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Pre-emptive breeding strategy to introgress *Triticum timopheevi*- derived gene *Pm6* to checkmate emerging wheat disease of powdery mildew(PM) caused by *Blumeria graminis* f. sp. *tritici* (DC) Speer (Syn. *Erysiphe graminis* DC f. sp. *tritici)*

Sivasamy.M[1], Vinod[2], S.M.S.Tomar[2], Jagdish Kumar[3], Vikas.V.K[1], P.Jayaprakash[1], G.P.Singh[4], R.Nisha[1], P.Sajitha[1], S.Bojan[1], K.Sivan[1] and C. Arun[1]

[1]ICAR-Indian Agricultural Research Institute, Regional Station, Wellington- 643 231
[2]ICAR-Indian Agricultural Research Institute, New Delhi-110 012
[3]ICAR-National Research Institute for Biotic Stress Management , Raipur, Chatishgarh
[4] ICAR-Indian Institute of Wheat and Barley Research Institute, Karnal

Introduction:

In India and other parts of the world wheat suffers from many major foliar diseases viz., rusts, blight, leaf spots, tan spots and other diseases like powdery mildew etc. Due to release of rust resistant wheat cultivars and adaptation of agro techniques like cultivation of wheat varieties under irrigated environment with closer spacing, increased use of nitrogenous fertilizer in intensive cultivation, modern wheat varieties are getting enhanced susceptibility to even minor diseases like powdery mildew etc. Further, under the changing climatic conditions the powdery mildew caused by *Erysiphe graminis* f. sp. *tritici* of wheat once considered as minor disease is assuming as major disease in recent times. Controversial and different opinions prevail upon the factors related to the powdery mildew development in nature. Mehta (1930), stated that cool moist weather favours powdery mildew of wheat. However there is contradictory opinion held by Butler (1925) that dry and warm summers favour the spread of mildew in U.K. The powdery mildew conidia are known to germinate at 0 – 100 percent relative humidly.

In India, powdery mildew (PM) incidence is mainly confined to the Northern and Southern hills. However it appears sporadically in the plains and foothills of North India. In the recent times PM disease has been observed in severe form in wheat cultivating areas under North Western Plain zone covering Uttarakhand, U.P., Punjab, Haryana, Rajasthan and Delhi (IIWBR report from 2006-2017). Everts and Leath (1992) reported that powdery mildew causes yield losses as high as 48% through premature dying of the leaves, reduction in tiller survival, kernels per head, and kernel size under disease severity. However In India, the accurate data regarding the losses caused by PM are not available, may be due to non availability of wheat varieties which are susceptible only to PM.

Occurrence of powdery mildew on early seedling stage, on leaf and on ear head of wheat at Wellington

The effective way to control the PM is the breeding resistant wheat varieties with race-specific host resistance which is the most consistent, environmentally friendly and economical method than the chemical control (Leath and Bowen 1989; Hardwick *et al.* 1994). Currently, 57 powdery mildew resistance (*Pm*) genes at 40 loci have been formally designated (Huang and Roder 2004; McIntosh *et al*. 2008). Although this task of breeding for PM resistance is complicated by the existence of many physiological races in the fungus, there are many race specific genes conferring various levels of resistance to PM

Back ground information on Powdery mildew resistance genes:

