotion/retention of varieties in AVT trials in SHZ 2011-12 based on zonal mean yield and response to diseases

Response to rust	Grain Yield	Others	Remarks
More than 20S Susceptibility with ACI of 10.0 and above for one or more rusts are rejected which include the varieties as under	Numerically not at par with the checks other than the final year entries are rejected include the varieties	Varieties sowing Seg/Mix more than 10% and very late mature than Std. Check and high lodging score.	Rejected/
MACS 6507 (Leaf Rust -40S, ACI-21.0)	None	None	MACS 6507
Less than 20S with ACI 10.0 or less to one or more rusts	Numerically at par and above with the best check	Genetically pure	Retained/Promoted
UAS 358	UAS 358	Checks and all other test entries	UAS 358

Initial Varietal Trials(IVT)

The results of IVTzonal mean grain yields are presented in Table-5. The trial was conducted at 6 locations viz., Wellington(TS/LS), Ooty, Kodaikanal, Mandya and Paiyur during Rabi 2013-14.The results are statistically significant when it was tested with 14 test entries including three checks i.e. HW2044, CoW(W)1 and HW 5216. At zonal level the varieties HW 3620, HW 5801, HW5049, HW 3607, HW 3906, HW 4215-1 and HW5047 remained in the first non-significant group and will qualify for promotion to AVT based on their yield performance.

Table- 8 : The probable varieties constitute for AVT trials in SHZ Rabi 2014-15

Sr. No.	Name of the Varieties qualify for promotion/retention	Year of testing in AVT (2014-15) (Three years AVT for SHZ)
1	UAS 358	**2**
2	HW 3620	1
3	HW 5801	1
4	HW5049	1
5	HW 3607	1
6	HW 3906	1
7	HW 4215-1	1
8	HW5047	1
9	COW(W)1	1
10	HW 5216	1

Table – 5: Mean Grain Yield (q/ha): Rabi 2013-14

IVT -RI- TS/LS- TAS-SHZ, 2013-14
State and Zonal Mean Yield (q/ha)

Sl. No.	Variety	Code	Tamilnadu			Karnataka			ZONAL		
			Yield	Rk	G	Yield	Rk	G	Yield	Rk	G
1.	HW 3620	IVT-SHZ-1	46.1	7	0	58.3	8	0	48.6	8	1
2.	HW 5801	IVT-SHZ-2	50.2	1	1	56.0	15	0	51.3	1	1
3.	HS 589	IVT-SHZ-3	44.9	10	0	54.5	17	0	46.8	11	0
4.	HW5049	IVT-SHZ-4	48.5	3	1	57.2	9	0	50.3	4	1
5.	UAS 368	IVT-SHZ-5	41.8	16	0	62.4	3	1	45.9	16	0
6.	HW3608	IVT-SHZ-6	43.1	15	0	60.3	6	1	46.5	14	0
7.	HW3627	IVT-SHZ-7	43.7	13	0	63.0	1	1	47.6	10	0
8.	HW 5802	IVT-SHZ-9	43.6	14	0	59.1	7	1	46.7	12	0
9.	HW 3607	IVT-SHZ-10	48.6	2	1	56.1	14	0	50.1	5	1
10.	HW 3906	IVT-SHZ-11	45.8	9	0	62.0	4	1	49.0	6	1
11.	UAS 367	IVT-SHZ-13	43.9	12	0	56.4	13	0	46.4	15	0
12.	HW 4215-1	IVT-SHZ-14	48.3	4	1	62.8	2	1	51.2	2	1
13.	HW5047	IVT-SHZ-15	46.6	6	0	56.9	11	0	48.7	7	1
14.	HW 5048	IVT-SHZ-16	41.7	17	0	57.0	10	0	44.8	17	0
15.	HW 2044 (C)	IVT-SHZ-8	43.9	11	0	56.8	12	0	46.5	13	0
16.	HW 5216 (C)	IVT-SHZ-12	45.9	8	0	55.5	16	0	47.8	9	0
17.	CoW (W) 1 (C)	IVT-SHZ-17	47.9	5	1	61.3	5	1	50.6	3	1
S.E.(M)			1.202			1.420			1.003		
C.D.			3.3			4.0			2.8		

