



Evaluation of wheat genotypes for adult plant resistance against powdery mildew caused by *Blumeria graminis tritici*

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Abstract

Powdery mildew, caused by *Blumeria graminis* f.sp. *tritici* (Bgt) has emerged as a devastating diseases of wheat (*Triticum aestivum* L.) worldwide. The disease is widely prevalent and causes severe losses in the north and southern hills and north western plain zone of India. It can be effectively managed by cultivation of resistant varieties, however majority of the varieties grown in epidemiologically important areas are susceptible. A successful breeding programme requires stable resistant donors and in this context, thirty-six diverse promising wheat germplasm lines were evaluated at multi hotspot locations i.e. Rice and Wheat Research Centre, Malan and IIWBR, summer nursery at Dalang Maidan (Lahaul & Spiti) under natural epiphytotic and controlled (net house) conditions for three consecutive years. Four lines (ONS 29, ONS 27, Pollemer and PMC 1) were free from the disease whereas, three lines (EIGN 33, TL 2995 and TL 2999) were resistant (score 1-3) at both the locations. These stable and durable resistant donors may be used in the breeding programme to diversify the powdery mildew resistance base of future wheat varieties.

Key words: Wheat, Powdery mildew, resistance, *Blumeria graminis* f.sp. *tritici*, adult plant resistance.

Powdery mildew caused by *Blumeria graminis* (DC). E.U. Speer f.sp. *tritici* Em. Marchal (Bgt) has emerged as one of the most devastating diseases of wheat (*T. aestivum* L.) worldwide (Cheng *et al.* 2020). It ranked sixth (among top 10) fungal pathogens of wheat (Dean *et al.* 2012), and caused eighth highest yield loss by pests and pathogens worldwide (Savary *et al.* 2019). This disease may lead to severe yield losses in areas with cool and humid climate especially, Northern Hills Zone (NHZ) and North-Western Plains Zone (NWPZ) of India (Gupta *et al.* 2014; Rana *et al.* 2006; Basandrai and Basandrai, 2017). Use of wheat varieties with better yield potential and resistance to diseases like powdery mildew is of prime importance for increasing wheat production. Thus, development of high yielding and disease resistant varieties has always been a major objective of wheat breeding programmes throughout the world. However, due to ever evolving nature of the pathogen leading to new

and matching virulences, sudden breakdown in resistance is the major constraint. It compels to continuously identify new sources of resistance among diverse unexplored wheat or related species to broaden the genetic base of newly evolved varieties. In the recent report of year 2019-20, Most of the commercially recommended varieties grown in the epidemiologically important NHZ and NWPZ are susceptible to powdery mildew (ICAR-IIWBR, 2020). Therefore, the present study was aimed to evaluate some promising bread wheat and triticales lines to identify new and diverse source of resistance.

Materials and Methods

Thirty-six bread wheat and triticales germplasm lines procured from CIMMYT (Mexico), NBPGR (New Delhi), IARI (Wellington, Tamil Nadu), IIWBR (Karnal) and some local land races along with susceptible check (*Agra Local*) were selected for the

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studies. List of experimental lines along with their pedigree and source is given in the table 1.

The test genotypes were grown in paired rows with spacing of 20 cm at experimental area of Rice and Wheat Research Centre, Malan located at 950 m a.m.s.l, 32° 1' N latitude and 76° 2' E longitude. In addition to it these were grown under controlled (nethouse) conditions during *rabi* 2016-17 to 2018-19, and at Dalang Maidan (3045 m a.m.s.l, 32° 30' N latitude, 76° 59' E longitude) during summer season 2016-17 to 2018-19. Both the locations are hotspots for powdery mildew infestation. The recommended package and practices were followed as prescribed by CSKHPKV to achieve a healthy crop stand. However, to avoid escape and to ensure uniform dissemination of disease, infector rows comprising mixture of powdery mildew susceptible lines were planted on the borders surrounding the experimental plots and after every five test lines. The data were recorded on terminal powdery mildew reaction according to 0-9 scale as described by Saari and Prescott (1975).

In addition to it, reaction of powdery mildew were also recorded using 0-9 scale (Saari and Prescott, 1975) at the regular interval of 15 days interval with the initiation of the infection i.e. at tillering stage (Z20) to completion of anthesis (Z69) (Zadok's growth scale (00-99) during the *rabi* 2018-19 at RWRC, Malan. This was used to calculate the area under the disease progress curve (AUDPC) as per Campbell and Madden (1990):

$$AUDPC = \sum_{i=1}^n (y_i + y_{i+1}/2) (t_{i+1} - t_i),$$

which n = total number of observations,

y_i = injury intensity (usually incidence in crop health data) at the i^{th} observation, and t = time at the i^{th} observation.

