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Estimation of Genetic Variability Parameters for Various Quantitative Traits and Rust Resistance in Bread Wheat (*Triticum aestivum* L.)

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A B S T R A C T

Genetic variability is prerequisite for any crop improvement program as it helps breeders in selection process. For this purpose, present study aimed to estimate genetic parameters of eleven quantitative characters along with reaction for yellow rust resistance of 243 segregating lines of wheat during F_4 and F_5 generations derived from two crosses, *viz*., WH 1105 x WH 711 and RAJ 3765 x WH 711. Moderate to high values of GCV and PCV were observed for grain weight/ear, grain yield/plant, biological yield/plant, 100-grain weight, ear weight, number of tillers/plant and number of grains/ear. The heritability estimates were high for number of tillers/plant, ear weight, number of grains/ear, 100-grain weight, biological yield/plant and grain yield/plant. The heritability estimates were high for number of tillers/plant, ear weight, number of grains/ear, 100-grain weight, biological yield/plant and grain yield/plant. Genetic advance as per cent of mean was moderate for grain weight/ear, grain yield/plant, 100-grain weight, biological yield/plant, ear weight, number of tillers/plant and number of grains/ear. High heritability with high genetic advance was observed for number of tillers/plant, grain weight/ear, 100-grain weight and grain yield/plant indicating predominance of additive gene effects and possibilities of effective selection for the improvement of these characters. The reaction to yellow rust varied from highly resistant to highly susceptible among the progenies of both the generations.

Introduction

Wheat (*Triticum aestivum* L. em. Thell) is the most important cereal crop cultivated worldwide that contributes substantially to human diet and food security. It holds a prominent position in the international food grain trade because of high productivity and the acreage it occupies. Wheat provides over 20% of calories, nearly 55% of the carbohydrate and protein in human nutrition (Gupta *et al.*, 2009). In view of ever increasing population and demand for global food production, there is an imperative need of 40–60% increase in wheat production in coming 40 years (Goutam *et al.*, 2015). However, both biotic and abiotic stresses are major hurdles for attaining the goal. Amongst the most important fungal diseases in wheat, yellow rust is most widely devastating disease especially in areas with cool and moist environments. Yellow rust infects cereal crops and grasses from early growth stages to maturity of the plant causing severe yield losses (50–100%) (Afzal *et al.,* 2007). In order to sustain wheat production, continuous efforts are to be made to develop high yielding and disease resistant wheat genotypes. Accomplishing this goal, the systematic attempts for wheat improvements are needed through manipulation of various yield components (Hussain *et al.,* 2007). Grain yield being a complex trait is highly influenced by many genetic factors and environmental fluctuations. Heritability and genetic advance are other important selection parameters which help the plant breeder in determining the characters for which selection would be done. Keeping in view the above perspectives, the present investigation was taken up to find out genetic variability for quantitative traits and yellow rust resistance in wheat.

Materials and Methods

The experiment was carried out on 243 F_4 and F_5 generation progenies generated from two crosses namely, WH 1105 x WH 711 and RAJ 3765 x WH 711, in which WH 1105 and RAJ 3765 are two yellow rust resistant parents whereas WH 711 is a rust susceptible parent. The crop was grown in research area of Wheat and Barley Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar, during the *Rabi* season of 2015-16 and 2016-17. Infector rows were planted and also artificial inoculation (using spray method) was carried out under field conditions using *Pst* (*Puccinia striiformis*) isolate as a source of inoculum. The F_4 and F_5 progenies were sown in the field in paired rows with two replications in a randomised block design (RBD). All the recommended package of practices were followed to raise the crop. To study the variability, data were recorded on five randomly selected plants of each parent and from each progeny of F_4 and F_5 population for grain yield and its component traits *i.e.,* plant height (cm), number of tillers/plant, ear length (cm), ear weight (g), number of grains/ear, grain weight/ear (g), number of spikelets/ear, 100-grain weight (g), biological yield/plant (g) and harvest index (%). Yellow rust severity (%) was recorded for each genotype from the time of rust first appearance and then every seven days. Estimates of severity were measured according to modified Cobb's scale (Peterson *et al.,* 1948). The data were analyzed for variabilty parameters like genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability (h^2_{bs}) and genetic advance as per cent of mean (GAM) using OPSTAT software.

