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Short Communication

Combining ability for quantitative traits in bread wheat (*Triticum aestivum* L.)

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The present investigation was carried out to estimate the combining ability and type of gene action governing the inheritance of important traits including rust resistance in bread wheat (*Triticum aestivum* L.). Twelve bread wheat genotypes comprising of six lines (Agra local, Lal Bahadur, NI-5439, C-306, Sonalika and Pusa-4) and six testers (HD-2189, NIAW-34, GW-324, DWR-248, DWR-247 and PBW-343) were crossed in a L × T mating design during rabi 2001-02. The 36 crosses produced and their parents were raised in randomized complete block design with two replications at Ugar Khurd under irrigated conditions. In each replication, single row of parents and F_1s were sown in 2 m row length with spacing of 5 cm between plants and 25 cm between rows. The data were recorded on five randomly chosen plants for twelve quantitative traits *viz.*, days to 50 per cent flowering, days to maturity, plant height (cm), number of tillers per plant, number of spikes per m^2, peduncle length (cm), spike length (cm), number of grains per spike, total biomass per plant, grain yield per plant, harvest index and 1000-grain weight (g). Leaf rust disease severity score was visually recorded three times at 15 days interval from tillering throughout green leaf stage. The data were later transformed into average coefficient of infection (AC1) by multiplying the per cent infection with response value assigned to each infection type as per Loegering rate [2]. The statistical analysis for combining ability was done as per the procedure developed by Kempthorne [3].

The analysis of variance revealed significant variation among the parents for all the traits. Combining ability analysis indicated that variance due to females, males and female × male was significant for all the traits. The *gca* and *sca* variance ratio revealed the preponderance of non-additive gene action in governing the expression of all the characters except plant height and peduncle length. This is in accordance with earlier reports [4-7]. In contrast, preponderance of additive gene action for grain yield and other traits was reported by other workers [8-11].

The estimates of *gca* effects (Table 1) revealed that the lines NI 5439, Sonalika, Pusa 4 and the tester DWR 248 were the better general combiners for grain yield. In addition, Sonalika, Pusa 4 and DWR 248 also recorded significant GCA effects in the desired direction for rust incidence, total biomass per plant and number of spikes per m^2. The lines Agra local, Lal Bahadur and NI 5439 and the testers HD 2189, NIAW 34 and DWR 248 recorded negatively significant *gca* effects for days to 50 per cent flowering and maturity and they form potential components in the breeding programmes intended to breed short duration genotypes for wheat growing areas with limited irrigation facilities or under residual soil moisture. For number of tillers per plant, Pusa 4, GW 324 and DWR 248 were found to be good general combiners. For peduncle length NI 5439, C 306. Pusa 4, HD 2189 and DWR 247 were the best general combiners. Whereas for spike length, Agra local, Pusa 4, HD 2189, GW 324 and PBW 343 recorded significant *gca* effects.

The nine crosses, which showed significant positive *sca* effects for grain yield, are presented in Table 2. The combinations Agra local × PBW 343 and Lal Bahadur × GW 324 exhibited significant *sca* effects in respect of number of grains per spike, harvest index and 1000 grain weight. In addition, the cross Lal Bahadur × GW 324 also showed significant *sca* effect in the desired direction for days to 50 per cent flowering, days to maturity, plant height and leaf rust score. The crosses NI 5439 × DWR 248, NI 5439 × DWR 247, C 306 × NIAW 34, Sonalika × PWB 343 and Pusa 4 × HD 2189 recorded positively significant *sca* effects for number of grains for spike and total biomass per plant. The cross Sonalika × PBW 343 also recorded significant *sca* effects in desired direction for leaf rust score, days to 50 per cent flowering and number of spikes per m^2 and the crosses C 306 × NIAW 34 and Pusa 4 × HD 2189 for spike length. For days to 50 per cent flowering, days to maturity, total biomass per plant and harvest index, the combination C 306 × DWR 248 exhibited *sca* effects in the desired direction. For peduncle length, none of these cross combinations showed significant *sca* effects because of the importance of both additive and non-additive genes in the expression of the character.

The two crosses NI 5439 × DWR 248 and Pusa 4 × HD 2189 with significant *sca* effects for grain yield involved both the parents with high *gca* effects. Thus,

