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Heterosis and Combining Ability in Wheat

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The magnitude and nature of heterosis and combining ability in a set of diallel crosses of wheat (*Triticum aestivum* L. em Thell.), involving five genotypes, were studied for grain yield, 100-kernel weight, spike number and plant height. Positive overall heterosis was observed for all the characters except for 100-kernel weight. Over dominance was evident only for grain yield. Heterosis and over dominance effects for grain yield were positive in all the crosses except Sharbati Sonora x IR Amber, where partial-dominance for yield was observed. For kernel weight except the cross WG 423 x Sharbati Sonora, negative heterosis was observed. Heterosis ranged from 20.54 to 64.95 per cent and over-dominance effects from 26.16 to 38.85 per cent for spike number. For plant height heterosis was positive in eight crosses and over-dominance in one cross only. Both GCA and SCA variances were significant for all the characters except in the case of number of spikes where the GCA variance alone was found to be significant. For grain yield the magnitude of GCA and SCA variances were of the same order. For other characters the GCA variances were of relatively higher order than the corresponding SCA values. The additive effects were predominant in general. For grain yield, however, dominance/over-dominance effects were equally important.

Heterotic values as exhibited by various economic plant characters, are reflected on the production potential of a hybrid. The magnitude of general and specific combining ability variances are helpful in the selection of suitable germ plasm for designing an efficient breeding schedule. The investigations reported herein relate to the extent and nature of heterosis for various characters in wheat (*Triticum aestivum* L. em Thell.) and to an inkling into the importance of the GCA and SCA in the selection of suitable germplasm.

MATERIAL AND METHODS

A diallel set of bread wheat crosses involving five genotypes were grown at the Punjab Agricultural University, Regional Research Station, Gurdaspur. The material comprising fifteen entries (5 parents and 10 crosses) was raised in single row plots in randomized block lay-out with three replications. The parental lines chosen, viz. WG 423, Sharbati Sonora, Lerma Rojo Amber, WG 450 and Justin were of diverse origin.

The seed of each entry was dibbled in rows, 4 metres length with 45 x 15 cm spacing. The observations on the plant height, the number of spikes per plant and the grain yield were recorded on ten randomly selected plants (excluding the border plants) and the 100-grain weight on five random samples

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drawn from the bulk produce of each line. The magnitude of heterosis and over-dominance was worked out as per cent deviation over the estimated mid-parent and better parent values respectively. The data on plot means were analysed for general (GCA) and specific (SCA) combining ability estimates according to method II and model I of Griffing (1956).

RESULTS AND DISCUSSION

Heterosis and Over-dominance: The mean values of parents and F_1 hybrids for different characters are presented in Table I and the estimates of heterosis and over-dominance in Table II. An overall positive heterosis was observed for the grain yield, the number of spikes per plant and the plant height while negative heterosis was recorded for the 100-kernel weight. Hybrid vigour for the grain yield over mid-parent ranged from 2.45 to 63.45 per cent and over better parent from 0.62 to 50 per cent. Increase in mean grain yield of hybrids over corresponding mean of mid and better parent values was 25.9 and 14.75 per cent respectively. Positive heterosis for the grain yield was observed in all crosses. Similar estimates were realized in all the crosses for over-dominance except Sharbati Sonora x IR Amber in which partial-dominance for yield was observed. The highest magnitude of heterosis was observed in the crosses, Sharbati Sonora x WG 450 and LR Amber x WG 450, involving a poorest yielding parent, WG 450, indicating that high yielding parents do not necessarily produce high yielding hybrids. High heterotic effects might be associated with high degree of genetic diversity among the parents and favourable gene combination in the hybrids (Ahluwalia and Dhawan, 1963).