Results and Discussion

Analysis of variance

The mean sum of squares with respect to seed yield and its component traits as a measure of variability in F_4 and F_5 generation of the two crosses, WH 1105 x WH 711 (Table 1) and RAJ 3765 x WH 711 (Table 2) indicated significant differences among the genotypes for all the characters. These differences could be used for distinguishing different genotypes from each other. Many earlier workers including Naghavi *et al.,* (2009); Riaz-Ud-Din *et al.,* (2010); Kaushik *et al.,* (2013) and Maurya *et al.,* (2014) reported high variability for different traits in wheat.

Variability and heritability parameters

For the adoption of suitable breeding programmes, the assessment of heritable and non-heritable components in the total variability observed is indispensable. The heritable component can be assessed by studying phenotypic coefficient of variation

(PCV), genotypic coefficient of variation (GCV), heritability and predicted genetic advance. The PCV values were higher than GCV in both the crosses for all the characters indicating that the expression of these traits were influenced by the environmental conditions which confirmed the finding of Kaushik *et al.,* (2013) and Shankarrao *et al.,* (2010).

In WH 1105 x WH 711 cross

GCV and PCV

In F_4 generation, PCV ranged from 5.91 for number of spikelets/ear to 23.78 for grain weight/ear whereas GCV ranged from 4.53 for ear length to 21.83 for grain weight/ear (Table 3). High GCV was observed for grain yield/plant while traits *viz*., 100-grain weight, biological yield/plant, ear weight and number of tillers/ plant showed moderate GCV. Rest of the traits had low values of GCV. Similarly grain yield/plant, biological yield/plant and 100-grain weight had high PCV whereas ear weight, number of tillers/plant and number of grains/ ear had moderate PCV. Rest of the traits had low values of PCV. Similar findings were also reported by Ali *et al.,* (2008) and Kalimullah *et al.,* (2012) for grain yield per plant and by Kumar *et al.,* (2012a) for number of tillers/ plant and biological yield per plant.

In F_5 generation, the maximum value of PCV was observed for grain yield/plant (24.02) and minimum for number of spikelets/ ear (5.67) whereas GCV was maximum for grain yield/plant (20.81) and minimum for ear length (4.38). The traits namely, grain weight/ ear, ear weight, harvest index, 100-grain weight and number of tillers/ plant showed moderate GCV. Rest of the traits had low GCV. Bhushan *et al.,* (2013) observed moderate GCV for harvest index and number of tillers/plant and Degewione *et al.,* (2013) observed high PCV for grain yield. Harvest index had high PCV while grain weight/ ear, ear weight, 100-grain weight, number of tillers/plant, biological yield/plant and number of grains/ ear had moderate PCV. Rest of the traits had low PCV which indicated low level of variability for the characters in the population under study. Choudhary *et al.,* (2015) observed similar results for number of effective tillers/plant. The differences between PCV and GCV were relatively very small which showed least environmental influence and supported by the findings of Shankarrao *et al.,* (2010).

Heritability and genetic advance

In F_4 generation, the heritability (broad sense) estimates were higher for all the traits, except ear length, harvest index and plant height for which these estimates were moderate. Similar results were reported by Ali *et al.,* (2008) for number of spikelets/spike, number of grains/spike, 1000-grain weight and yield/plant and Ajmal *et al.,* (2009) for tillers/plant.

Genetic advance as per cent of mean was high for grain weight/ ear, grain yield/ plant, 100-grain weight, biological yield per plant, ear weight and number of tillers/ plant whereas moderate for number of grains/ ear. Rest of the characters showed low (<10%) values of genetic advance as per cent of mean. Johnson *et al.,* (1955) reported that heritability value along with genetic advance was a better approach for selecting the desirable individuals rather than heritability value alone. Number of tillers/plant, ear weight, grain weight/ear, 100-grain weight, grain yield/plant and biological yield/plant had high heritability with high genetic advance. It indicates the presence of additive gene action. These results are in agreement with the earlier findings of Eid (2009) for 1000 grain-weight and Shankarrao *et al.,* (2010) for grain weight/spike.