Table 1. General combining ability effects of 12 parents in wheat

Parents	Days to 50 % flowering	Days to maturity	Plant height	No. of tillers/ plant	No. spikes/ m^2	Pedu- ncle length	Spike length	No. of grains/ spike	Total biomass /plant	Grain yield/ plant	Harvest index	1000 grain weight	Leaf rust score
Lines													
Agra local	–3.06**	–2.89**	2.38**	1.14	32.11**	0.09	0.72**	2.49**	–2.12	–8.9**	–0.09**	3.2**	1.24**
Lal Bahadur	–2.31**	–2.56**	–16.27**	0.65	–7.98*	–5.49**	–0.31**	–2.76**	–8.15**	–0.51	0.05*	–5.42**	1.49**
NI 5439	–1.47**	–2.31**	–3.78**	–1.05	–28.31**	1.22**	–0.84**	–0.88**	–9.17**	2.29*	0.12*	0.4**	–0.06
C-306	6.69**	7.86**	8.37**	–2.26**	12.85**	1.61**	0.11	3.34**	1.95	–0.09	–0.03	1.4**	0.07
Sonalika	0.11	–2.56**	–0.77**	0.1	10.08*	–0.3	–0.02	3.86**	5.78**	2.98**	–0.01	–1.53**	–1.47**
Pusa 4	0.03	2.44**	10.06**	1.41**	–18.74**	2.86**	0.34**	–6.05**	11.72**	4.23*	–0.02**	1.95**	–1.27**
Correlation with *per se* performance	0.9	0.53	0.87	0.12	–0.37	0.73	0.62	–0.55	0.79	0.57	–0.06	0.69	–0.001
Testers													
HD 2189	–1.81**	–0.72**	4.79**	0.85	24.96**	3.3**	0.19*	1.33**	–0.63	–3.88**	–0.07**	0.89**	–0.24
NIAW 34	–1.64**	–3.06**	–5.01**	–1.05	–32.01**	0.1	–0.51**	–1.53**	–7.25**	–0.97	0.06**	1.78**	1.66**
GW 324	4.11**	2.69**	–1.55**	2.54**	–6.35	–0.5**	0..36*	5.64**	0.72	–1.72	–0.01	1.05**	–1.03**
DWR 248	–3.89**	–2.06**	–7**	2.59**	36.87**	–1.32**	0.09	–1.37**	4.93**	6.68**	0.06**	–2.95**	–1.02**
DWR 247	1.03**	2.44**	13.56**	–3.53**	–13.71**	0.56**	–0.29**	–0.02	7.28**	1.75	–0.04**	–2.08**	–0.36
PBW 343	2.19**	0.69**	–4.79**	–1.41**	–9.76**	–2.14**	0.17**	–4.04**	–5.05**	–1.85**	–0.01	1.32**	0.99*
Correlation with *per se* performance	0.4	0.42	0.94	–0.13	–0.05	0.72	0.62	0.33	0.59	0.01	0.32	0.71	0.03
S.E.±	0.28	0.11	0.23	0.76	4.19	0.25	0.08	0.08	1.55	1.08	0.02	0.23	0.42

Significant at 5 and 1 % level respectively.

Table 2. Specific combining ability effects of eight best crosses in bread wheat for yield and its component traits.

Crosses	Days to 50 % flowering	Days to maturity	Plant height	No. of tillers/ plant	No. spikes/ m^2	Pedu- ncle length	Spike length	No. of grains/ spike	Total biomas s/plant	Gram yield/ plant	Harvest index	1000 grain weight	Leaf rust score
Agra local × PBW 343	2.64**	–0.11	1.61**	0.02	–38.12**	–2.47**	0.69**	4.94**	2.10	10.47**	0.13*	8.53**	–0.96
Lal Bahadur × GW 324	–6.53**	–14.44**	–1.53**	–4.68**	–82.18**	–1.79**	–0.68**	7.82**	–0.04	13.2**	0.25**	7.98**	–4.94**
NI 6439 × DWR 247	–2.78**	1.56**	1.17*	–3.71*	–51.10**	–0.65	–0.49**	0.45*	6.42*	5.92*	0.04	–0.21	–1.12
C-306 × NIAW 34	7.72**	2.89**	–1.61**	1.37	–86.71**	–0.89	0.58**	9.19**	20.92**	4.83*	–0.09	0.98*	1.79*
C-306 × DWR 248	–2.53**	–2.61**	0.33	2.38	11.02	–1.66**	0.18	–1.77**	15.74**	7.07**	0.001	1.01*	–0.58
Sonalika × HD 2189	–0.03	–5.03**	4.33**	–0.14	–31.25**	–0.47	–0.09	3.61**	–0.17	6.47**	0.13*	0.40	2.63**
Sonalika × PBW 343	–1.53*	2.06**	7.11**	1.56	20.02	–0.44	0.23	10.77**	17.00**	8.28**	0.03	–1.69**	–3.34**
Pusa 4 × HD 2189	–3.94**	5.47**	4.5**	2.28	–14.33	–0.33	1.36**	2.01**	8.89**	9.27**	0.09	0.46	–1.22
Correlation with *per se* performance	0.73	0.78	0.48	0.96	8.79	0.53	0.70	0.83	0.62	0.76	0.76	0.70	0.76
S.E. ±	0.83	0.25	0.52	1.70	9.36	0.55	0.19	0.19	3.47	2.42	0.08	0.52	0.94

*Significant at 5 and 1 % level respectively

additive genetic variation was predominant and progeny selection in the segregating generations will be effective for further genetic improvement. The rest of the crosses with significant *sca* effects for grain yield involved parents with low × low or high × low *gca* effects indicating the presence of non-allelic interactions. Therefore, recurrent selection for specific combining ability could be followed in the segregating generations of the crosses Agra local × PBW 343, Lal bahadur × GW 324, NI 5439 × DWR 247, C 306 × NIAW 34 and Sonalika × PBW 343.

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