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Identification of Fusarium head blight resistant sources in wheat under artificially inoculated condition

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ABSTRACT

A set comprising 164 wheat genotypes were evaluated for Fusarium head blight (FHB) resistance under artificially inoculated conditions during 2019–20 at ICAR-IARI, New Delhi. Five spikes per plant of each genotype were inoculated with cotton web technique with *Fusarium graminearum* during mid anthesis stage. Scoring of disease data (percent spike and spikelet infection) was done after 7, 14 and 21 days of inoculation for calculating the Area Under Disease Progress Curve (AUPDC). No genotype was found immune, resistant and moderately resistant on the basis of per cent spike infection. On the basis of % spikelet infection recorded after 7 days of inoculation, 11 genotypes, viz. UP 3016, HI 1624, HS 668, DBW 290, HD 3331, K 1317, HD 3377, MACS 6747, HD 2864, NIDW 1149 (durum) and MACS 4087 (durum) were free from disease. On the basis of disease grade based on spikelet data recorded after 21 days of inoculation, only two genotypes, viz. HI 1636 and HD 3377 were having disease score up to 2 (moderately resistant). On the basis of categorization of varieties based on AUDPC values, only three wheat genotypes were grouped between 101-200 group (HD 3377, NIDW 1149 (durum) and HI 1612). In rest of the genotypes, AUDPC values were more than 200 while maximum AUDPC value of 900 was obtained in highly susceptible variety, Sonalika. Four genotypes, viz. HI 1612, MACS 6747, UP 3016 and MACS 4059 (durum) were having rAUDPC values less than 25 % of susceptible variety, Sonalika. Such genotypes showed slow progress of head blight.

Key words: FHB, Genotype, Resistance, Susceptible, Wheat

Wheat (*Triticum aestivum* L.) is an important cereal crop grown all over the world. India is the second largest producer of wheat in the world. Among wheat diseases to be affected by climate change in future in India is Fusarium head blight (FHB) or head scab caused by different *Fusarium* spp. It is one of th most destructive diseases of bead wheat and durum wheat (*Triticum durum* Desf.) worldwide. The disease epidemics have been reported with the adoption of conservation tillage and reduced-till systems in the Upper Midwest of the United States of America (Dill-Macky and Jones 2000). Presently, FHB is considered of minr importance in India but due to adoption of zero tillage on large scale by farmers in north western plains and north eastern plains zones along with the increase in precipitation during mid anthesis can result in severe occurence of disease.

During 1989-90 crop season, disease was observed in some farmers' field in severe form in variety HD 2329 in Amritsar and Gurdaspur districts of Punjab (Chahal *et al.* 1993). During March 2005, moderate to severe incidence of FHB was observed in the bread wheat cultivar PBW 343 and durum wheat cultivar PDW 274, respectively in the Gurdaspur district of Punjab (Bagga and Saharan 2005, Saharan *et al.* 2007). Among *Fusarium* species isolated from head scab infected samples, *F. graminearum* was in more proportion in diseased samples collected from Lahaul valley (Himachal Pradesh), Punjab as well as from Wellington, Nilgiris hills, Tamil Nadu (Saharan *et al.* 2007). Most wheat cultivars, currently grown in India are susceptible to FHB. Control of the disease has been difficult, beacause of the complex nature of the host/pathogen/environment interaction and availability of limited sources of resistance. Hence effort has been made in present study to find resistant sources to head scab in diverse set of genotypes.

MATERIALS AND METHODS

Evaluation of wheat genotypes for FHB resistance: One hundred sixty-four wheat genotypes including advance lines and released cultivars of *Triticum aestivum*, *T. durum* and *T. dicoccum* received from ICAR-IIWBR, Karnal were sown in polyhouse at Division of Plant Pathology, ICAR-IARI, New Delhi during 2019–20. *Fusarium graminearum* macroconidial suspension was prepared and inoculation was done at mid anthesis using cotton swab method (Singh

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Table 1 Disease response of wheat lines to Fusarium head blight under artificially inoculated conditions