At least 57 resistance loci have been identified for powdery mildew (McIntosh *et al*. 2008). However, only a few genes have been used in the breeding programmes in various countries for developing powdery mildew resistant varieties. In India, genes *Pm3c*, *Pm5* and *Pm8* in combination with some unidentified genes have been used. Attila, Veery, Kavkaz, Bob White lines with 1BL/1RS translocation carrying *Yr9/Lr26/Sr31/Pm8* gene complex provided high level of resistance against the Indian populations of *E. graminis tritici* This helped in preventing the yield losses not only against powdery mildew but also against leaf, stripe and yellow rust. However, Robert *et al*. (2011) reported that the effectiveness of *Pm8* under spring wheat is suppressed by the *Pm3* locus. Additionally, the resistance of cultivars viz. PBW 343, UP 2338, HS 240, WH 542, PBW 502 etc., carrying linked genes *Sr31/Lr26/Yr9/Pm8* occupying most of the wheat growing areas in India, succumbed to the emergence of new pathotypes with matching virulence's. Subsequently, The prevalence and severity of PM disease has increased tremendously in the recent years (IIWBR reports from 2006-2017). In this context, identification of new and diverse sources of resistance and their characterization against the prevalent virulences have become imperative and a pre – requisite for developing new resistant wheat cultivars. Pyramiding multiple diverse resistance genes into otherwise desirable genetic background is an effective strategy to increase the durability and stability resistance. However, detection and screening of several genes for resistance in the same population simultaneously is hardly possible in practice by the conventional methods. A number of powdery mildew resistance genes have been tagged by molecular markers, some of which remained valid after resistance was transferred to different genetic backgrounds and were successfully exploited in wheat breeding programmes. Among the various resistance sources tested for their effectiveness against *E. graminis tritici* by various workers in India, virulences matching genes *Pm 1, Pm 2, Pm 3b, Pm 4a, Pm 13* and *Pm 20* are rare and these can be exploited. Sivasamy *et a.l* (2009) reported the effectiveness of *Pm6* gene in tackling the PM disease which is tightly linked to stem rust gene *Sr36.*

Materials and methods

Keeping the above in mind a meticulously planned breeding programme was initiated at ICAR-IARI, Regional station Wellington in 2010 to pyramid the effective *Triticum thimopheevi*- derived *Pm6* gene linked to stem rust resistance gene *Sr36.* Thirty two popular Indian bread wheat cultivars viz.,. C 306, GW 273, HD 2009, HD 2189, HD 2285, HD 2329, HD 2402, HD 2687, HD 2733, HD 2877, HI 977, HI 1077, HP1205, HS 240, HUW 234, J 24, KALYANSONA, Lalbhahadur, LOK-1, MACS 2496, NI 5439, NIAW 34, PBN 51, PBW 226, PBW 343, PBW 502, RAJ 3077, UP 262, UP 2338, UP 2425, WH 147 and WH 542 were taken for pyramiding of this effective *Pm6/Sr36* gene with stable lines already introgressed with *Lr24/Sr24, Lr19/Sr25* and *Lr45* separately at ICAR-IARI, RS, Wellington. The genetic stock HW 4444 developed at Wellington carrying only *Sr36/Pm6* and Australian cultivar 'Cook' carrying *Lr19/Sr25* and *Sr36/Pm6* were used as donor parents and which were crossed to lines already carrying *Lr24/Sr24, Lr19/Sr25* and *Lr45. T*he stable lines pyramided with *Sr36/Pm6* were constituted at BC2F6 stage. The conventional methodology proved successful in phenotype-based selection of resistance gene combinations in the absence of molecular markers initially and the lines which were conferring resistance against leaf, stem and powdery mildew were selected under severe rust and powdery mildew incidence at Wellington and advanced to further filial stages.

Results and discussion

The resultant lines were constituted at BC2F6 stage based on the adult plant response to rust and powdery mildew diseases under natural high disease pressure. The lines carrying *Sr26/Pm6* and *Lr24/Sr24*, *Sr36/Pm6* and *Lr19/Sr25*, *Sr36/Pm6* and *Lr45* under the background of 32 popular bread wheat cultivars were constituted. The field response to rust and powdery mildew diseases were meticulously scored for more than three seasons under natural epiphytotic conditions as given in the **Table-1.**

Table-1: Recurrent parent, pedigree of constituted lines, christened name, adult plant response to diseases under natural epiphytotic conditions at Wellington