In F_5 generation, highest heritability (broad sense) was recorded for grain weight/ear (87.02%) and lowest for ear length (41.19).

Heritability estimates were high for ear weight, 100-grain weight, grain yield/plant, number of spikelets/ear and number of grains/ear while moderate values of heritability were observed for the traits, namely, number of tillers/plant, harvest index, plant height, biological yield/plant and ear length. These results were supported by Khan and Naqvi (2011) for spike length and Kumar *et al.,* (2012a) for grain yield/plant and number of grains/ear. Genetic advance as per cent of mean was high for grain yield/plant, grain weight/ear, ear weight, 100-grain weight and harvest index whereas moderate for number of tillers/ plant, number of grains/ ear and biological yield/plant.

Rest of the characters showed low (<10%) values of genetic advance as per cent of mean. Ear weight, grain weight/ear, 100-grain weight and grain yield/plant had high heritability with high genetic advance. Genetic advance as per cent of mean ranged from 5.80 to 37.15%. Similar findings were also reported by Bhushan *et al.,* (2013) for number of tiller/plant and number of grain/spike and Degewione *et al.,* (2013) for grain yield.

In RAJ 3765 x WH 711 cross

GCV and PCV

In F_4 generation, high values of GCV were observed for number of tillers/plant and grain yield/plant while the traits *viz*., grain weight/ear, harvest index, 100-grain weight, ear weight, number of grains/ear and biological yield/plant showed moderate GCV. Rest of the traits had low (<10%) GCV (Table 4). Jan and Kashyap (2013) also found high GCV for number of tillers and grain yield/ plant. Grain yield/plant, number of tillers/plant, harvest index and grain weight/ear had high PCV. Ear weight, 100-grain weight, biological yield/plant and number of grains/ear had moderate PCV. Rest of the traits had low (<10%) PCV. These observations are in agreement with the earlier reports of Dutamo *et al.,* (2015) for yield/plant and Fikre *et al.,* (2015) for 1000 kernel weight.

In F_5 generation, moderate GCV was observed for the traits, *viz*., number of tillers/ plant, grain yield/ plant, grain weight/ ear, harvest index, 100-grain weight and ear weight. Rest of the traits had low (<10%) GCV. The traits namely, number of tillers/ plant, harvest index, grain yield/plant and grain weight/ear had high PCV whereas ear weight, 100-grain weight, number of grains/ear and biological yield/plant had moderate PCV. Rest of the traits had low (<10%) PCV. Similar findings were also reported by Yadawad *et al.,* (2015) and Arya *et al.,* (2017) for grain yield/plant and Rathwa *et al.,* (2018) for number of productive tillers/plant followed by grain yield/plant and harvest index. Low values of GCV and PCV indicated low level of variability for the characters in the population under study.

Heritability and genetic advance

In F_4 generation, heritability (broad sense) estimates were high for number of tillers/plant followed by grain weight/ear, 100-grain weight, number of grains/ear and grain yield/plant. Rest of the traits had moderate values values of heritability. Similar findings were also reported by Choudhary *et al.,* (2015) for number of effective tillers/plant; Arya *et al.,* (2017) for grain yield/plant and Rathwa *et al.,* (2018) for number of productive tillers/plant followed by grain yield/plant, harvest index and grain weight/main spike. Genetic advance as per cent of mean ranged from 6.59 for number of spikelets/ear to 42.84 for number of tillers/plant. GAM was high for number of tillers/plant, grain weight/ear, grain yield/plant, 100-grain weight, harvest index, ear weight and number of grains/ear whereas biological yield/plant showed moderate genetic advance.

Rest of the characters showed low (<10%) values of genetic advance as per cent of mean. High heritability coupled with high genetic advance was exhibited by number of tillers/plant, number of grains/ear, grain weight/ear, 100-grain weight, and grain yield/plant. Ear weight and harvest index had moderate heritability with high genetic advance. Similar findings were also reported by Maurya *et al.,* (2014) for yield/plant, grains/spike and 1000-grain weight; Dutamo *et al.,* (2015) for kernels/spike, 1000-grain weight, harvest index and grain yield.