Disease score	Host response	No. of lines (% spike infection recorded after 21 days)	No. of lines (% spikelet infection recorded after 21 days)	AUDPC values	No. of lines
1	Resistant	0	0	1-100	0
2	Moderately resistant	0	2	101-200	3
3	Moderately resistant	10	39	201-500	74
4	Susceptible	65	78	>500	87
5	Highly susceptible	89	45		

et al. 1995). Five spikes per plant were inoculated with macroconidial suspension (100000 spores/ml) during mid anthesis stage. Butter paper Glassine bags were rinsed with sterile water and placed over inoculated spikes for 5 days. Humidity (>90.00%) was maintained in the poly house by a mist rainfall for 2 min at 30-min intervals in the morning after each inoculation. A temperature of 25°C was maintained in the automated polyhouse for 30 days after inoculation. Due to differences in the maturity of varieties, inoculations were done at different times. Symptoms on spikes varied from light brown, water-soaked spots on the glumes to bleached spikelets. Scoring of disease data (percent spike and spikelet infection) was done after 7, 14 and 21 days after inoculation for calculating the Under Disease Progress Curve (AUDPC) following standard protocol (Shaner and Finney 1977, CIMMYT 1988). For categorizing the genotypes in resistance/susceptible groups, following rating classes on 0 to 5 scale were assigned: 0 = no symptoms visible, 1 = 10 % of all spikelets diseased, 2 = 11 to 25% of all spikelets diseased, 3 = 26 to 50% of all spikelets diseased, 4 = 51 to 75% of all spikelets diseased, 5 = >75 of all spikelets diseased (Ireta and Gilchrist 1994). For identifying the slow head blight accessions, AUDPC values of genotypes were categorized in different classes like AUDPC values 0, 1-100, 101-200, 201-500 and 501-1000. Relative AUDPC (rAUDPC) was calculated by dividing the AUDPC value of a genotype divided by highest values of AUDPC in susceptible genotype. Genotypes exhibiting rAUDPC values less than 20% of check, highly susceptible variety (Sonalika) were considered slow blighting lines.

Table 2 Evaluation of wheat genotypes against Fusarium head blight under artificially inoculated conditions

Genotype	Av. spike infection	Disease grade	Average % spikelet infection			Disease grade	AUDPC values	rAUDPC values (% of check var. Sonalika)
			1st Obs	2nd Obs	3rd Obs.			
GW 1346	66.67	4	06.25	20.00	41.67	3	307.72	34.19
HPW441	80.00	4	01.13	18.18	43.18	3	282.38	31.37
HS660	66.67	4	15.00	30.50	45.00	3	423.50	47.05
MACS4059(d)	83.33	5	02.50	15.00	30.00	3	218.75	24.30
UP3016	75.00	4	00.00	10.61	40.90	3	217.42	24.15
HI1625	86.67	5	02.77	19.44	61.11	4	359.72	39.96
HI1628	83.33	5	19.09	27.50	44.55	3	415.20	46.13
HI8800	80.00	5	02.38	11.90	66.67	4	325.00	36.11
UAS466	49.23	4	11.11	20.00	36.11	3	305.27	33.91
DBW187	83.33	5	17.00	30.00	45.00	3	427.00	47.44
HI1624	50.00	4	00.00	10.41	52.08	3	255.20	28.35
HS 507	60.00	3	16.66	32.50	32.50	3	399.58	44.39
HS 562	66.67	4	01.85	12.96	40.74	3	239.81	26.64
HS 668	50.00	3	00.00	20.00	40.00	3	280.00	31.11
VL 907	66.67	4	11.11	25.55	55.55	4	412.20	45.80
HS 680	75.00	4	15.00	30.00	52.50	4	446.25	49.58
VL 3023	83.33	5	11.81	31.81	51.81	4	445.42	49.49
VL 892	60.00	4	01.78	15.70	35.71	3	241.13	26.79
PBW 840	93.75	5	01.42	14.50	40.00	3	246.50	27.38
PBW 803	83.33	5	14.28	23.50	53.57	4	401.99	44.66
HD 3332	73.33	4	01.38	13.88	61.11	4	315.97	35.10

Cond.