No. of Trials: Proposed = 07, Conducted = 06, Trials not Conducted (01) :Yercaud
Trials not reported (01) : Paiyur (ID)

Table-6Adult plant response of IVT material against wheat rusts under field conditions(artificial inoculations) during 2013-14

RUST RESPONSE (HIGHEST SCORE AND ACI)									
SOUTHERN HILLS ZONE		South				North			
		STEM		LEAF.		LEAF		STRIPE	
Sr. No.	Variety	HS	ACI	HS	ACI	HS	ACI	HS	ACI
1	HW3620	10MS	2.1	15MS	3.1	10MR	0.8	80S	31.8
2	HW5801	15MS	2.4	10MS	1.9	10S	3.0	80S	34.0
3	HS589	5MR	0.5	0	0.0	20S	5.6	100S	45.6
4	HW5049	20MR	1.2	5S	1.5	30S	7.0	80S	66.7
5	UAS368	5S	0.8	5S	1.8	10S	2.0	80S	40.0
6	HW3608	5S	0.8	TMR	0.1	20S	5.0	80S	58.9
7	HW3627	10MS	1.7	0	0.0	10S	3.0	90S	38.9
8	HW5802	10MR	0.9	TR	0.0	20MS	3.2	60S	28.9
9	HW3607	10MS	3.6	15MS	1.7	30S	7.0	20S	7.1
10	HW3906	10S	2.6	5MS	0.6	10S	4.0	100S	58.4
11	UAS367	20S	4.2	20S	3.0	10MR	0.8	100S	54.4
12	HW 4215-1	10S	1.8	40S*	7.0	10MR	1.2	80S	38.9
13	HW5047	5S	1.2	TS	0.1	10S	2.0	60S	32.2
14	HW5048	5MR	0.4	5MS	0.6	20S	5.0	100S	38.3

Under natural conditions all three rusts incidences were reported only from Wellington and from other centres the sporadic incidences of S*clerotium* foot rot were reported.

Table-7: Promotion/retention of varieties from IVT trials SHZ 2011-12 based on zonal mean yield and response to diseases

Response to rust	Grain Yield	Others	Remarks
More than 20S Susceptibility with ACI of 10.0 and above for one or more rusts are rejected which include the varieties as under (For black and Brown South reaction)	**Numerically not at par with the checks other than the final year entries are rejected include the varieties as under**	**Varieties sowing Seg/Mix more than 10% and very late mature than Std. Check and high lodging score.**	**Rejected/**
None	None	None	None
Less than 20S with ACI 10.0 or less to one or more rusts	**Numerically at par and above with the best check as under**	**Genetically pure**	**Promoted**
HW 3620, HW 5801 ,HW5049 ,HW 3607, HW 3906, HW 4215-1, HW5047	HW 3620, HW 5801, HW5049, HW 3607, HW 3906, HW 4215-1, HW5047	HW 3620, HW 5801, HW5049, HW 3607, HW 3906, HW 4215-1, HW5047	HW 3620, HW 5801, HW5049, HW 3607 ,HW 3906, HW 4215 -1, HW5047

Table -9: Proposed entries for IVT, SHZ Rabi 2014-15 and its details (based on CVT meeting of IARI, New Delhi)