Sl. No.	Donors/ Backcrossed lines/ Recurrent parents /	Constituted lines	Resistance genes carried	Adult Plant response to diseases under natural epiphytotic conditions at Wellington			
				Stem Rust	Leaf Rust	Yellow Rust	Powdery mildew
1	**Cook*6/C 80-1**		***Sr25/Lr19, Sr36/Pm6***	**F**	**F**	**F**	**1**
2	C 306*2//Cook*6/C 80-1	HW 3601	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
3	C 306			90S	90S	F	3
4	GW 273* 2//Cook* 6/C 80-1	HW 3602	*Sr25/Lr19, Sr36/Pm6*	F	F		1
5	GW 273						
6	HD 2009*3//Cook*6/ C 80-1	HW 3603	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
7	HD 2009			40S	60S	100S	3
8	HD 2189*3//Cook*6/ C 80-1	HW 3604	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
9	HD 2189						
10	HD 2285*3//Cook*6/ C 80-1	HW 3605	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
11	HD 2285			30MS	100S	30S	3
12	HD 2329*3//Cook*6 /C 80-1	HW 3606	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
13	HD 2329			80S	90S	80S	3
14	HD 2402*3//Cook*6/ C 80-1	HW 3607	*Sr25/Lr19, Sr36/Pm6, Sr31/Lr26/ Yr9/ Pm8*	F	F	F	1
15	HD 2402			30S	100S	F	3
16	HD 2687*3//Cook*6 / C 80-1	HW 3608	*Sr25/Lr19, Sr36/Pm6, Sr31/Lr26/ Yr9/ Pm8*	F	F	F	1
17	HD 2687		*Sr31/Lr26/ Yr9/ Pm8*	10R MR	80S	F	3
18	HD 2733*3//Cook*6 / C 80-1	HW 3609	*Sr25/Lr19, Sr36/Pm6*	F	F		1
19	HD 2733						
20	HD 2877*3//Cook*6 / C 80-1	HW 3610	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
21	HD 2877				80S		
22	HI 977*3//Cook*6 / C 80-1	HW 3611	*Sr25/Lr19, Sr36/Pm6*	F	F		1
23	HI 977						
24	HI 1077*3//Cook*6 / C 80-1	HW 3612	*Sr25/Lr19, Sr36/Pm6*	F	F		1
25	HI 1077			30MS S	50S	40MS	3
26	HP 1205*3//Cook*6 / C 80-1	HW 3613	*Sr25/Lr19, Sr36/Pm6*	F	F		1
27	HP 1205						
28	HS 240*3//Cook*6 / C 80-1	HW 3614	*Sr25/Lr19, Sr36/Pm6, Sr31/Lr26/ Yr9/ Pm8*	F	F	F	1
29	HS 240		*Sr31/Lr26/ Yr9/ Pm8*	5R MR	70S	F	3
30	HUW 234*3//Cook* 6 /C 80-1	HW 3615	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
31	HUW 234			20MS S	100S	F	3
32	J 24*3//Cook*6/C 80-1	HW 3616	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
33	J 24			90S	100S	100S	3
34	Kalyansona*3//Cook*6/C 80-1	HW 3617	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
35	Kalyansona			80S	80S	90S	3
36	Lal Bahadur*3// Cook*6/C 80-1	HW 3618	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
37	Lal Bahadur				80S		3
38	Lok-1*3//Cook*6/C 80-1	HW 3619	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
39	Lok-1			70S	80S	80S	3
40	MACS 2496*3//Cook *6/C 80-1	HW 3620	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
41	MACS 2496				90S		3
42	NI 5439*3//Cook*6/ C 80-1	HW 3621	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
43	NI 5439			90S	90S	100S	3
44	NI 5439*3//Cook*6/ C 80-1	HW 3621A	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
45	NI 5439			90S	90S	100S	3
46	NIAW34*3//Cook*6/ C 80-1	HW 3622	*Sr25/Lr19, Sr36/Pm6*	F	F		1
47	NIAW 34						

