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Research Article

Yield performance of resistant derivatives from cross involving DPW 621-50 and HD 2967 cultivars of wheat

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Abstract

In this study, 191 highly stripe rust resistant lines were selected from F_6 population of cross DPW 621-50/HD 2967 with the objective of recovering transgressive segregants for yield and related traits. Yield performance of these 191 lines along with checks and parental lines was evaluated across two crop seasons (2013-14 and 2014-15). Preliminary yield trial (2013-14 season) displayed a large amount of variation present in derivatives for different yield related traits. Evaluation yielded 40 highly productive entries out of which, two lines namely, BWL 4438 (PBW 709) and BWL 4443 (PBW 724) were promoted to national co-ordinated trials. Healthy and vigorous ears were observed to produce more number of grains per spike but early flowering genotypes showed lesser number of grains per spike and were poor yielding. During 2014-15 season evaluation of selected forty lines was taken up along with the parents and checks. Entry BWL 4550 was found to have highest 1000-grain weight (51.050 g), surpassing all the checks. An important observation was recorded that grains per spike had negative correlation with plant height thus showing the adverse effect of lodging on grain filling due to excessive plant height. On the whole, strategy for extracting the transgressive segregants for different yield related parameters from the derivatives of cross involving two genetically diverse released cultivars (DPW 621-50 and HD 2967) proved to be an effective strategy.

Keywords: *Triticum aestivum*, genetic variability, association, agronomic traits

1. Introduction

Wheat (*Triticum aestivum*) is the second most important staple food crop of the world providing more calories in human diet than any other crop worldwide and accounting nearly 30% of global cereal production covering an area of 222.42 million hectare with total production of 725.12 million tonnes (Anonymous, 2015 a). In India, during year 2014-15 the wheat production was recorded as 90.78 million tonnes from an area of 30.37 million hectares (Anonymous, 2015 b). But with an ever growing population, the country needs to produce 109 million tonnes of wheat by 2025 which is a major challenge under changing climatic scenario (FAO, 2010). Therefore, increasing wheat production is one of the strategies to meet the global food demand. According to world estimates, an average of 50% yield losses in agricultural crops is due to different biotic stresses under these changing climatic conditions (IPCC, 2007). Steady increase in wheat productivity since the green revolution is associated with genetic improvements in yield potential, resistance to diseases and adaptation to abiotic stresses as well as better agronomic practices (Evenson and Gollin, 2003). Growing worldwide demand for wheat and limited availability of land is placing pressure on breeding programs to provide elite cultivars that can adapt to a range of environments without compromising agronomic performance, grain quality, stress tolerance or disease resistance. Wheat production is constrained not merely due to limited natural resources and changing climate but to a greater extent by emergence of new virulent pathotypes of economically important pathogens.

Among the diseases of wheat, cereal rusts are the most important constraints to wheat productivity. Stripe rust caused by *Puccinia striiformis* f. sp. *tritici*, is one of the most destructive diseases of wheat throughout the world (Chen, 2005). Over recent years, the disease has become increasingly important in a number of wheat-growing areas. In all regions in which wheat is grown, rusts have caused periodic severe epidemics (Roelfs *et al.*, 1992). The principle outcome of stripe rust epidemics is reduced yield and quality of grain. The intensity of loss primarily depends upon the resistance level of the cultivars (Beard *et al.*, 2007). Severe infection causes shrivelling of grains leading to low test weight, bulk density and low overall yield etc. While it is possible to mitigate losses due to these pathogens through the timely application of fungicides, the low profitability of wheat production cannot sustain such costly inputs under many dryland situations. Also, the application of chemicals is hazardous to the environment and poses health risks. Therefore, genetic control is considered to be the most viable, eco-friendly and sustainable means to combat these diseases. The use of resistant cultivars is the most economical, effective, and environment-friendly method to reduce damage and yield loss caused by stripe rust (Line and Chen, 1995). Breeders continuously seek effective resistance sources to genetically develop resistant cultivars. Keeping these things in mind, a cross was attempted at Punjab Agricultural University, Ludhiana involving two released highly resistant cultivars in North West Plain Zone (NWPZ) to stripe rust namely, DPW 621-50 and HD 2967 (although the source of resistance in both the cultivars is not known). The basic idea was to combine stripe rust resistance with high productivity in the derived lines. The present study was carried out to evaluate and thus identify promising genotypes showing resistance to stripe rust as well as high productivity.