Table 2 (*Concluded*)

Genotype	Av. spike infection	Disease grade	Average % spikelet infection			Disease grade	AUDPC values	rAUDPC values (% of check var. Sonalika)
			1st Obs	2nd Obs	3rd Obs.			
DBW 173	60.00	4	05.00	20.00	40.00	3	297.50	33.05
DBW 291	60.00	4	03.12	25.50	62.50	4	408.18	45.35
JKW 261	77.78	5	09.37	23.50	45.31	3	355.89	39.54
HD 3331	75.00	4	00.00	25.80	51.85	4	362.07	40.23
HD 3043	80.00	5	02.38	27.50	54.76	4	392.49	43.61
PBW 644	72.73	4	01.66	25.00	68.33	4	420.00	46.66
HI 1628	81.25	5	13.63	29.50	50.00	3	429.00	47.67
JAUW 672	70.00	4	03.57	15.50	35.71	3	245.98	27.33
DBW 187	92.31	5	08.88	30.50	51.11	4	423.49	47.05
DBW 39	83.33	5	05.55	20.50	50.00	3	337.94	37.54
HD 3171	70.00	4	02.22	23.50	53.33	4	358.93	39.88
HD 3293	66.67	4	03.63	26.70	46.36	3	361.88	40.20
K 1317	90.91	5	00.00	15.50	45.83	3	268.90	29.87
HI 1612	33.33	3	01.66	10.00	28.33	3	174.98	19.44
HI 1636	50.00	3	05.55	22.22	72.22	2	427.77	47.53
MP 1361	60.00	4	03.70	15.00	35.18	3	241.09	26.78
MACS 6747	60.00	4	00.00	10.00	38.09	3	203.31	22.59
HD 3377	60.00	4	00.00	08.50	21.42	2	134.47	14.94
HI 1637	83.33	5	05.55	25.50	52.78	4	382.67	42.51
RAJ 4541	85.71	5	03.57	22.50	42.85	3	319.97	35.55
HI 1634	50.00	3	05.55	20.70	42.22	3	312.11	34.67
HD 2932	62.50	4	08.33	32.50	47.92	3	424.38	47.15
MP 3336	62.50	4	03.12	15.50	43.75	3	272.56	30.28
HD 2864	90.91	5	00.00	20.00	67.85	4	377.47	41.94
DDW 47 (d)	75.00	4	13.75	30.50	53.75	4	449.75	49.97
MACS3949 (d)	87.50	5	08.75	20.00	66.25	4	402.50	44.72
UAS 428 (d)	66.67	4	16.25	30.50	51.25	4	449.75	49.97
DDW 49 (d)	60.00	4	01.85	15.00	33.33	3	228.13	25.34
GW 322 (d)	50.00	3	15.00	30.50	46.25	3	427.87	47.54
HI 1646	75.00	4	10.71	25.00	42.86	3	362.51	40.27
RAJ 4083	60.00	4	05.55	20.00	41.67	3	305.28	33.92
UAS 3008	40.00	3	09.37	20.00	50.00	3	347.81	38.68
HI 1633	75.00	4	08.18	21.59	70.90	4	427.95	47.55
NIDW 1149 (d)	83.33	5	00.00	10.00	33.33	3	186.65	20.73
HI 1605	75.00	4	05.00	25.00	58.33	4	396.65	44.07
MACS 4087 (d)	71.43	4	00.00	24.50	64.28	4	396.48	44.05
MACS 6222	92.31	5	08.33	25.00	60.00	4	414.16	46.01
DBW 187	40.00	3	12.50	30.00	50.00	3	428.75	47.63
DBW 329	40.00	3	03.12	15.00	34.37	3	236.23	26.24
WH 1270	50.00	3	02.08	33.33	33.33	3	357.28	39.69
DBW 333	83.33	5	12.50	25.50	51.78	4	403.48	44.83
DBW 331	83.33	5	10.00	20.00	50.00	3	350.00	38.88
Sonalika	85.00	5	23.00	72.00	90.25	5	900.37	

d: durum

RESULTS AND DISCUSSION

Evaluation of wheat genotypes under artificially inoculated conditions: One hundred sixty-four wheat genotypes including advance lines and released cultivars were evaluated for resistance against FHB. This set of genotypes included bread wheat (139 lines), as well durum (19 lines) and dicoccum (6 lines). Inoculation was done (100000 macroconidia/ml) at mid anthesis using cotton swab method and proper microclimatic conditions were created artificially. Disease data (percent spike and spikelet infection) recorded after 7, 14 and 21 days after inoculation was subjected to calculate the area under disease progress curve. Out of 164 genotypes evaluated for FHB resistance, no lines were found immune, resistant and moderately resistant on the basis of per cent spike infection (Table 1).