48	PBN 51*3//Cook*6 /C 80-1	HW 3623	*Sr25/Lr19, Sr36/Pm6*				
49	PBN 51						
50	PBW 226*3//Cook*6 /C 80-1	HW 3624	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
51	PBW 226			20S	90S	F	3
52	PBW 343*3//Cook*6 /C 80-1	HW 3625	*Sr25/Lr19, Sr36/Pm6*	F	F		1
53	PBW 343				80S		3
54	PBW 502*3//Cook*6 /C 80-1	HW 3626	*Sr25/Lr19, Sr36/Pm6*	F	F		1
55	PBW 502						3
56	Raj 3077*3//Cook*6 /C 80-1	HW 3627	*Sr25/Lr19, Sr36/Pm6*	F	F		1
57	Raj 3077						3
58	Raj 3077*3//Cook*6 /C 80-1	HW 3627 A	*Sr25/Lr19, Sr36/Pm6*	F	F		1
59	Raj 3077						3
60	UP 262*3//Cook*6/C 80-1	HW 3628	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
61	UP 262			50S	50S	50S	3
62	UP 2338*3//Cook* 6/C 80-1	HW 3629	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
63	UP 2338			70S	80S	80S	3
64	UP 2425*3//Cook* 6/C 80-1	HW 3630	*Sr25/Lr19, Sr36/Pm6*	F	F		1
65	UP 2425						
66	WH 147*3//Cook*6 /C 80-1	HW 3631	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
67	WH 147			90S	90S	90S	3
68	WH 542*3//Cook*6 /C 80-1	HW 3632	*Sr25/Lr19, Sr36/Pm6, Sr31/Lr26/ Yr9/ Pm8*	F	F	F	1
69	WH 542		*Sr31/Lr26/ Yr9/ Pm8*	10R MR	80S	F	3
70	*Yr10**3//Cook*6 /C 80-1	HW 3633	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
71	*Yr10*			10R MR	80S	F	3
72	*Yr 15**3//Cook*6 /C 80-1	HW 3634	*Sr25/Lr19, Sr36/Pm6*	F	F	F	1
73	*Yr 15*				90S	F	3
74	**RL 6144// HW 4444**		***Sr36/ Pm6, Lr45***	**F**	**F**	**F**	**1**
75	C306*3// RL 6144// HW 4444	HW 3637	*Sr36/ Pm6, Lr45*	10R MR	F	F	3
76	C 306			90S	90S	F	3
77	GW 273*3// RL 6144 // HW 4444	HW 3638	*Sr36/ Pm6, Lr45*		F	F	
78	GW 273						
79	HD 2189*3// RL 6144 // HW 4444	HW 3639	*Sr36/ Pm6, Lr45*		F	F	
80	HD 2189						
81	HD 2285*3// RL 6144 // HW 4444	HW 3640	*Sr36/ Pm6, Lr45*	10R MR	F	F	3
82	HD 2285			30MS	100S	30S	3
83	HD 2329*3// RL 6144 // HW 4444	HW 3641	*Sr36/ Pm6, Lr45*	10R MR	F	F	3
84	HD 2329			80S	90S	90S	3
85	HD 2402 *3// RL 6144 // HW 4444	HW 3642	*Sr36/ Pm6, Lr45*	TR	F	F	3
86	HD 2402			30S	100S	F	3
87	HD 2687*3// RL 6144 // HW 4444	HW 3643	*Sr36/ Pm6, Lr45, Sr31/Lr26/ Yr9/ Pm8*	10R MR	F	F	3
88	HD 2687		*Sr31/Lr26/ Yr9/ Pm8*	15R MR	80S	F	3
89	HD 2733*3// RL 6144 // HW 4444	HW 3644	*Sr36/ Pm6, Lr45*		F	F	
90	HD 2733						
91	HD 2877*3// RL 6144 // HW 4444	HW 3645	*Sr36/ Pm6, Lr45*	5 MR	F	F	3
92	HD 2877			5MR	40SS	F	3
93	HI 977*3// RL 6144 // HW 4444	HW 3646	*Sr36/ Pm6, Lr45*	F	F	F	3