In F_5 generation, high heritability (broad sense) was recorded for grain weight/ear followed by number of tillers/plant, grain yield/plant, 100-grain weight and number of grains/ear. Moderate values of heritability were observed for rest of the traits. Genetic advance as per cent of mean was high for number of tillers/plant, grain yield/plant, grain weight/ear and harvest index whereas moderate for 100-grain weight, number of grains/ear, ear weight and biological yield/plant. Rest of the characters showed low (<10%) values of genetic advance as per cent of mean.

Number of tillers/plant, grain weight/ear and grain yield/plant had high heritability with high genetic advance. High heritability coupled with high genetic advance was reported by Rajshree and Singh (2018) for number of tillers/plant and grain yield and Singh *et al.,* (2018) for grain yield. Harvest index had moderate heritability with high genetic advance. Genetic advance as per cent of mean ranged from 6.86 to 36.84%.

Response to yellow rust

Yellow rust infects green tissues of cereal crops within a temperature range of 11°C to 23°C and the affected plants show the symptoms of yellow-colored parallel stripes along the venations of leaf blade which are actually the characteristic of uredia that produce yellow colored uredospores. The data on disease reaction of parents, F_4 and F_5 generations revealed that all the plants of both the resistant parents (WH 1105 and RAJ 3765) were free from the symptoms of yellow rust disease, whereas, the susceptible parent (WH 711) showed the symptoms of yellow rust. The reaction to yellow rust has been described crosswise separately.

Cross I: WH 1105 x WH 711

In this cross, a total 114 plants in F_4 and F_5 generations were screened by spraying the urediospores of prevalent races under natural field conditions. In F_4 generation, 84 plants showed no infection, 7 showed traces of infection, 8 plants showed 5-10 on the scale, 20 was shown by 3 plants, 40 by 2 plants, 60 by 7 plants and 100 by 3 plants (Table 5). Similarly, in F_5 generation, 55 plants showed no infection, 39 plants were on 5-10 scale, 13 showed 20 percent infection, 6 plants showed 40 percent infection and 1 showed 60 percent severity (Table 6).

Most of the plants which were highly resistant in F_4 generation were also identified as highly resistant in F_5 generation. Plant No. 6, 7, 8, 27, 37, 42, 96, 97, 106, 107, 109, 113 and 114 were moderately to highly susceptible in F_4 but they appeared as resistant to highly resistant in F_5 progenies whereas plant No. 10, 11, 14, 15, 16, 20, 32, 36, 38, 44, 71, 103 and 111 were moderately to highly resistant in F_4 but they appeared as to be susceptible to highly susceptible in F_5 progenies.

Table.1 Mean sum of squares for 11 morphological characters in F_4 and F_5 generations of the cross WH 1105 x WH 711 in wheat

S.V.		d.f.	Plant height (cm)	No. of Tillers / plant	Ear length	Ear weight (g)	No. of Grains/ear	Grain weight / ear	No. of spikelets / ear	100 grain wt.	Grain yield/ plant	Biological yield/ plant (g)	Harvest index (%)
Replicatio	F	1	42.67	0.54	0.98	0.05	1.68	0.15	0.65	0.19	3.29	18.66	34.35*
	F	1	0.67	0.14	1.27	0.16	12.79	0.09	1.15	0.003	1.92	6.79	6.08
Treatment	F	11	91.33*	1.99**	0.85*	0.69*	78.60**	0.56**	2.73**	1.20*	16.21*	61.15**	26.93**
	F	11	72.60*	1.33**	0.94*	0.51*	77.09**	0.42**	2.53**	0.67*	13.19*	19.03**	112.59*
Error	F	11	32.89	0.19	0.27	0.05	10.34	0.05	0.54	0.11	1.45	7.52	8.25
	F	11	27.30	0.34	0.39	0.07	16.94	0.03	0.42	0.09	1.88	7.32	31.72
C.V. (%)	F		6.65	7.43	4.32	7.64	5.23	9.44	3.39	8.82	9.48	10.32	5.94
	F		6.11	10.28	5.24	8.79	6.54	7.16	3.03	8.02	11.99	9.71	13.70
CD	F		11.37	0.86	1.02	0.47	6.38	0.43	1.45	0.65	2.39	5.44	5.70
	F		10.36	1.16	1.24	0.53	8.16	0.34	1.29	0.61	2.72	5.37	11.17