On the basis of % spike infection recorded after 21 days of inoculation, only 10 wheat genotypes, viz. HS 507, HS 668, HI 1612, HI 1636, HI 1634, UAS 3008, DBW 187, DBW 329, WH 1270 and GW 322 (Durum) were found moderately susceptible (disease grade up to 3). Rest of genotypes was categorized either as susceptible or highly susceptible. Data on the percent spikelet infection showed a different range of infection rate compared to percent spike infection indicating that even after initial infection some varieties offered resistance to spread of pathogen within spike (Table 2). On the basis of % spikelet infection recorded after 7 days of inoculation, 11 genotypes, viz. UP 3016, HI 1624, HS 668, DBW 290, HD 3331, K 1317, HD 3377, MACS 6747, HD 2864, NIDW 1149 (durum) and MACS 4087 (durum) were free from disease. After 14 days of inoculation, disease was observed in all genotypes.

On the basis of disease grade based on spikelet data recorded after 21 days of inoculation, only two genotypes, viz. HI 1636 and HD 3377 were having disease score up to 2 (moderately resistant). Thirty six genotypes, GW 1346, HPW 441, HS 660, WH 1270, UP 3016, HI 1628, UAS 466, DBW 187, DBW 331, HI 1624, HS 507, HS 562, HS 668, VL 892, PBW 840, DBW 173, JKW 261, JAUW 672, DBW 39, NIAW 3170, DBW 329, HD 3293, K 1317, HI 1612, MP 1361, MP 3336, RAJ 4541, HI 1634, HD 2932, HI 1646, RAJ 4083, UAS 3008, MACS 4059 (durum), DDW 49 (durum), GW 322 (durum) and NIDW 1149 (durum) showed disease score of 3 (moderately susceptible) based on spikelet data recorded after 21 days of inoculation (Table 2). AUDPC values were also calculated by recording three observations at an equal interval of 7 days on spikelet infection in all varieties. Out of 164 genotypes, 64 genotypes showed rAUDPC values less than 50% (Table 2). On the basis of categorization of varieties based on AUDPC values, only three wheat genotypes were grouped between 101-200 group (HD 3377, NIDW 1149 (durum) and HI 1612). In other genotypes, AUDPC values were more than 200 while maximum AUDPC value of 900 was obtained in highly susceptible variety, Sonalika (Table 2). Relative AUDPC values presented in Table 2 revealed that only four genotypes, viz. HI 1612, MACS 6747, UP 3016 and MACS 4059 (durum) were having less than 25% of rAUDPC of susceptible variety, Sonalika. Such genotypes showed slow progress of head blight disease. Overall, there were very limited sources of resistance in wheat genotypes evaluated in present study.

Control of the FHB disease has been difficult, because of the complex nature of the host/pathogen/environment interaction and limited sources of resistance. Present study revealed that most of genotypes screened were either grouped as susceptible or highly susceptible indicating lack of resistance sources in Indian wheat cultivars to FHB. In earlier studies, many moderately resistant lines of Indian wheat cultivars have been identified by evaluating nearly 4000 genotypes like AKDW 2997-16, DBW 62, PBW 396, PDW 311, UAS 415, UP 2747, UP 2798, VL 926, VL 829 and WH 1021 etc. (Saharan *et al*. 2020). Sumai 3 and Chinese cultivar are the widely known and best researched resistant genotypes. In addition to the Sumai 3 and its derivatives from China, other two FHB resistant sources from Brazil and Eastern European cultivars such as Arina and Frontana were also reported (Miedaner 1997). Durum wheat varieties were found to be highly susceptible to FHB. Four landraces from Syria (ICDW 92330, ICDW 95842, ICDW96165, Chahba) were found as resistant to FHB (Von der Ohe and Miedaner 2010). Sources of resistance to FHB other than Sumai 3 have also been reported in Korean cultivar Chokwang (Shaner and Buechley 2001), Romanian cultivar Fundulea 201R (Shen *et al*. 2003) and from USA Ernie and Freedom (Rudd *et al.* 2001).

This study revealed that there are very limited sources of resistance against FHB disease. Therefore, to identify FHB resistance sources, there is a need to evaluate more number of indigenous and exotic genotypes of wheat and its wild relatives.

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