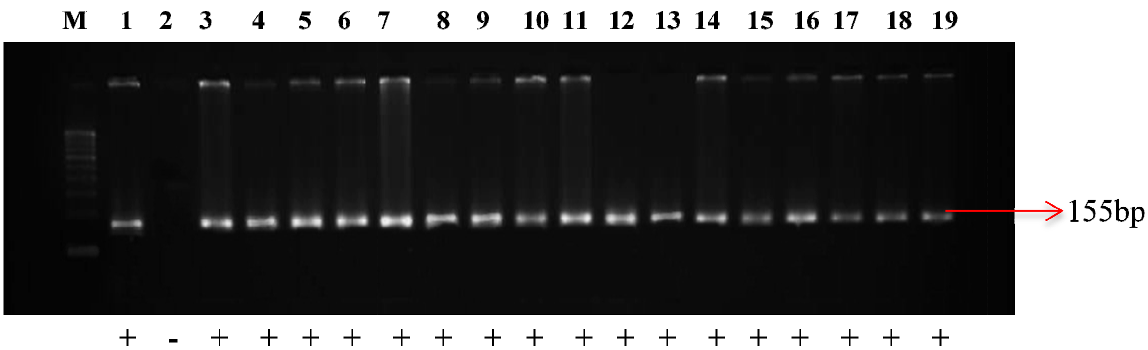
94	HI 977			F	60S	40S	2
95	HI 1077*3// RL 6144 // HW 4444	HW 3647	*Sr36/ Pm6, Lr45*	10R MR	F	F	3
96	HI 1077			30MS S	50S	40S	3
97	HP 1205*3// RL 6144 // HW 4444	HW 3648	*Sr36/ Pm6, Lr45*	15R MR	F	F	3
98	HP 1205			60 SS	80SS	90S	3
99	HS 240*3// RL 6144 // HW 4444	HW 3649	*Sr36/ Pm6, Lr45, Sr31/Lr26/ Yr9/ Pm8*	5R MR	F	F	3
100	HS 240		*Sr31/Lr26/ Yr9/ Pm8*	5R MR	70S	F	3
101	HUW 234*3// RL 6144// HW 4444	HW 3650	*Sr36/ Pm6, Lr45*		F	F	
102	HUW 234						
103	J 24*3// RL 6144 // HW 4444	HW 3651	*Sr36/ Pm6, Lr45*	10R MR	F	F	3
104	J24			90S	100S	100S	3
105	Kalyasona*3// RL 6144 // HW 4444	HW 3652	*Sr36/ Pm6, Lr45*	15R MR	F	F	3
106	Kalyansona			80S	90S	90S	3
107	LalBahadur*3// RL 6144 // HW 4444	HW 3653	*Sr36/ Pm6, Lr45*		F	F	
108	LalBahadur						
109	Lok 1*3// RL 6144 // HW 4444	HW 3654	*Sr36/ Pm6, Lr45*	10R MR	F	F	3
110	Lok-1			70S	80S	80S	3
111	MACS 2496*3// RL 6144 // HW 4444	HW 3655	*Sr36/ Pm6, Lr45*	10R MR	F	F	3
112	MACS 2496						
113	NI 5439*3// RL 6144 // HW 4444	HW 3656	*Sr36/ Pm6, Lr45*	15R MR	F	F	3
114	NI 5439			90S	90S	100S	3
115	NIAW 34*3// RL 6144 // HW 4444	HW 3657	*Sr36/ Pm6, Lr45*	10R MR	F	F	3
116	NIAW 34			90S	90S	90S	3
117	PBN 51*3// RL 6144 // HW 4444	HW 3658	*Sr36/ Pm6, Lr45*	10R MR	F	F	2
118	PBN 51			20MR	40S	S	2
119	PBW 226*3// RL 6144 // HW 4444	HW 3659	*Sr36/ Pm6, Lr45*	10R MR	F	F	3
120	PBW 226			20S	90S	F	3
121	PBW 343*3// RL 6144 // HW 4444	HW 3660	*Sr36/ Pm6, Lr45*	10R MR	F	F	3
122	PBW 343			20MR	60S	5S	3
123	PBW 502*3// RL 6144 // HW 4444	HW 3661	*Sr36/ Pm6, Lr45*	10R MR	F	F	3
124	PBW 502						
125	Raj 3077*3// RL 6144// HW 4444	HW 3662	*Sr36/ Pm6, Lr45*	5 MR	F	F	1
126	Raj 3077			5MR	60SS	60SS	1
127	Raj 3077*3// RL 6144// HW 4444	HW 3662 A	*Sr36/ Pm6, Lr45*	5 MR	F	F	1
128	Raj 3077			5MR	60SS	60SS	1
129	UP 2338*3// RL 6144 // HW 4444	HW 3663	*Sr36/ Pm6, Lr45*		F	F	
130	UP2338						
131	UP 2425*3// RL 6144 // HW 4444	HW 3664	*Sr36/ Pm6, Lr45*		F	F	
132	UP 2425						
133	WH 147*3// RL 6144 // HW	HW 3665	*Sr36/ Pm6, Lr45*	10R MR	F	F	3