2. Materials and methods

The recombinant inbred lines developed from cross of two elite released cultivars viz; DPW 621-50 and HD 2967 were used as experimental material. During 2012-13 season, 191 highly resistant derivative lines were selected from F_6 generation of above mentioned cross. The evaluation of these selected lines for yield performance and other agronomic traits was done across two consecutive years 2013-14 and 2014-15 at experimental area of the department of Plant Breeding & Genetics, Punjab Agricultural University, Ludhiana. During season 2013-14, preliminary evaluation of selected 191 lines along with five checks HD 2967, WH 1105, DPW 621-50, PBW 717 and PBW 713 was done. The trial was planted in -Lattice design layout with 14 x 14 matrices (196 plots per replication) with four replications. Each plot had four rows of 1.6 meter length spaced at 30 cm each. A total of 40 stripe rust resistant (under artificial epiphytotic conditions) and highest productive lines were selected based on 2013-14 season evaluation. During season 2014-15, these 40 lines were subjected to re-evaluation for yield components and other agronomic traits in the form of two independent randomized block design (RBD) trials. Each trial consisted of 24 genotypes including four checks. Each plot in these trials had four rows of 4 meter length spaced at 30 cm. All the management and agronomic practices according to package and practices were followed to raise the plant material to realise the full yield potential of the crop. The morphological and physiological observations recorded were days to flowering (no. of days), plant height (cm), effective tillers per metre row length, grains per spike, 1000-grain weight (g) and grain yield per plot (kg/plot size). The analysis of variance for different traits was performed using SAS ver. 9.3 to determine differences among the genotypes and identification of superior genotypes.

3. Results and discussion

3.1 Preliminary evaluation of selective 191 lines during 2013-14 season: Preliminary evaluation of selective resistant 191 lines (based on lowest stripe rust score) for yield components and other agronomic traits of cross DPW 621-50 X HD 2967 along with five checks HD 2967, WH 1105, DPW 621-50, PBW 717 and PBW 713 was carried out during season 2013-14 at PAU, Ludhiana. The analysis of variance for different traits was performed and presented in Table 1. The mean sum of squares for genotypes was highly significant for all the traits, thus indicating significant variation present among lines for different traits under study. Blocking was effective as evident from the analysis and based on that, adjusted means for different traits were worked out. The top 40 highly productive genotypes based on yield per plot and also showing resistance against stripe rust were selected for next year evaluation. Two of these entries, namely BWL 4438 (PBW 709) and BWL 4443 (PBW 724) were promoted to national co-ordinated trials.

Although the parental lines viz; DPW 621-50 and HD 2967 are released cultivars, but they still possess genetic diversity and hence show differences for various agronomic traits, thus justifying the evaluation of their derivatives to recover some of the transgressive segregants. Even though the set of lines under evaluation was a selected one, still it possessed a fairly large amount of variation for different traits as shown in the form of frequency bar graphs from Fig. 1 to Fig. 6.