Relative area under disease progress curve (rAUDPC) was calculated as:

$$rAUDPC = (AUDPC / \text{Max. value of AUDPC}) * 100$$

Table 1. Pedigree and source of the wheat genotypes used

Sr. No.	Experimental lines	Pedigree	Source
1	IC 296681	Local germplasm	NBPGR, New Delhi
2	IC 443618	WL 711/C 306	NBPGR, New Delhi
3	EIGN 33	METSO/ER2000/3/EMB16/CBRD//CBRD	NBPGR, New Delhi
4	HSB 6	ODIEL	Australia
5	HS 562	OASIS/SKAUZ//4*BCN/3/2* PASTOR	IARI, RS, Shimla
6	HD 3086	DBW14/HD2733//HUW468	IARI, New Delhi
7	HD 2687	CPAN 2009// HD 2329	IARI, Wellington, Tamil Nadu
8	HPW 155	BT 2549/FATH	RWRC, Malan
9	HPW 349	OASIS/SKUAZ114*BCN/3/PASTOR/4/KAUZ*2/YACO//KAUZ	RWRC, Malan
10	HPW 368	NAC/TH.AC//3*PVN/3/MIRLO/BUC/4/2*PASTOR	RWRC, Malan
11	HW 2436-1	HD 2833//HW 4444	IARI, Wellington, Tamil Nadu
12	HW 2436-2	HW 5207//HW 4444	IARI, Wellington, Tamil Nadu
13	HW 3643	HW 3608//HW 4444	IARI, Wellington, Tamil Nadu
14	HW 5207	HW 3029/Yr15 (V763-2312*T.dicoccoides)	IARI, Wellington, Tamil Nadu
15	HW 5216	HW 3094//HW 4028	IARI, Wellington, Tamil Nadu
16	LWH	Local Wheat Hongo	IWBR, RS, Shimla
17	ONS 27	LUTESCENS 70//SUNCO/2*PASTOR	NBPGR, New Delhi
18	ONS 29	LUTESCENS 70//SUNCO/2*PASTOR	NBPGR, New Delhi
19	PMC 1	-	CIMMYT, WIP
20	PBW343	ND/VG1944//KAL//BB/3/YACO'S'/4/VEE#5'S'	PAU, Ludhiana
21	RKVY 33	D67.2/P66.270//AE.SQUARROSA(320)/3/CUNNINGHAM/4/CROC_1/AE.SQUARROSA(205)//KAUZ/3/SASIA	CIMMYT, WIP
22	RKVY 37	PASTOR/3/URES/JUN//KAUZ/4/WBLL1	CIMMYT, WIP

23	RKVY 46	BOW/VEE/5/ND/VG9144//KAL/BB/3/YACO/4/CHIL/6/ CASKOR/3/CROC_1/AE.SQUARROSA(224)//OPAT/7/ PASTOR// /KAUZ/3/BAV92	CIMMYT, WIP
24	RKVY 47	ATTILA//DGO/SERI/3/PASTOR	CIMMYT, WIP
25	RKVY 74	BAV92//IRENA/KAUZ/3/HUITES*2/4/CROC_ 1/AE.SQUARROSA (224)//KULIN/3/WESTONIA	CIMMYT, WIP
26	RKVY 133	KFA/5/2*KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUITES	CIMMYT, WIP
27	RKVY 134	CAL/NH//H567.71/3/SERI/4/CAL/NH//H567.71/5/2*KAUZ/6/ PASTOR/7/KRONSTAD F2004	CIMMYT, WIP
28	WH 1105	MILAN/S87230//BABAX	CCSHAU, Hisar
29	Pollmer	-	CIMMYT, WIP
30	VL 1003	HD 2747/ZANDER 13	ICAR-VPKAS, Almora
31	TL 2995	TL 2608/JNIT 141//JNIT 128	ICAR-IIWBR, Karnal
32	TL 2999	T 2749/TL 2762	ICAR-IIWBR, Karnal
33	TL 3000	T 2969/T 2987	ICAR-IIWBR, Karnal
34	DesiMundla	Local collection/ landrace	RWRC, Malan
35	Agra Local	A local selection from Uttar Pradesh	Uttar Pradesh
36	Kanku	Local collection/ landrace	RWRC, Malan

Results and Discussion

The data on terminal disease reaction on 36 test genotypes are given in Table 2. Out of 36 lines, four lines i.e. ONS 29, ONS 27, Pollmer and PMC 1 were

free from the disease 'DR=0' and three lines i.e. EIGN 33 (*T. aestivum*), TL 2995 and TL 2999 (triticale) were found resistant (DR= 1-3) to powdery mildew at both the locations.