TABLE I. Mean performance of parents and F_1 hybrids for different characters

Parent/cross	Grain yield per plant (g)	100-Kernel weight (g)	Spikes/plant	Plant height (cm)
WG 423	15.6	4.06	9.5	64.8
Sharbati Sonora	15.8	4.22	11.5	82.3
LR Amber	20.9	4.73	13.9	90.2
WG 450	13.2	4.62	13.6	83.1
Justin	16.1	3.25	17.2	132.5
WG 423 × Sh. Sonora	17.8	4.32	11.6	73.9
WG 423 × LR Amber	22.5	3.69	19.3	72.2
WG 423 × wG 450	18.0	4.07	12.2	77.8
WG 423 × Justin	19.1	3.62	17.4	96.8
Sh. Sonora × LR Amber	17.9	4.13	10.6	89.8
Sh. Sonora WG 450	23.7	4.37	13.6	88.8
Sh. Sonora × Justin	19.6	3.66	13.4	110.3
LR Amber × WG 450	22.5	4.24	14.1	87.0
LR Amber × Justin	21.3	3.63	12.9	121.1
WG 450 × Justin	16.2	3.52	12.7	122.3
C.D. (5%)	2.12	0.18	2.29	11.19

In all the crosses except WG 423 x Sharbati Sonora, negative heterosis was observed for 100-kernel weight. This indicated the partial-dominance of small seeded type over the bold one.

High degree of heterosis, ranging upto 64.95 per cent, was observed for spike number in the cross WG 423 x LR Amber where WG 423 was the poorest tillering parent. Varying degree of over-dominance for spike number was

TABLE II. Expression of heterosis and over-dominance (%)

Cross	Grain yield		100-kernel weight		Spike number		Plant height	
	Hetero-sis	Over-dominance	Hetero-sis	Over-dominance	Hetero-sis	Over-dominance	Hetero-sis	Over-dominance
WG 423×Sh. Sonora	13.38	12.74	4.34	2.37	10.47	0.87	0.75	-10.26
WG 423×LR Amber	23.29	7.65	-16.13	-21.98	64.95	38.85	-6.59	-19.95
WG 423×WG 450	25.00	15.32	-6.22	-10.90	5.63	-10.29	5.35	-6.49
WO 423×Justin	20.50	18.63	0.00	-10.84	30.34	1.16	-1.07	-26.94
Sh. Sonora×LR Ambet	2.45	-14.35	-7.81	-12.69	-17.32	-23.74	4.11	-0.44
Sh. Sonora×WG 450	63.45	50.00	-1.13	-2.41	0.39	0.00	7.37	6.87
Sh. Sonora×Justin	22.88	21.74	-2.14	-13.27	-7.09	-22.09	2.70	-16.75
LR Amber×WG 450	31.38	7.65	-9.40	-10.36	2.54	1.44	0.44	-3.55
LR Amber×Justin	15.05	1.91	-9.02	-21.14	-20.54	-25.00	8.75	8.60
WG 450×Justin	10.58	0.62	-10.67	-23.80	-17.53	-26.16	13.45	7.69
Mean	25.90	14.75	-5.82	-12.90	5.18	-6.50	3.47	-9.38
C. D. (5%)	1.85		0.15		1.98		9.56	

observed in the crosses WG 423 x LR Amber, LR Amber x WG 450, WG 423 x Justin and WG 423 x Sharabati Sonora. Mehndiratta (1968) also observed dominance and over-dominance for spike number in wheat.

Justin was the tallest parent and WG 423 the shortest. WG 450, Sharbati Sonora and IR Amber were semi-dwarf strains. Moderate heterosis was observed for plant height in various crosses. Over-dominance was observed in one cross, i. e. Sharbati Sonora x WG 450.

Combining Ability Analysis: The analysis of variance for the general and the specific combining ability indicated highly significant differences for all the characters except the number of spikes per plant, where general combining ability was significant and specific combining ability was not significant (Table II). The high magnitude of GCA variances for traits showed that the inheritance of these characters was predominantly influenced by additive component of genetic variance which is fixable and heritable. Highly significant variances for general and specific combining ability for the grain yield, the 100-kernel weight and the plant height indicate that both additive genetic components made a significant contribution in bringing about heterotic effects. Kronstad and Foote (1964) and Brown *et al*. (1966) reported high influence of additive gene effects in determining the grain yield, while Tandon (1961) reported the presence of complementary epistasis. Variety LR Amber was good combiner for the grain yield, LR Amber, Sharbati Sonora and WG 450 for the 100-kernel weight and Justin for the spike number and plant height (Table IV).