The genotypic values for different traits were subjected to correlation analysis (Table 2). Number of effective tillers per area is one of the limiting factors of grain yield. Grain and biological yield depend upon many factors such as effective tillers, test weight, ear length etc. The traits like days to flowering and tillers per meter showed

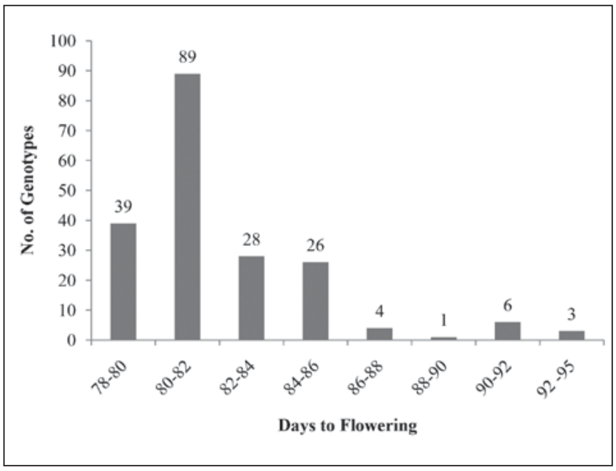

Fig. 1 Variation for Days to flowering in PYT 2013-14.

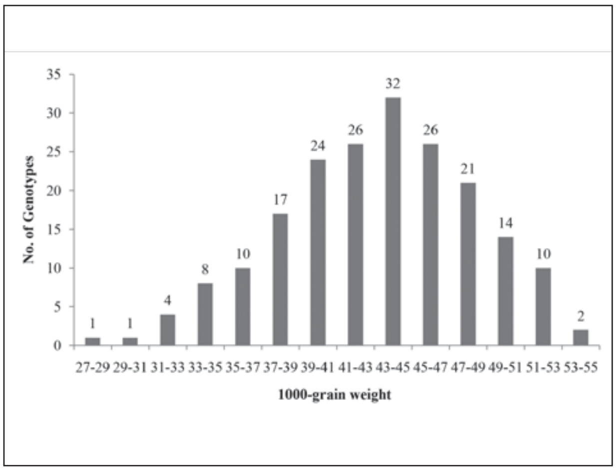

Fig. 2 Variation for 1000-grain weight (gm) in PYT 2013-14

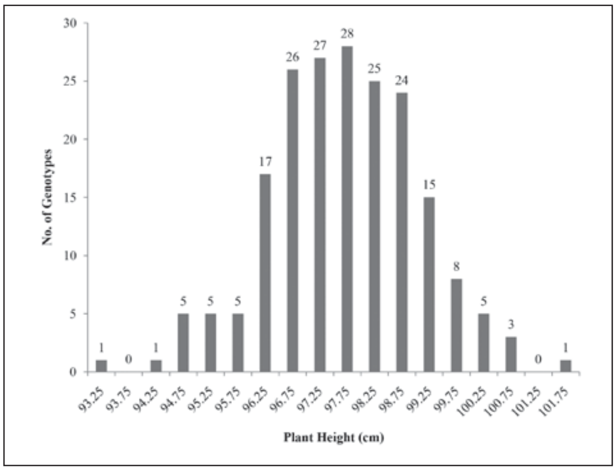

Fig. 3 Variation for Plant height (cm) in PYT 2013-14

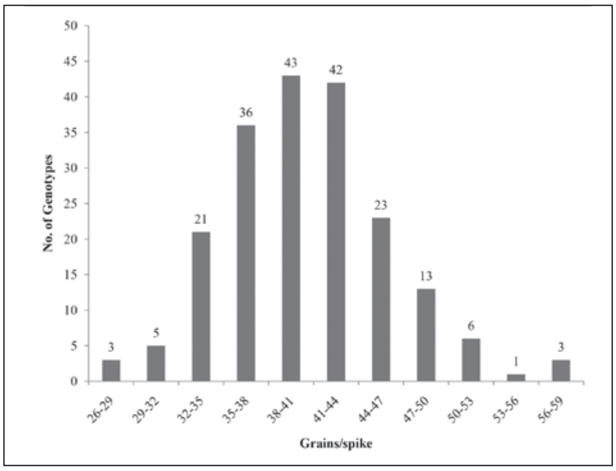

Fig. 4 Variation for grains/spike in PYT 2013-14

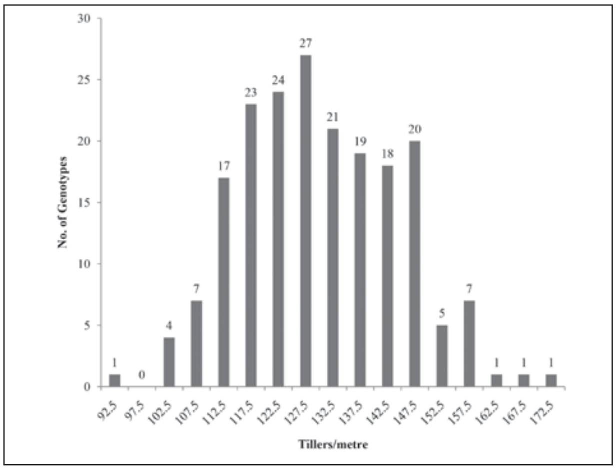

Fig. 5 Variation for tillers/metre in PYT 2013-14

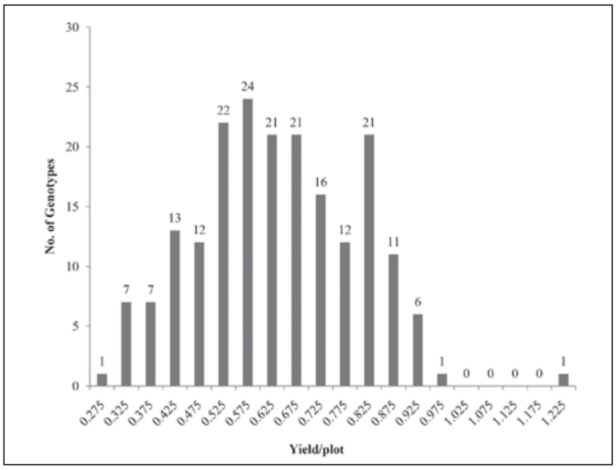

Fig. 6 Variation for Yield/ plot (kg) in PYT 2013-14

significant positive correlation with plant height. Healthy and vigorous ears were observed to produce more number of grains per spike but early flowering genotypes showed lesser number of grains per spike. Grains per spike and 1000-grain weight showed inverse relationship among them. Yield per plot correlated positively with 1000-grain weight and grains per spike. However, it was evident that late flowering genotypes were poor yielding because of lesser number of