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Heterosis in Wheat

by

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The value of heterosis is known since ancient times to animal breeders. Considerable interest has been generated during recent years in the exploitation of hybrid vigour in crop improvement. The utilization of heterosis appears to be quick, cheap and easy method of increasing yield in vegetatively propagated crops and in cross-fertilized crops like maize, pearlmillet, *sorghum*, onion *etc.* But little use has been made of heterosis breeding in self-fertilized crops. The development of genetic and chemical methods of emasculation (Pal and Sikka, 1956) has brought economic production of hybrid seed in self-fertilized crops into the realm of probability. Recent studies in barley (Jain and Allard, 1960), in Mungbean (Bhatnagar and Singh, 1964) have suggested that heterozygote advantage might be met with in self-fertilized crops also. While studying a large number of economic crosses it was considered desirable to investigate whether any heterosis could be exhibited by crosses among different pure lines of wheat.

Review of literature: Observations on heterosis in wheat date back to 1919, when Freeman studied date of first head, height and leaf width in crosses involving a *durum* wheat and three common wheats. Engledow and

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Pal in 1934 suggested the possibility of increasing wheat yields by growing F_2 and F_3 generations of particular crosses which exhibited hybrid vigour in the F_1, since growing the F_1 generations in wheat was impractical. Several instances of significant heterosis in wheat have been reported in the literature. Harrington (1940) tested F_2s which produced from 52 to 64 per cent more grain than the parental mean. Varenica (1948) reported F_1s which yielded 72 per cent more than the mean of the parents and Cho and Chiang (1958) indicated yields up to 88 per cent more than the parental mean. Sikka *et al.* (1959) reported a particular cross which yielded 131·4 per cent more than the mean of the parents. In comparing F_1s and the higher yielding parent, Boyce (1948) listed a 32·7 per cent; Lupton (1961) 44 per cent and Sikka *et al.* (1959) an 84 per cent advantage for a respective F_1 hybrid. Briggle (1963) has given a comprehensive review of such studies in wheat.

Material and methods: The material consisted of seven pure lines, K. 103–17, Pb. C. 303, Pb, C. 306, E. 5573, E. 5580, K. 13 and Sonora. 63. From these parents four intraspecific hybrids were studied. All the parents and hybrids were space planted. The distance from seed to seed was 6" and row to row was 24". They were sown in non-replicated rows due to paucity of hybrid seeds. The seeds of hybrids were sown in the central row flanked on either side by parents. Observations were taken on a number of tillers per plant, number of spikelets per ear, leaf length and breadth, height, number of seeds per ear and yield per plant.

The mean of five plants was taken in case of parents. But in the case of hybrids, the observations could be taken only on four, five, two and one plant respectively in the four crosses. Since parents and F_1s were grown under identical conditions, a valid comparison of their relative performance can be made. In the table, the best performing parent in respect of each character has been underlined. The performance of the hybrid in respect of the various characters is presented in terms of percentage increase or decrease over (i) the mean of respective parents $\frac{P_1 + P_2}{2}$ (ii) the better of the two parents.

TABLE 1 *Performance of seven parents and four intraspecific hybrids in wheat.*

No.		Cross Combination	Tillers / Plant	Spikelets / Ear	Length of leaf (cm)	Width of leaf (cm)	Height (cm)	Seeds / Ear	Yield in gm / Plant
1		2	3	4	5	6	7	8	9
I	(i)	K. 103-17 (P_1)	13·0	15·5	**24·6**	**1·9**	90·0	35·3	16·0
	(ii)	Pb. C. 303 (P_2)	**20·0**	**19·0**	20·7	1·6	**110·4**	**43·4**	**24·6**
	(iii)	F_1	27·0	19 0	28 3	2·1	107·2	46·1	39·1
	(iv)	$\frac{P_1+P_2}{2}$	16·50	17·25	22·65	1·75	100 00	39·35	20·30

S. No.		Cross combination	Tillers	Spikelets	Length of leaf (cm)	Width of leaf (cm)	Height (cm)	Seeds Yield in gr	
			Plant	Ear				Ear	Plant
1		2	3	4	5	6	7	8	9
	(v)	Percentage increase/decrease over better parent.	+35·00	...	+15·04	+10·57	—2·89	+6·22	+58·01
	(vi)	Percentage increase/decrease over mean of parent.	+63·63	+10·14	+24·04	+20·00	+6·97	+17·16	+92·61
II	(i)	E. 5580 (P_1)	**15·0**	**18·0**	**24·8**	1·7	**99·0**	**39·5**	**20·2**
	(ii)	K. 103-17 (P_2)	13·0	15·5	24·6	**1·9**	90·0	35·3	16·0
	(iii)	F_1	26·0	21·0	23·1	2·1	87·0	44·4	31·6
	(iv)	$\frac{P_1+P_2}{2}$	14·0	16·75	24·70	18·0	94·50	37·4	16·1
	(v)	Percentage increase/decrease over mean of parent.	+73·33	+16 66	—6·85	+10·53	—12·12	+12·41	+56·44
	(vi)	Percentage increase/decrease over mean of parents.	+85·71	+25·43	—6·47	+16·66	—7·94	+18·72	+74·58
III	(i)	E. 5573 (P_1)	24·0	19·0	**27·1**	1·9	50·4	49·0	25·2
	(ii)	Pb. C. 306 (P_2)	**29·0**	**22·0**	25·8	**1·9**	**104·0**	**53·0**	**40·0**
	(iii)	F_1	50·0	24·0	28·0	1·7	96·0	51·6	56·0
	(iv)	$\frac{P_1+P_2}{2}$	26·50	20·50	26·45	1·9	77·2	51·0	32·6
	(v)	Percentage increase/decrease over the better parent.	+72·41	+9·09	+3·32	—10·53	—7·69	—2·64	+40·00
	(vi)	Percentage increase/decrease over mean of parents.	+88·68	+17·07	+5·86	—10·53	+24·35	+1·18	71·77
IV	(i)	Sonora 63 (P_1)	**18·0**	**17·0**	21·3	**1·7**	75·0	**40 0**	**21·2**
	(ii)	K. 13 (P_2)	16·0	16·0	**25·8**	**1·7**	**101·0**	34·0	17 8
	(iii)	F_1	38·0	22·0	28·9	2·0	106·0	44·7	64·0
	(iv)	$\frac{P_1+P_2}{2}$	17·00	16·50	23·55	1·70	88·0	37·0	19·50
	(v)	Percentage increase/decrease over better parent	+111·11	+29·53	+12·01	+17·65	+4·95	+10·75	+201·88
	(vi)	Percentage increase/decrease over mean of perents.	+123·53	+33·33	+22·72	+17·65	+20·45	+20·81	+228·20