Table 2. Disease reaction of wheat and triticale genotypes against powdery mildew at different locations

Sr. No.	Genotype	Disease reaction (0-9) at Malan		Powdery mildew response	Disease reaction (0-9) at Dalang Maidan	Powdery mildew response
		Field	Net house			
1	IC 296681	5	7	Susceptible	8	Susceptible
2	IC 443618	5	7	Susceptible	8	Susceptible
3	EIGN 33	2	2	Resistant	2	Resistant
4	HSB 6	4	7	Susceptible	7	Susceptible
5	HS 562	5	7	Susceptible	8	Susceptible
6	HD 3086	5	7	Susceptible	9	Highly Susceptible
7	HD 2687	7	7	Susceptible	9	Highly Susceptible
8	HPW 155	7	8	Susceptible	8	Susceptible
9	HPW 349	5	7	Susceptible	9	Highly Susceptible
10	HPW 368	7	7	Susceptible	9	Highly Susceptible
11	HW 2436-1	3	3	Resistant	5	Moderately Susceptible
12	HW 2436-2	3	3	Resistant	5	Moderately Susceptible
13	HW 3643	3	5	Moderately Resistant	7	Susceptible
14	HW 5207	5	7	Susceptible	9	Highly Susceptible
15	HW 5216	5	7	Moderately Susceptible	9	Highly Susceptible
16	LWH	5	7	Susceptible	9	Highly Susceptible
17	ONS 27	0	0	Highly Resistant	0	Highly Resistant
18	ONS 29	0	0	Highly Resistant	0	Highly Resistant

19	PMC 1	0	0	Highly Resistant	0	Highly Resistant
20	PBW 343	7	9	Susceptible	9	Highly Susceptible
21	RKVY 33	5	7	Susceptible	8	Susceptible
22	RKVY 37	4	6	Moderately Susceptible	7	Susceptible
23	RKVY 46	6	8	Susceptible	9	Highly Susceptible
24	RKVY 47	4	5	Moderately Susceptible	7	Susceptible
25	RKVY 74	4	6	Moderately Susceptible	7	Susceptible
26	RKVY 133	5	7	Moderately Susceptible	9	Highly Susceptible
27	RKVY 134	5	8	Susceptible	9	Highly Susceptible
28	WH 1105	7	9	Susceptible	9	Highly Susceptible
29	Pollmer	0	0	Highly Resistant	0	Highly Resistant
30	VL 1003	5	5	Moderately Susceptible	7	Susceptible
31	TL 2995	1	2	Resistant	2	Resistant
32	TL 2999	2	3	Resistant	3	Resistant
33	TL 3000	5	5	Moderately Susceptible	7	Susceptible
34	Desi Mundla	8	8	Susceptible	8	Susceptible
35	Agra Local	9	9	Highly Susceptible	9	Highly Susceptible
36	Kanku	9	9	Highly Susceptible	9	Highly Susceptible

Based on the powdery mildew reaction at both the locations two local landraces, *Agra Local* and *Kanku* were highly susceptible and rest of the 25 lines were susceptible. As has been observed in the present studies, based on evaluation of 370 Indian bread wheat varieties at four locations (*viz.*, Karnal, Ludhiana, Dhaulakuan and Yamunanagar), Gupta *et al.* (2016) reported that genotypes Amrut, DDK 1025, DWR 1006, DWR 195, GW 1139, HD 4672, HD 4530, HD 2278, HD 1981, DDK 1001, HI 8627, Jay, TL 2942, DT 46, K 8020, DDK 1029, K 9107, K 816, Lok 1, MACS 6145, DDK 1009, NP 111 and NP 200 were free from disease. Similarly, powdery mildew resistance sources have also been reported in various countries by different workers (Singh *et al.* 2005, 2016; Asad *et al.* 2014; Basandrai and Basandrai, 2017; Cheng *et al.* 2020; Sood *et al.* 2020). Recently, Vikas *et al.* (2020) evaluated 19,460 wheat germplasm accessions, conserved in the National Genebank of ICAR–National Bureau of Plant Genetic Resources, at Wellington, a hotspot location for the disease, for two