days for grain formation. All these characters under study can be effectively used as selection criteria for grain yield under timely sown conditions (Monpara, 2011; Wani *et al.,* 2011; Singh *et al.,* 2012).

Table 1. ANOVA for various traits for Preliminary Yield Trial during 2013-14 season

Analysis of Variance							
Source of Variation	Mean Sum of Squares						
	DF	Days to Flowering	Plant Height	Tillers/m	1000-grain weight	Grains/ spike	Yield/plot
Replications	1	27.06	79.92	24294	0.4869	1303.79	0.3815
Blocks within Replications (Adjusted)	26	5.23	13.75	5748.03	0.9171	194.96	0.0534
Treatments (Unadjusted)	195	17.18**	6.67**	3660.28**	51.84**	271.38**	0.0507**
Intra Block Error	169	2.74	6.75	3913.99	0.8689	34.5	0.0067
Eb		0.2012	0.0342	18.7707	0.2658	1.3917	0.0003
Ee		0.2325	0.5502	175.9809	0.1595	9.4886	0.0027
Total	391	10.17	7.36	3961.54	26.29	166.55	0.0327
F value (Treatments)		73.87**	12.12**	20.79**	325.03**	28.60**	18.91**
Additional Statistics		DTF	Plant Height	Tillers/m	1000-gw	Grains/ spike	Yield/plot
Variance of Means in Same Block		2.84	6.99	61.46	1.36	36.52	0.0071
Variance of Means in Different Block		2.93	7.24	68.54	1.48	38.55	0.0075
Average of Variance		2.92	7.21	65.00	1.42	38.28	0.0075
LSD at .01 Level		4.45	6.99	63.01	2.42	16.11	0.22
LSD at .05 Level		3.37	5.30	47.77	1.83	12.21	0.171
Efficiency Relative to RCBD		105.38	106.59	101.91	100.04	146.00	172.61