"t" value for seed yield could not be calculated because individual plant yields of parents were not taken.

Results and Discussion: The performance of hybrids and parental varieties are presented in table.

All the four crosses namely K. 103–17 x Pb. C. 303, E. 5580 x 103–17, E. 5573 x Pb. C. 306 and Sonora. 63 x K. 13 showed considerable heterotic effect for grain yield; the increase ranging from 71·77 to 228·20 per cent compared to the mean of the respective parents and 40·0 to 201·88 per cent as compared to the superior parent.

In self-fertilized cross, comparison with the best available pure line rather than with the better parent of a particular cross, is of interest in the practical utilization of hybrid vigour. Pb. C. 306 is one of the best varieties of India. Therefore, the performance of four hybrids was also compared with Pb. C. 306 which in these studies also has proved to be the top yielder. With such comparison only two crosses E. 5573 x Pb. 306 and Sonora. 63 x K. 13 out yielded— C. 306 parents. Since both these crosses involve one indigenous and one exotic variety, it appears that genetic diversity plays an important role in case of wheat crops also.

Heterosis for other characters: It would be seen from the results presented in table 1 that apart from yield heterosis was also observed with respect to other characters in all the cross-combinations. The main characters which are the components of yield *e. g.* number of ear bearing tillers per plant, number of spikelets per ear and number of seeds per ear showed heterosis. The record of grain weight was not taken. The percentage increase over the mean of the parents and over the better parent for these characters, was calculated in these cross-combinations. As regards number of tillers, percentage increase ranged from 35·00 to 111·1 over the better parent and percentage increase over the mean of the parents ranged from 63·6 to 123·5. The spikelet number has not shown much heterosis and percentage increase over the better parent is from 0 to 29·53 and over the mean of the parents the increase is from 10·14 to 33·33. However with regard to number of seeds per ear, in one combination (E. 5573 x Pb. C. 336) there was slight decrease over the better parent by 2·64 indicating negative heterosis. In other cross-combinations, the number of seeds per ear show an increase from 6·22 to 12·41 per cent over the better parent and from 17·16 to 20·81 per cent over the mean of parents. These results tend to support the view that yield is a composite character and there may be no yield genes *per se*, (which is largely an artefact) but rather only for the various components of yield, the multiplicative interaction of which results in yield. Other characters studied were, the length and breadth of the leaf and height of the plant. The heterosis with respect to height was noticed over the mean of the parents in the three crosses except E. 5580 x

K. 103–17 in which there was slight decrease from the mean of the parents. Only Sonora 63 x K. 13 showed increase over the better parent with respect to height. In other two crosses (K. 103–17 x Pb. C. 303 and E. 5573 x Pb. C. 306), there was decrease over better parents, but increase over the mean of the parents. Heterosis for the length and breadth of the leaf was noticed in the cross combinations K. 103–17 x Pb. C. 303 & Sonora. 63 x K. 13 over the better parents but in cross combination E. 5580 x K. 103–17 there was increase over the better parent and over the mean of the parents for leaf breadth but leaf length in F_1 decreased from the mean of the parents. In the cross combination of E. 5573 x Pb. C. 306, the percentage increase for leaf length was 3·32 and 5·86 over the better parent the mean of the parents respectively. In the same cross leaf breadth showed decrease of 10·53 over better parent as well as the mean of the two parents. It therefore, appears that heterosis is manifest on some characters and not on all the characters.

Summary: A preliminary study of four intervarietal crosses involving seven pure lines in wheat has shown that two of them (Sonora. 63 x K. 13 and E. 5573 x Pb. C. 306) have significantly outyielded the best parent Pb. C. 306. The best hybrid combination (Sonora. 63 x K. 13) in which heterosis was manifested for all the characters studied gave an yield of 64 gm per plant as compared to 40 gm given by the best parent. This increase indicates the role of genetic diversity in the exploitation of heterosis in wheat crop, if and when the production of hybrid seed becomes economically feasible.

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