	4444						
134	WH 147			90S	90S	90S	3
135	WH 542*3// RL 6144 // HW 4444	HW 3666	*Sr36/ Pm6, Lr45, Sr31/Lr26/ Yr9/ Pm8*	10R MR	F	F	3
136	WH 542		*Sr31/Lr26/ Yr9/ Pm8*	10R MR	80S	F	3
137	**TR380-14*7/3Ag# 14// HW 4444**		***Lr24/Sr24, Sr36/Pm6***	**F**	**F**	**F**	**1**
138	C306*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3668	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
139	C 306			90S	90S	F	3
140	GW 273*3**//**TR380-14*7/3Ag# 14// HW 4444	HW 3669	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
141	GW 273						
142	HD 2009*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3670	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
143	HD 2009						
144	HD 2189*3**//**TR380-14*7/3Ag# 14// HW 4444	HW 3671	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
145	HD 2189						
146	HD 2285*3**//**TR380-14*7/3Ag# 14// HW 4444	HW 3672	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
147	HD 2285			30MS	100S	30S	3
148	HD 2329*3// RL 6144 // HW 4444	HW 3673	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
149	HD 2329			80S	90S	90S	3
150	HD 2402 *3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3674	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
151	HD 2402			30S	100S	F	3
152	HD 2687*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3675	*Lr24/Sr24, Sr36/Pm6, Sr31/Lr26/ Yr9/ Pm8*	F	F	F	1
153	HD 2687		*Sr31/Lr26/ Yr9/ Pm8*	15R MR	80S	F	3
154	HD 2733*3**//**TR380-14*7/3Ag# 14// HW 4444	HW 3676	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
155	HD 2733						
156	HD 2877*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3677	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
157	HD 2877			5MR	40SS	F	3
158	HI 977*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3678	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
159	HI 977			F	60S	40S	2
160	HI 1077*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3679	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
161	HI 1077			30MS S	50S	40S	3
162	HP 1205*3**//**TR380-14*7/3Ag# 14// HW 4444	HW 3680	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
163	HP 1205			60 SS	80SS	90S	3
164	HS 240*3**//**TR380-14*7/3Ag# 14// HW 4444	HW 3681	*Lr24/Sr24, Sr36/Pm6, Sr31/Lr26/ Yr9/ Pm8*	F	F	F	1
165	HS 240		*Sr31/Lr26/ Yr9/ Pm8*	5R MR	70S	F	3
166	HUW 234*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3682	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
167	HUW 234						
168	J 24*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3683	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
169	J24			90S	100S	100S	3