F value at 1% = 1.4177 and at 5 % = 1.2793, respectively (at 195, 169 d.f.)

* and ** at 5% and 1%, respectively

Table 2. Correlation among different traits for Preliminary Yield Trial during 2013-14 season

Characters	Days to flowering	Plant hight	Tillers/m	1000 - Grain weight	Grains/spike	Yield/plot
Days to flowering	1.000	0.1826*	-0.0215	-0.0534	-0.2426**	-0.6790**
Plant height		1.000	0.1538*	0.0189	-0.0317	-0.1444*
Tillers/m			1.000	0.0233	0.0086	0.0059
1000 - Grain weight				1.000	-0.4126**	0.2299**
Grains/spike					1.000	0.8172**
Yield/plot						1.000

Critical value of 'r' at 5%= 0.1402 and that at 1%= 0.1835

* and ** at 5% and 1% level of significance, respectively.

3.2 Evaluation of highly productive selected lines in Advanced Yield Trials during 2014-15 season: The forty highly productive entries selected from 2013-14 preliminary yield trial were subjected to re-evaluation for yield components and other agronomic traits in two independent advanced yield trials in randomized block design (RBD) during 2014-15 season. Each advanced yield trial had 20 selected entries along with DPW 621-50, HD 2967, WH 1105 and HD 3086 as checks in first trial (AYT-I) while DPW 621-50, PBW 725, HD 2967 and HD 3086 as checks in second trial (AYT-II). Analysis of variance was worked out for both the trials and the mean sum of square for genotypes re-confirmed the variation possessed by these selected set of lines. The mean performance of all entries in AYT-I and AYT-II during 2014-15 season along with checks for different traits is given in Table 3 and Table 4, respectively. The entry BWL 4550 was found to have highest 1000-gw (51.050 g), which was better than all the checks. Though, a few lines from the selected set became moderately susceptible during this period owing to pre-disposing factor for disease spread and escalated inoculum pressure, thus loss in yield was quite evident in them. During advanced yield trials, no selected entry could surpass the yield potential of checks HD 3086 and PBW 725 in AYT-I and AYT-II, respectively. These selected set of entries were also subjected to correlation analysis. Since they were selected, thus their correlation among traits was bound to decrease. However, grains per spike had negative correlation with traits like plant height and 1000-grain weight, which embarks the adverse effect of lodging due to excessive plant height on grain filling. Though, late flowering entries were poor yielding in this season also, but spikelets per spike and grains per spike contributed positively towards yield per plot.

On the whole, strategy for extracting the transgressive segregants for different yield related parameters from the derivatives of cross involving two genetically diverse released cultivars (DPW 621-50 and HD 2967) proved to be an effective strategy. It merits wide application in breeding for productivity related traits.

Table 3. Mean performance of genotypes for different traits in Advanced Yield Trial-I during 2014-15 season