consecutive seasons and indicated that 7271 (45 per cent) bread wheat, 756 (22 per cent) durum wheat, and 22 (14 per cent) of the emmer wheat genotypes were resistant. As has been observed in the present studies, susceptibility of HW 5207 to *Bgt* has also been reported by Sivasamy *et al.* (2016) under Southern Hill Zone conditions of the country. Further, they have also reported that lines HW 2436-1 and HW 3643, carrying genes *Pm6* and *Pm8*, were resistant but these genotypes were found to be susceptible at Dalang Maidan. Genotypes HW 2436-1 and HW2436-2, reported to be resistant under Southern Hill Zone conditions, were resistant at RWRC Malan also but both of these genotypes were moderately susceptible at Dalang Maidan. It is evident that at Dalang Maidan matching virulences were prevalent for the resistant genes in genotypes HW 2636-1 and HW 2426-2 however, these genes showed residual effect against some virulences as reported by Basandrai and Basandrai (2017) in many genotypes with known defeated genes.

Dynamics of disease development

Area under disease progress curve (AUDPC) and rAUDPC are the preferred indicators of disease expression. The AUDPC and rAUDPC in the test genotypes ranged between 90-307.5 and 29.3 to 100, respectively (Table 3, Fig 1). Genotypes were

categorized into four different categories on the basis of AUDPC value. Two genotypes i.e. EIGN 33 and TL 2995 had AUDPC value less than 100 and rAUDPC score of 29.3. Nine genotypes i.e. HW 2436-1, HW 2436-2, TL 2999, RKVY 47, HSB 6, HW 3643, VL 1003, TL 3000 and RKVY 74 had AUDPC and

Table 3. Disease reaction, AUDPC and rAUDPC of wheat lines to powdery mildew

Sr. No.	Genotype	Disease reaction at growth stage					AUDPC	rAUDPC
		Z20	Z30	Z41	Z51	Z69		
1	IC 296681	2	3	5	7	7	292.5	95.1
2	IC 443618	2	3	5	7	7	292.5	95.1
3	EIGN 33	0	1	2	2	2	90.0	29.3
4	HSB 6	0	1	3	5	7	187.5	61.0
5	HS 562	2	3	5	7	7	292.5	95.1
6	HD 3086	1	3	5	7	7	285	92.7
7	HD 2687	2	3	5	7	7	292.5	95.1
8	HPW 155	2	3	5	7	8	300.0	97.6
9	HPW 349	1	2	5	7	7	270	87.8
10	HPW 368	2	3	5	7	7	292.5	95.1
11	HW 2436-1	0	1	3	3	3	127.5	41.5
12	HW 2436-2	0	1	3	3	3	127.5	41.5
13	HW 3643	0	2	3	5	5	187.5	61.0
14	HW 5207	0	3	5	5	7	247.5	80.5
15	HW 5216	2	3	5	7	7	292.5	95.1
16	LWH	0	3	5	7	7	277.5	90.2
17	PBW 343	2	3	5	7	9	307.5	100
18	RKVY 33	0	3	5	5	7	247.5	80.5
19	RKVY 37	0	2	3	6	6	210	68.3
20	RKVY 46	1	3	5	7	8	292.5	95.1
21	RKVY 47	0	1	3	5	5	172.5	56.1
22	RKVY 74	0	2	3	5	6	195	63.4
23	RKVY 133	2	3	5	7	7	292.5	95.1
24	RKVY 134	2	3	5	7	8	300	97.6
25	WH 1105	2	3	5	7	9	307.5	100
26	VL 1003	0	2	3	5	5	187.5	61.0
27	TL 2995	0	1	2	2	2	90	29.3
28	TL 2999	0	2	3	3	3	142.5	46.3
29	TL 3000	0	2	3	5	5	187.5	61.0
30	Desi Mundla	1	3	5	7	8	292.5	95.1
31	Agra Local	2	3	5	7	9	307.5	100
32	Kanku	2	3	5	7	9	307.5	100