170	Kalyasona*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3684	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
171	Kalyansona			80S	90S	90S	3
172	Kalyasona*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3685	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
173	Kalyansona			80S	90S	90S	3
174	LalBahadur*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3686	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
175	LalBahadur						
176	Lok 1*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3687	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
177	Lok-1			70S	80S	80S	3
178	MACS 2496*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3688	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
179	MACS 2496						
180	NI 5439*3**//**TR380-14*7/3Ag# 14// HW 4444	HW 3689	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
181	NI 5439			90S	90S	100S	3
182	NIAW 34*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3690	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
183	NIAW 34			90S	90S	90S	3
184	PBN 51*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3691	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
185	PBN 51			20MR	40S	S	2
186	PBW 226*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3692	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
187	PBW 226			20S	90S	F	3
188	PBW 343*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3693	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
189	PBW 343			20MR	60S	5S	3
190	PBW 502*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3694	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
191	PBW 502						
192	Raj 3077*3**//**TR380-14*7/3Ag# 14// HW 4444	HW 3695	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
193	Raj 3077			5MR	60SS	60SS	1
194	Raj 3077*3**//**TR380-14*7/3Ag# 14// HW 4444	HW 3695 A	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
195	Raj 3077			5MR	60SS	60SS	1
196	UP 262*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3696	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
197	UP262						
198	UP 2338*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3697	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
199	UP2338						
200	UP 2425*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3698	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
201	UP 2425						
202	WH 147*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3699	*Lr24/Sr24, Sr36/Pm6*	F	F	F	1
203	WH 147			90S	90S	90S	3
204	WH 542*3 **//**TR380-14*7/3Ag# 14// HW 4444	HW 3700	*Lr24/Sr24, Sr36/Pm6, Sr31/Lr26/ Yr9/ Pm8*	F	F	F	1
205	WH 542		*Sr31/Lr26/ Yr9/ Pm8*	10R MR	80S	F	3

The constituted lines carrying *Sr36/Pm6* were showing resistant reaction to powdery mildew under 'hot spot' evaluation were subsequently confirmed for the presence of *Sr36/Pm6* molecularly . These are expected to serve as genetic resources for further wheat improvement in the country or if it is properly evaluated for yield under co-ordinated wheat improvement programmme it can be released as cultivars. From these seven wheat stocks has been registered as genetic stock with NBPGR, New Delhi.

Confirmation of *Sr36* gene using STM marker STM773-2



M- Marker (100bp); Lane 1- Cook (*Sr36*) (positive control); Lane 2- HSB 6 (Recurrent parent); Lanes 3-19 HSB 6 x *Sr24,Sr36* (BC_1F_3 pyramided lines)

Stem, leaf, stripe rusts and Powdery mildew Resistant wheat stocks

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Development of innovative methods for urediospore conidiogenesis from aecia of *Puccina* spp from Barberry habituated in Nilgiri Hills

P. Nallathambi[1], C. Uma Maheswari[1], C. Manjunatha[1], J. Berliner[1], M. Sivasamy1, Jagdish Kumar[2] and Rajesh Kumar Meena[1]

[1]ICAR-Indian Agricultural Research Institute, Regional Station, Wellington- 643 231
[2]ICAR-National Research Institute for Biotic Stress Management , Raipur, Chatishgarh