Table.2 Mean sum of squares for 11 morphological characters in F_4 and F_5 generations of the cross RAJ 3765 x WH 711 in wheat

S.V.		d.f.	Plant height (cm)	No. of Tillers / plant	Ear length	Ear weight (g)	No. of Grains/ear	Grain weight / ear	No. of spikelets / ear	100 grain wt.	Grain yield/ plant	Biological yield/ plant (g)	Harvest index (%)
Replicatio	F	1	44.91	0.41	0.47	0.04	1.48	0.05	0.16	0.24	1.42	7.97	61.75
	F	1	25.52	0.12	0.67	0.20	1.35	0.004	0.63	0.07	0.99	1.80	0.42
Treatment	F	13	59.35*	5.17**	1.03*	0.46*	107.22**	0.52**	3.10**	0.73*	18.56*	29.08**	140.59*
	F	13	67.45*	4.49**	1.02*	0.42*	98.07**	0.52**	3.12**	0.56*	14.84*	19.71**	143.33*
Error	F	13	22.49	0.26	0.28	0.12	15.48	0.04	1.15	0.10	2.97	7.86	45.36
	F	13	20.60	0.44	0.32	0.18	22.90	0.05	1.06	0.12	1.73	8.32	36.90
C.V. (%)	F		5.52	7.12	4.44	10.97	6.53	7.98	5.15	7.91	13.26	9.50	15.26
	F		5.38	9.19	4.69	12.72	7.77	8.11	4.83	8.31	9.67	9.33	13.70
CD	F		9.39	1.01	1.04	0.70	7.79	0.39	2.13	0.64	3.41	5.55	13.34
	F		8.99	1.31	1.12	0.83	9.48	0.43	2.04	0.69	2.60	5.71	12.03

Table.3 Genetic variability parameters for 11 quantitative traits in F_4 and F_5 generations of the cross WH 1105 x WH 711 in wheat

Characters		Mean ± SE	Range	Coefficient of variation		Heritability (bs) (%)	Genetic advance	Genetic advance as 5% of mean
				Genotypic (%)	Phenotypic (%)			
Plant height (cm)	F_4	86.27±5.73	66.27-104.85	6.27	9.13	47.06	7.64	8.86
	F_5	85.58±5.22	68.3-99.75	5.56	8.26	45.36	6.60	7.72
Number of tillers/ plant	F_4	5.85±0.43	3.5-9.1	16.19	17.81	82.61	1.77	30.31
	F_5	5.68±0.59	4-9.5	12.34	16.06	59.04	1.11	19.53
Ear length (cm)	F_4	11.92±0.51	9.94-13.86	4.53	6.26	52.30	0.80	6.74
	F_5	11.94±0.63	10.2-14	4.38	6.83	41.19	0.69	5.80
Ear weight (g)	F_4	3.07±0.23	1.85-4.395	18.30	19.84	85.15	1.07	34.80
	F_5	3.03±0.27	1.87-4.22	15.53	17.85	75.74	0.84	27.85
Number of grains/ ear	F_4	61.50±3.22	48.25-78.6	9.50	10.84	76.75	10.54	17.14
	F_5	62.95±4.12	48.65-80.4	8.71	10.89	63.96	9.03	14.35
Grain weight/ ear (g)	F_4	2.32±0.22	1.295-3.725	21.83	23.78	84.26	0.96	41.28
	F_5	2.39±0.17	1.34-3.69	18.53	19.87	87.02	0.85	35.61
Number of spikelets/ ear	F_4	21.62±0.73	17.55-24.55	4.84	5.91	67.08	1.77	8.17
	F_5	21.42±0.65	18.25-24.03	4.82	5.67	71.52	1.79	8.36
100 grain wt (g)	F_4	3.75±0.33	1.96-6.01	19.68	21.56	83.29	1.39	37.00
	F_5	3.82±0.31	2.2-5.73	14.01	16.14	75.33	0.96	25.05
Grain yield/ plant (g)	F_4	12.71±1.20	6.92-20.96	21.37	23.37	83.56	5.12	40.24
	F_5	11.43±1.37	7.68-18.81	20.81	24.02	75.09	4.24	37.15
Biological yield/ plant (g)	F_4	26.56±2.74	15.08-38.9	19.49	22.05	78.09	9.43	35.48
	F_5	27.85±2.70	22.05-36.10	8.69	13.03	44.45	3.32	11.93
Harvest index (%)	F_4	48.36±2.87	36.79-53.88	6.32	8.67	53.10	4.59	9.48
	F_5	41.11±5.63	31.77-52.50	15.47	20.66	56.04	9.81	23.85

