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Heterosis studies in bread wheat (*Triticum aestivum* L.)

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Abstract: *A 6 × 6 parent full diallel set of bread wheat (Triticum aestivum L) was studied for better parent and standard variety. The magnitude of heterosis from F_1s was calculated for days to heading, days to maturity, tillers per plant, plant height, spike length, spikelets per spike, grain yield and 1000 grain weight. This study showed that the manifestation of heterosis in F_1 hybrids over better parents and standard variety were present for grain yield and yield components. In general positive heterosis was observed for grain yield for both the best parent and standard variety. The increase in grain yield in F_1 hybrids seemed to be due to high manifestation of hybrid vigour in the yield components. The maximum heterosis for better parent and standard variety for yield per plant were 194.10% and 193.97% respectively.*
Key words: *Bread Wheat, Plant Height, Grain Yield, Better Parent, Standard Variety*

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I. Introduction

Exploitation of heterosis is considered to be one of the outstanding achievements of plant breeding. In a self pollinated crop like wheat the scope of utilization of heterosis depends mainly on the direction and magnitude of heterosis. Estimation of heterosis over better parent (heterobeltiosis) may be useful in identifying true heterotic cross combinations but these cross combinations may be of immense value if they show superior to the standard variety or the best variety of the area. The present study was undertaken to quantity the magnitude of heterosis over the standard variety of bread wheat apart from that of better parent in grain yield and seven other yield components viz., days to heading, days to maturity, tillers per plant, plant height, spike length, spikelets per spike and 1000 grain weight.

The aim of heterosis is to exploit increased vigour in self-pollinated crops like wheat in order to getting increased yield. Heterosis in wheat was first reported in 1919 by Freeman. It was first observed by Englendow and Pal for grain yield in 1934 and subsequently by other workers. For exploitation of heterosis there is necessary for male sterile line. However discovery of cytoplasmic male sterility in this crop was reported by Kihara (1951), Fukasawa (1953) and Wilson and Ross (1961, 1962) and restorer genes by Schmidt, Johnson and Mann (1962) which was important for exploitation of commercial hybrid wheat. Workers like Wilson and Ross (1962) reported 71 percent seed set on male sterile plants under naturally cross-pollinated conditions. However, there is disadvantage also. Lahr and Atkinsons (1965) obtained only 1.8 to 14.1 percent seed set. Porter and Atkinsons (1963) and Miri (1966) have reported on the problems and potentials of economic production of hybrid wheat.

II. Materials and methods

Genotypes of bread wheat *viz*., HD 2888, C306, DBW 39, PBW 343, K 8027 and HD 3083 were crossed in all possible combinations excluding reciprocals at Jaguli Instructional Farm, B.C.K.V, West Bengal. The 6 parents and 15 F_1s were grown in a randomised Block Design with 3 replications with normal sown and irrigated condition (three irrigation). Each plot consisted of single row of 4 meter with a spacing 23 cm . Plant to plant distance was kept for 10 cm apart. The data were recorded on 10 randomly selected plants from each row for 8 characters *Viz.*, days to heading, days to maturity, tillers per plant, plant height, spike length, spikelets per spike, 1000 grain weight and grain yield per plant. Heterosis over better parent (BP) and standard variety (SV) was calculated as per standard procedures in the following ways-

$$\text{Heterosis over better parent} = \frac{F_1 - BP}{BP} \times 100 \text{, where, BP is Better Parent}$$

And heterosis over standard variety = $\frac{F_1\text{-SV}}{\text{SV}} \times 100$, where, SV is Standard Variety

S.E of heterosis over better parent = $\sqrt{\frac{3Me}{r}}$ Where, Me = error mean square of ANOVA,

r = number of replication

S.E of over standard variety = $\sqrt{\frac{2Me}{r}}$

C.D at 5% or 1% = S.E ×$t_{5\% \text{ or } 1\%}$ error d.f
Genotype K 8027 was selected as standard variety of bread wheat for the present study.