The establishment of infection for pathogenesis investigation is important event to ascertain disease cycle in crop plants. The synthetic or semi-synthetic media are not suitable to culture biotrophic fungal pathogens like *Puccinia* species but utility of host plants either as whole or its callus culture may be suitable to grow certain stages of *Puccinia* spp. In our routine varietal evaluation procedures, urediospores are recurrently deposited on moist leaves of desired genotypes. These dikaryotic spores are artificially placed over tender leaves with help of sterile inoculation tools like lancet needle under controlled conditions like glass houses, growth chambers and poly houses etc. However, to investigate complete life cycle of target pathogens by using the sexual or dikaryotic spores from their respective stages viz., pycnia, aecia and basidiospores from telia, lancet needle inoculation may not be suitable in certain circumstances, owing to sensitiveness and fragile to handle such spores for cross inoculations. Although, cross inoculation of aeciospores from aecia is found to be convenient host injuries and cross contamination of the inoculums are not ruled out. Therefore, alternate strategies were worked out and simple methods of inoculation were devised with available facilities under ambient conditions. Seeds of susceptible varieties (WH147 and Agra local) were sown in paper cups as well as differential set plastic boxes. Plastic boxes were shifted to Barberry bushes wherein recurrent isolates have been made and placed in such a way that test plants seedlings receive natural weather conditions as similar to Barberry plants without performing any artificial inoculations. Seedling plants were also kept in wire baskets (17x15 cm^2). Plants were placed on plastic trays. Top of boxes were covered by plastic lids having square shape holes (1cm^2) and the aecia along with Barberry leaves were placed down side. Likewise, entire top of baskets was covered by layering Barberry leaves and covered by moist cloths in layers with direct likely contact on leaves (Plate 1-4). Blotter papers were used for final covering. Sterile water was sprinkled to maintain adequate moisture in these mini chambers and incubated under aseptic conditions for 3 days with intermittent blow of sterile air from laminar flow chamber. Seedlings were observed at 24h intervals for deposition of aeciospores and marked. Seedlings were shifted to glass house after 24h of hardening and discarding barberry leaves. Critical observations were carried out constantly on all seedlings.

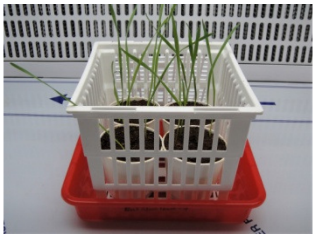

Plate 1. Preparation of seedlings

Plate 2. Arrangement of Barberry with Aecia

Plate 3. Seedling leaves to receive aeciospores

Plate 4. Incubation with moist cloth

Plate 5 Aeciospores dropped on leaves

Plate 6. Brown rust incidence

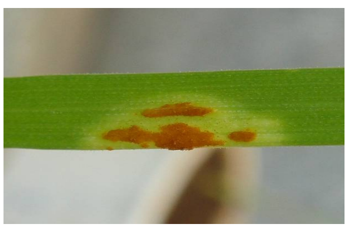

Plate 7. Black rust incidence

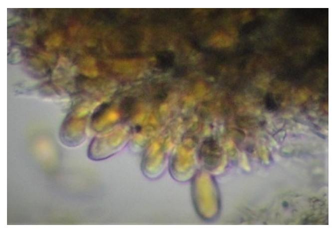

Plate 8. Urediospores of black rust

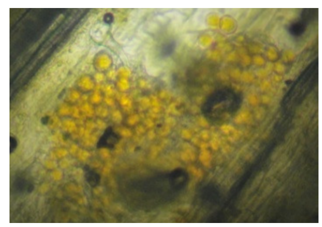

Plate 9. Urediospores of brown rust

Overall data revealed the flow of aeciospores from aecial cups and deposition over tender leaves of wheat and subsequent infections on later case (Plates 5 and 6). However, infection rate was very less and slow as compared to artificial inoculations in both sets of experiment. Black and brown rusts infections were observed and their respective pathogens were also confirmed under light microscope (Plates 6-9). Further works are in progress to adopt these innovative methods to trap natural inoculums and purification of other obligate fungal pathogens of wheat. Works are also in progress to investigate their phenotypic and molecular characterization of both rusts pathogens and their associated relationships on pathogenesis on wheat and allied crops and economic significances.

Awards:

Dr.M.Sivasamy, PS and Head and **Dr.P.Jayaprakash** Principal Scientist, IARI, Regional Station Wellington has been awarded, **the fellow** of Indian Society of Plant Breeding and Genetics 2017