Specific combining ability effects for grain yield were significant in 7

TABLE. III. Analysis of variance for combining ability

Source of variation	d.f.	Mean squares			
		Grain yield (g)	100-kernel weight (g)	Spike number	Plant height (cm)
GCA	4	9.928**	0.4888**	6.7875**	1351.550**
SCA	9	10.695**	0.0618**	0.0706	24.915*
Error	28	0.053	0.0004	0.9107	1.476

** Significant at P=0.01 * Significant at P=0.05

crosses, viz., Sharbati Sonora x WG 450, LR Amber x WG 423 x LR Amber, Sharbati Sonora x Justin, WG 423 x Justin, IR Amber x Justin and WG 423 x WG 450 in that order. Except LR Amber other parents involved in these crosses had negative general combining ability effects, showing that dominance/over-dominance gene effects were involved in determining the yield. Whitehouse *et al.* (1958) and Tandon (1961) also reported the effect of dominance to over-dominance with complementary epistasis in yield.

Bold seeded varieties, LR Amber, WG 450 and Sharbati Sonora were good general combiner for 100-grain weight and Justin the poorest, Specific combining ability effects for 100-grain weight in the crosses, WG 423 x Sharbati Sonora, WC 423 x Justin and Sharbati Sonora, x WG 450 were significant. In the cross WG 423 x Sharbati Sonora, dominance/over-dominance and in the crosses WG 423 x Justin and Sharbati Sonora x WC 450 the additive gene effects contributed largely to 100-grain weight.

For spike number, specific combining ability effects were positive and significant in the crosses WG 423 x LR Amber, WG 423 x Justin and Sharbati Sonora x WG 450. Non-additive gene effects in these crosses were important in determining the spike number.

Except Justin, GCA effects for plant height for all the varieties were negative. Specific combining ability effects for this character were significant in the crosses, WG 450 x Justin, LR Amber x Justin, WG 423 x WG 450, Sharbati Sonora x WG 450 and Sharbati Sonora x LR Amber in that order of merit. In all the crosses dominance gene effects were involved in determining the plant height. However, in the crosses WG 423 x WG 450, Sharbati Sonora x WG 450 and Sharbati Sonora x LR Amber additive genetic component was also important.

LR Amber had significant GCA effects for grain yield and 100-kernel weight, Justin for spike number and plant height, and Sharbati Sonora and WG 450 for the 100-kernel weight. These studies would help the selection of germ plasm for the incorporation of the specific character in the new progeny.

TABLE IV. Estimates of GCA effects for the parents and SCA effects for the crosses.

Parent/cross	Grain yield	100-kernel weight	Spike number	Plant height
GCA effects				
WG 423	-0.667	-0.033	-0.271	-15.366
Sh. Sonora	-0.714	0.124	-1.314	-4.220
LR Amber	2.114	0.157	0.471	-0.923
WG 450	-0.629	0.056	0.229	-2.137
Justin	-0.400	-0.446	1.343	22.649
C. D. (5%)	0.252	0.021	1.044	1.331
SCA effects				
WG 423 × Sh. Sonora	0.350	0.220	-0.381	0.662
WG 423 × LR Amber	2.224	-0.443	5.104	-4.338
WG 423 × WG 450	0.467	-0.104	-0.867	2.376
WG 423 × Justin	1.338	0.090	2.761	-3.309
Sh. Sonora × LR Amber	-2.032	-0.160	-2.124	2.119
Sh. Sonora × WG 450	6.509	0.039	1.576	2.334
Sh. Sonora × Justin	2.166	0.023	-0.195	-0.952
LR Amber × WG 450	2.481	0.124	0.290	-2.766
LR Amber × Justin	1.052	-0.090	-2.481	6.548
WG 453 × Justin	-1.276	-0.244	-1.981	8.962
C.D. (5%)	0.3645	0.0305	1.5135	1.747

The cross Sharbati Sonora x WG 450 was conspicuous for significant SCA values for grain yield, 100-kernel weight, spike number and plant height; WG 423 x Justin for grain yield, spike number and 100-kernel weight; WG 423 x LR Amber for the grain yield and spike number and WG 423 x Sharbati Sonora for 100-kernel weight. Transgressive segregates would be expected in the segregating generations of these crosses.

Additive component had predominant influence on all the characters under study except grain yield where dominance / over - dominance gene effects were important. The grain yield, the 100-grain weight and the plant height were influenced both by additive and non-additive components.

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