Sl.No	Entry Name	Pedigree
1	HW 3624-1	PBW 226*3//COOK*6/C80-1
2	HW 3658	PBN51*3/RL6144//HW 4444
3	HW 4205-2	HD 2402*3//COOK*6/C80-1
4	HW 4206	HD2687*3//COOK*6/C80-1
5	HW 4207	HS 240*3//COOK*6/C80-1
6	HW 4305-2	HD 2329*7/CS 2A/2M 4/2*2//WH 542
7	HW 4501	C 306*3//RL 6144
8	HW 5245	HW 3083 // HD 2733
9	HW 5246	HW 3083 // PBW 502
10	HW 5247	HW 3083//UP 2338
11	HW 5248	HW 3083 // PBW 226
12	HS 609	WBM1975/HS 469
13	HS 610	MANGO/CORYDON/FLW32
14	UAS 376	
15	UAS 377	
16	NIAW 2613	PFAU/SERI.1B//AMD/3/INGALAB91*2/KUKUNA/4/WBLL1*2/KUKURU
17	MACS 6670	SHA7/VEE#S/5/VEE#8//JUP/BJY/3/F3.71/TRM/4/2*WEAVER/6/KAUZ/PARUS//PARUS
18	HW 2044#	PBW 226*5 // SUNSTAR*6 / C 80-1
19	COW(W)1#	HD 2646 // HW 2002A / CPAN 3057
20	HW 5216#	PBW 343//HW 3083

Other Trials

The special trial on *dicoccum* and agronomy trial for dates of sowing were were conducted at Wellington and at Mandya only yield trial was conducted.

1. Problems in conducting the trials

Problems encountered in constitution, conduction and monitoring of trials

The coding of trials faced with some difficulty and next time I request that scientists from UAS, Dharward may help in this matter.

2. Suggestions for Improvement

The trial centre at Yercaud, Kodaikanal may kindly be dropped. Instead the trials in the farms of progressive farmers/farmers who traditional grow wheat at Kenthorai and Thummanatti may be explored. Hence the trial centres for 2014-15 may include: Wellington (TS), Wellington(LS), CSWCR&TI, Ooty(TS), Kenthorai(TS), Thummanatti(TS), Paiyur(TS), Thiruvannamalai and Mandya(TS) for AVT and IVT trials. Dicoccum trials may be Wellington and Mandya(TS).

Rusts resistance in wheat lines grown at I.A.R.I., Regional Station, Wellington

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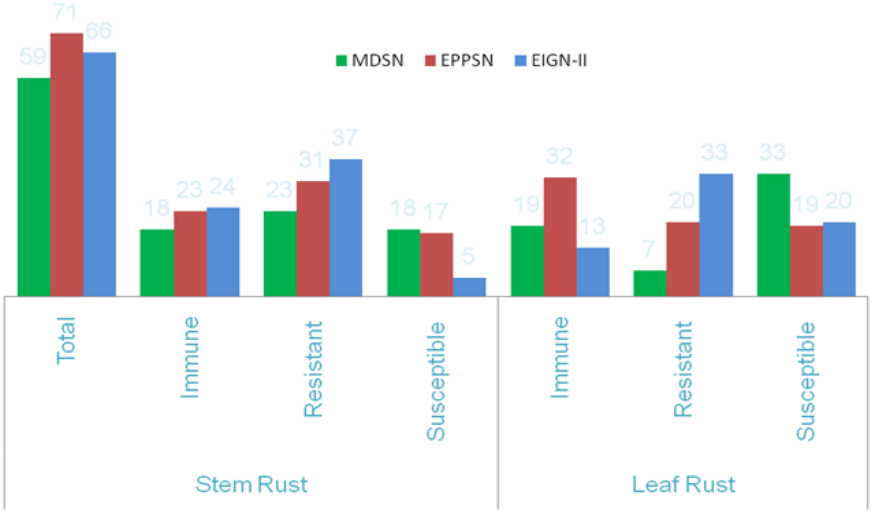
A total of 196 lines of wheat comprising 59 from multiple diseases screening nursery (MDSN), 71 from elite plant pathological screening nursery(EPPSN) and 66 from elite international germplasm nursery (EIGN) have been systematically evaluated against leaf and stem rust resistance under natural and high level of infection under field conditions during Rabi season (2012-13) against the predominantly occurring pathotypes of leaf rust viz.,.77A, 77-5, 17, 77-7,77-8 and stem rust races viz.,.40A and 40-1. Out of these, about 30 percentage of the lines irrespective of the nursery materials expressed immune reaction against both type of rusts. Similar proportion was also recorded against leaf rust. However, 46% of lines have shown resistant reaction to stem rust. Overall, the leaf rust susceptible lines were higher (36%) than stem rust (20%) Both rusts could infect the standard check line (Agra local) with a minimum mean of 60S. It implies that the genetic stocks which are immune to both rusts can be further evaluated and purified under known level of inoculum of both rust based on SRT and APR to understand the genetic basis of resistance.