S. No	Genotype	Days to flowering	Plant height (cm)	Tillers/ metre	Spklt/ Spike	1000-grain weight (g)	Grains / spike	Yield/plot (Kg/5. 4m^2)	Yellow rest Score
1	BWL 4438 (PBW 709)	101	106	80	20	48.783	39	2.950	10S
2	BWL 4436	104	105	76	22	44.917	41	2.450	10S
3	BWL 4439	103	107	73	20	44.533	41	2.733	10S
4	BWL 4441	101	106	71	19	29.600	46	1.867	40S
5	BWL 4538	108	107	78	22	39.167	41	2.200	40S
6	BWL 4539	107	105	72	20	41.267	46	2.383	20S
7	BWL 4540	105	103	75	20	31.200	43	1.400	40S
8	BWL 4541	107	107	76	20	37.017	37	2.017	10S
9	BWL 4542	106	107	78	20	30.383	48	1.750	40S
10	BWL 4543	106	110	87	20	43.233	31	2.467	10S
11	BWL 4544	110	107	85	24	36.483	39	1.833	40S
12	BWL 4545	105	106	79	20	35.983	41	2.567	10S
13	BWL 4546	107	101	75	22	39.100	43	2.033	20S
14	BWL 4547	106	100	71	21	41.767	39	2.400	10S
15	BWL 4548	106	103	78	18	44.900	43	2.700	10S
16	BWL 4549	106	102	73	20	39.367	48	2.817	10S
17	BWL 4550	104	109	68	20	51.050	34	2.783	10S
18	BWL 4551	104	107	80	20	38.433	39	2.600	10S
19	BWL 4552	106	102	69	20	44.267	43	2.433	10S
20	BWL 4553	106	106	72	20	42.800	39	2.400	10S
21	DPW 621-50	101	103	85	20	37.567	47	2.067	40S
22	HD 2967	104	103	74	18	36.083	44	1.833	40S
23	WH 1105	105	104	79	20	31.533	37	2.000	20S
24	HD 3086	102	102	81	16	42.967	37	3.200	5S
CD (0.05)		5.03	15.50	1.86	3.03	4.50	4.64	1.12	

Table 4. Mean performance of genotypes for different traits in Advanced Yield Trial-II during 2014-15 season

S. No.	Genotype	Days to flowering	Plant height (cm)	Tillers/ metre	Spklt/ Spike	1000-grain weight (g)	Grains / spike	Yield/plot (Kg/5. 4m^2)	Yellow rest Score
1	BWL 4443 (PBW 724)	98	102	88	20	42.250	46	2.983	20S
2	BWL 4437	94	96	86	20	39.267	44	2.917	20S
3	BWL 4440	95	93	79	20	43.183	44	3.033	20S
4	BWL 4442	94	99	68	19	43.283	41	2.967	20S
5	BWL 4554	95	95	76	19	39.117	38	2.733	20S
6	BWL 4555	95	97	84	18	44.717	44	3.083	20S
7	BWL 4556	99	98	90	18	37.083	47	2.833	20S
8	BWL 4557	99	99	93	19	41.083	41	2.750	40S
9	BWL 4558	97	92	92	18	39.583	40	2.467	40S
10	BWL 4559	101	89	81	16	34.683	48	2.283	40S
11	BWL 4560	101	96	93	16	42.717	37	2.533	40S
12	BWL 4561	101	95	84	17	41.417	41	2.500	40S
13	BWL 4562	102	102	85	16	39.700	44	2.833	20S
14	BWL 4563	98	95	75	17	36.017	42	2.700	20S
15	BWL 4564	98	98	86	18	39.900	47	3.200	10S
16	BWL 4565	99	100	91	16	41.550	45	2.900	10S
17	BWL 4566	99	102	88	19	42.433	43	2.917	20S
18	BWL 4567	98	99	92	18	41.483	40	2.767	20S
19	BWL 4568	98	94	89	18	43.883	38	2.633	10S
20	BWL 4569	99	100	94	18	34.400	51	2.917	20S
21	DPW 621-50	98	93	94	18	37.833	49	2.750	40S
22	PBW 725	97	95	88	20	41.900	55	4.000	5S
23	HD 2967	102	95	88	18	36.767	38	2.783	40S
24	HD 3086	96	94	80	17	39.833	44	2.967	5S
CD (0.05)		3.30	18.50	2.80	2.27	7.19	5.39	1.52	

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