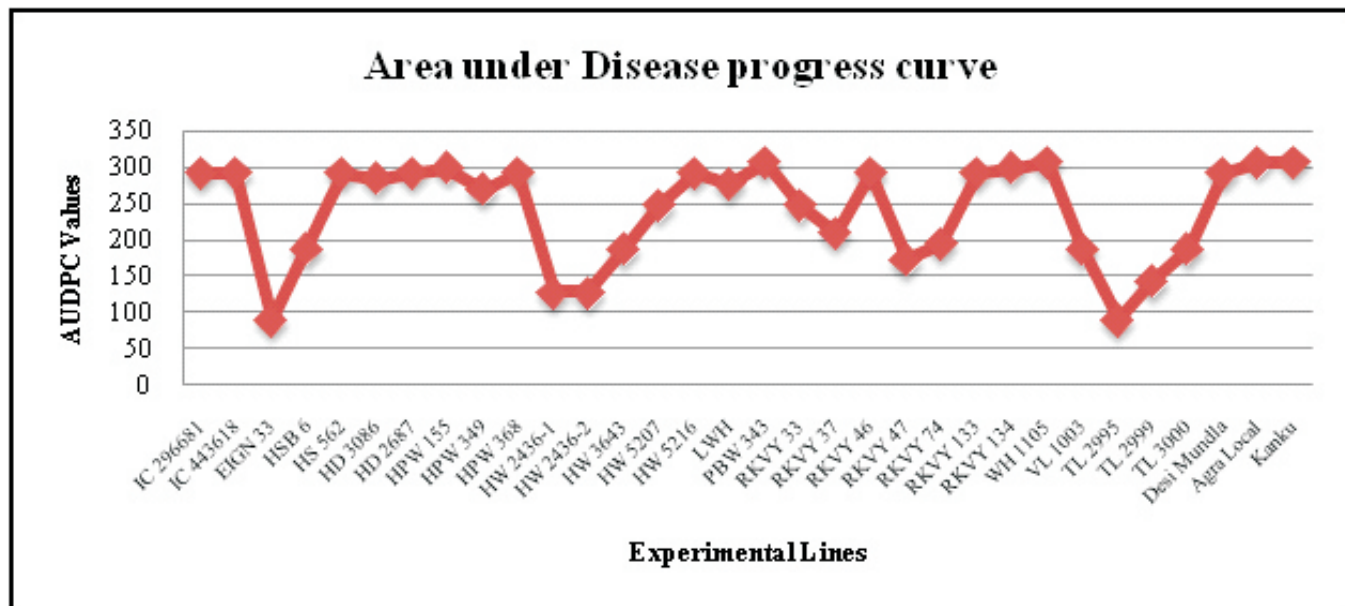


Figure 1. Area under Disease progress curve of wheat lines for powdery mildew

rAUDPC value ranging from 100 to 200 and 41.5 to 63.4, respectively. Seventeen genotypes showed AUDPC and rAUDPC values ranging between 200-300 and 68.3-97.6, respectively whereas four genotypes had shown AUDPC and rAUDPC value greater than 300 and 100, respectively which included the highly susceptible check, *Agra Local* having the highest AUDPC and rAUDPC values i.e 307.5 and 100, respectively. The results suggested that genotypes characterized by slow disease development (low AUDPC) e.g. EIGN 33, TL 2995, HW 2436-1, HW 2436-2 and TL 2999 may be considered as having partial or adult plant resistance for powdery mildew.

Contrary to the present findings, Kaur (2017) showed that genotypes HSB 6 and HD 3043 were the most resistant genotypes on the basis of lowest AUDPC, as HSB 6 showed susceptibility under controlled and hot spot conditions. On the other hand, higher susceptibility of *Kanku* and HS 562 recorded in the present study was also reported by Kaur (2017). As has been reported in the present studies, sources with

slow mildewing resistance have also been reported by Basandrai and Basandrai (2017); Shamanin *et al.* (2019) and Sood *et al.* (2020).

Resistance in lines ONS 29, ONS 27, Pollemer, PMC 1, EIGN 33, TL 2995 and TL 2999 has been reported for the first time which supported the novelty of the work. However, identification of more durable and stable sources of resistance among the wide germplasm of wheat along with allied species and genera cannot be refuted. These genotypes may be used as donors for powdery mildew resistance in wheat improvement programmes to develop agronomically desirable powdery mildew resistant varieties. The genotypes with low AUDPC may be directly deployed in disease prone areas after agronomic evaluations. However, the ever evolving nature of pathogen compels to hunt for new sources of resistance as a continuous process.

Conflict of interest: The authors declare that there is no conflict of interests in this research paper.

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