National Off season/Summer nursery at Indian Agricultural Research Institute, Regional Station, Wellington

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Off- season/Summer nursery for crops such as Wheat, barley, oats, mustard, linseed etc. were successfully sown from the month of May, 2014 and the crops are in different stages of crop

growth. Nearly 20,000 lines of above mentioned crops belonging to various ICAR institutes (8) and SAUs(12) were sown for generation advancement, corrective crossing, rust disease scoring etc.

Table No. 1: Summer nursery participants at I.AR.I., Regional Station, Wellington, 2014.

Sl. No.	Crops	Research Institutes			Total
		ICAR	SAUs	Others	
1	Wheat	10546	6039	1669	18254
2	Barley	100	270	-	370
3	Oats	-	96	-	96
4	Mustard	855	50	-	905
5	Linseed	-	-	200	200
Total		**11501**	**6455**	**1869**	**19825**

Screening of wheat lines with leaf tip necrosis (LTN) against stripe rust

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In continuation of the research article published in cereal research communication titled "Phenotypic and molecular confirmation of durable adult plant leaf rust resistance (APR) genes *Lr34+*, *Lr46+* and *Lr67+* linked to leaf tip necrosis (LTN) in select registered Indian wheat *(T. aestivum)* genetic stocks ", where in thirty six lines with leaf tip necrosis (LTN) were screened at seedling and adult plant stage against stem and leaf rust pathotypes prevailing at Wellington which were later confirmed using molecular markers for the presence of three APR genes viz., *Lr*34+, *Lr*46+ and *Lr*67+. Twenty three lines and two checks were subjected to natural/field screening at I.A.R.I., Regional Station, Tutikandi centre, Shimla against stripe rust. All the lines showed resistant reaction (Table No. 1) except IC536136. Resistance based on minor/ APR genes are non-specific and are found to be durable. So these lines have considerable potential as a source of rust resistance and could enhance the existing gene pool of rust resistance.

Table 1: Response of LTN wheat lines for stripe rust reaction under natural condition at I.A.R.I., Regional Station, Tutikandi Centre, Shimla.

S.No.	Genotype	Stripe rust reaction
1.	IC542574	20S
2.	IC536197	10MS
3.	IC536155	10MS
4.	IC542568	TMS
5.	IC542569	F
6.	EC573553	5S
7.	IC536136	40S
8.	IC536178	20S
9.	IC536201	20S
10.	IC536210	20S
11.	IC536141	10MS
12.	IC536147	10S
13.	IC536186	5S
14.	IC536204	5S
15.	IC536167	10S
16.	IC536187	5S
17.	IC536196	10S
18.	IC536199	5S
19.	EC573556	5S
20.	EC573589	5MS
21.	EC573562	F
22.	IC536140	F
23.	IC536144	TMS
24.	Agra Local (Check)	60S
25.	A-9-30-1 (Check)	80S

News

Dr. M. Sivasamy, Principal Scientist, assumed as Head of the station after ASRB selection with effect from 17.09.2014

Awards

Dr. M. Sivasamy, Principal Scientist was awarded the fellow of Society for advancement of wheat research (SAWR)