Table.4 Genetic variability parameters for 11 quantitative traits in F_4 and F_5 generations of the cross RAJ 3765 x WH 711 in wheat

Characters		Mean ± SE	Range	Coefficient of variation		Heritability (bs) (%)	Genetic advance	Genetic advance as 5% of mean
				Genotypic (%)	**Phenotypic (%)**			
Plant height (cm)	F_4	85.88 ± 4.74	74.70-98.08	5.00	7.45	45.07	5.94	6.92
	F_5	84.43±4.54	73.32-98.42	5.73	7.86	53.24	7.28	8.62
Number of tillers/ plant	F_4	7.16 ±0.51	3.45-10.10	21.87	23.00	90.41	3.07	42.84
	F_5	7.21±0.66	3.89-9.8	19.73	21.76	82.18	2.66	36.84
Ear length (cm)	F_4	11.83 ±0.52	10.00-13.89	5.22	6.81	58.82	0.98	8.25
	F_5	12.1±0.57	10.83-14.3	4.89	6.77	52.09	0.88	7.27
Ear weight (g)	F_4	3.20 ±0.35	2.12-4.62	12.80	16.86	57.64	0.64	20.02
	F_5	3.31±0.42	2.36-4.81	10.44	16.46	40.25	0.45	13.65
Number of grains / ear	F_4	60.25 ±3.93	42.45-79.90	11.24	13.00	74.76	12.06	20.02
	F_5	61.61±4.78	44.2-80.79	9.95	12.62	62.14	9.95	16.16
Grain weight/ ear (g)	F_4	2.48 ±0.20	1.21-3.81	19.75	21.30	85.96	0.94	37.71
	F_5	2.66±0.22	1.42-3.78	18.30	20.02	83.57	0.92	34.46
Number of spikelets/ ear	F_4	20.86 ±1.07	16.50-24.20	4.73	6.99	45.79	1.37	6.59
	F_5	21.35±1.03	17.05-25.05	4.75	6.78	49.17	1.46	6.86
100 grain wt (g)	F_4	4.10 ±0.32	2.20-5.79	13.65	15.78	74.85	0.99	24.34
	F_5	4.21±0.35	2.62-5.70	11.08	13.85	64.02	0.77	18.26
Grain yield/ plant (g)	F_4	13.00±1.72	6.14-19.25	21.47	25.23	72.39	4.89	37.63
	F_5	13.59±1.31	7.13-17.78	18.84	21.17	79.14	4.69	34.52
Biological yield/ plant (g)	F_4	29.54 ±2.80	18.73-38.39	11.04	14.56	57.45	5.09	17.24
	F_5	30.92±2.88	22.25-38	7.72	12.11	40.65	3.13	10.14
Harvest index (%)	F_4	44.13 ±6.73	29.61-52.49	15.64	21.85	51.22	10.17	23.05
	F_5	44.33±6.07	30.62-51.93	16.45	21.43	59.05	11.55	26.05

Table.5 Reaction to yellow rust in F_4 generation of WH 1105 x WH 711

Per cent leaf area infected	Reaction	Plant number	Number of plants
T (Traces)	HR	15, 28, 55, 87, 98, 111 and 112	7
5-10	R	9, 23, 39, 44, 66, 73, 108 and 110	8
20	MR	40, 95 and 97	3
40	MS	8 and 114	2
60	S	7, 27, 37, 42, 107, 109 and 113	7
100	HS	6, 96 and 106	3

Table.6 Reaction to yellow rust in F_5 generation of WH 1105 x WH 711

Per cent leaf area infected	Reaction	Plant number	Number of plants
T (Traces)	HR	--	0
5-10	R	1, 2, 3, 4, 6, 8, 9, 12, 13, 18, 19, 24, 28, 35, 39, 41, 48, 53, 54, 62, 63, 64, 66, 67, 74, 75, 81, 84, 86, 91, 92, 94, 95, 99, 104, 106, 110, 113 and 114	39
20	MR	10, 11, 14, 15, 16, 20, 32, 36, 38, 44, 71, 103 and 111	13
40	MS	17, 29, 37, 73, 93 and 112	6
60	S	42	1
100	HS	--	0

Table.7 Reaction to yellow rust in F_4 generation of RAJ 3765 x WH 711

Per cent leaf area infected	Reaction	Plant number	Number of plants
T (Traces)	HR	7, 24, 32, 33, 66, 67, 79, 81, 88, 116, 118, 120, 126 and 128	14
5-10	R	1, 8, 37, 50, 52, 54, 70, 77, 78, 89, 119, 124 and 129	13
20	MR	19, 34, 45, 49, 72, 82, 95, 115, 121 and 123	10
40	MS	46, 83 and 122	3
60	S	47, 73, 117, 125 and 127	5
100	HS	23 and 90	2

Table.8 Reaction to yellow rust in F_5 generation of RAJ 3765 x WH 711

Per cent leaf area infected	Reaction	Plant number	Number of plants
T (Traces)	HR	--	0
5-10	R	12, 28, 31, 38, 40, 108, 120, 122 and 128	9
20	MR	7, 10, 26, 27, 32, 35, 36, 37, 43, 50, 53, 56, 61, 62, 73, 75, 76, 77, 78, 82, 83, 88, 89, 91, 102, 106 and 127	27
40	MS	34, 39, 46, 47, 48, 49, 51, 52, 57, 64 and 90	11
60	S	21, 23 and 33	3
100	HS	--	0

Cross II: Raj 3765 x WH 711

In this cross, a total of 129 plants in F_4 and F_5 generations were screened for reaction to yellow rust under natural field conditions. In F_4 generation, 82 plants showed no infection, 14 showed traces of infection, 13 showed 5-10 on the scale, 20 was shown by 10 plants, 40 by 3 plants, 60 by 5 plants and 100 by 2 plants (Table 7). Similarly, in F_5 generation, 79 plants showed no infection, 9 plants were on 5-10 scale, 27 showed 20 percent infection, 11 plants showed 40 percent infection and 3 showed 60 percent severity (Table 8). Most of the plants which were highly resistant in F_4 generation were also identified as highly resistant in F_5 generation. Plant No. 73, 83, 117, 122, 125 and 127 were moderately to highly susceptible in F_4 but they appeared as resistant to highly resistant in F_5 progenies whereas plant No. 21, 33, 34, 39, 48, 49, 51, 52, 57 and 64 and were moderately to highly resistant in F_4 but they appeared as to be susceptible to highly susceptible in F_5 progenies.

In conclusion, the present study was conducted with F_4 and F_5 generations of two crosses, *viz*., WH 1105 x WH 711 and RAJ 3765 x WH 711 of wheat to assess the genetic variability for yield and its component traits and disease reaction for yellow rust. Analysis of variance revealed that highly significant differences among the treatments for all the characters, indicating significant differences among the genotypes for all the characters. The minimum differences between GCV and PCV values showed least influence of environment. The reaction to yellow rust varied from highly resistant to highly susceptible among the plants of both the generations.

Most of the plants which were highly resistant in F_4 generation were also identified as highly resistant in F_5 generation. High to medium values of PCV and GCV were recorded for grain weight/ear, grain yield/plant, 100-grain weight, biological yield/plant, ear weight and number of tillers/plant which suggested the possibility of improving these traits through selection**.**

The characters having high heritability estimates are of immense importance as it permits selection at phenotypic level and there would be greater correspondence between phenotypic worth and breeding values. High heritability along with high genetic advance were recorded for number of tillers/plant, ear weight, grain weight/ear, 100-grain weight and grain yield/plant which shows a strong contribution of additive genetic variance in expression of the traits indicating that simple selection scheme would be sufficient for these traits can help in the improvement of grain yield.

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