III. Results and Discussion

The range of heterosis, number of economic crosses (in parenthesis) and number of crosses showing significant economic heterosis over better parent and over standard variety for all the 15 crosses were presented in table-1. Maximum heterosis for grain yield per plant over better parent (BP) and standard variety (SV) was observed to be 194.10% and 193.97% respectively. Heterosis over better parent for grain yield was reported by several wheat workers in the past (Briggle *et al*. 1967, Yadav and Murty 1967, Gyawali *et al*. 1968, Sharma *et al*. 1986 and Prasad *et al*. 1998) some workers (Singh and Kandola 1969, and Singh and Singh 1978) reported grain yield to show maximum heterosis than any other character they studied. In the present study also heterosis observed on grain yield per plant was maximum. Heterosis was found in tillers per plant next to grain yield per plant. In case of standard variety heterosis was maximum in grain yield and next heterosis was found in tillers per plant also.

From the table -2 it was seen that non-additive components were greater than additive components for all the characters studied except for days to maturity. This is desirable in case of studying heterosis.

From the table-3 it was quite evident that in better parent heterosis for yield per plant was negatively related with days to flowering, days to maturity, plant height and 1000 grain weight and positively relation with tillers per plant, spike length and spikelets per spike. Days to flowering and maturity showed negative heterosis by workers like Patwary *et al*. (1986) and Sadeque *et al*. (1991). Early maturity type was desirable where multiple cropping were followed. Plant height in the present study was followed negative heterosis. Negative heterosis of plant height was recorded by Sadeque *et al*. (1991); Bhutta *et al*. (2005), Ilkar *et al*. (2010) and Bilgin *et al*. (2011). Inamulla *et al*. (2006) reported that taller plant are likely to lodge quite often. Tall plants require more energy to translocate solutes to grain and Jan *et al*. (2005) also reported that negative heterosis is desirable when breeding for lodging resistance was required. In the present study 14 out of 15 crosses exhibited positive heterosis for better parents for spike length. Higher and lower values from the hybrids were C306 × PBW 343 (36.08) and C306 × K 8027 (3.00). These findings were supported by Moisc *et al*. (1984), Cifci and Yagdi (2000), Chowdhury *et al*. (2005), Bilgin *et al*. (2011) and Cifci (2012). Significant and positive heterosis values for spikelets per spike were found for 12 out of 15 crosses. These findings were in agreement with Singh *et al*. (2004), Ilker *et al*. (2010) and Cifci (2012). For tillers per plant all of the 15 crosses exhibited significant positive values.

Heterosis was estimated over wide adapted and high yield variety K8027 and results were presented in table-4. The significant standard heterosis in desirable direction was observed in C 306 × PBW 343 and K 8027 × HD 3083 for early flowering and grain yield per plant. Standard heterosis for number of tillers per plant was observed in all the crosses studied. The standard heterosis for plant height in desirable direction was observed in 7 crosses out of 15. Eight crosses in economic heterosis for spike length and 6 crosses for spikelets per spike were observed in desirable direction. 10 crosses out of 15 for 1000 grain weight and 14 crosses out of 15 were observed for grain yield. Hence Enhancement of grain yield is possible through hybridization. The crosses which exhibited significant economic heterosis for grain yield per plant were HD 2888 × C306, HD 2888 × DBW 39, HD 2888 × PBW 343, HD 2888 × K 8027, HD 2888 × HD 3083, C 306 × DBW 39, C 306 × PBW 343, C 306 × K 8027, C 306 × HD 3083, DBW 39 × PBW 343, DBW 39 × K 8027, DBW 39 × HD 3083, PBW 343 × K 8027 and K 8027 × HD 3083. It indicated that high yielding varieties involved in the crosses were predominantly responsible for enhancing the yield. Similar findings were reported by Sharma *et al*. (1991) and Kumar *et al*. (2011).

Table 1: Range of heterosis, number of economic crosses (in parenthesis) and significant economic crosses for eight characters in bread wheat

Characters	Range of heterosis		Number of crosses showing heterosis	
	BP	SV	BP	SV
Days to heading	-15.8-5.35	-10.34-10.34	4(15)	6(15)
Days to maturity	-9.99-0.29	-2.02-7.05	6(15)	5(15)
Number of tillers per plant	45.66-173.99	43.50-173.97	15(15)	15(15)
Plant height	-25.29-4.71	-25.30-5.65	8(15)	7(15)
Spike length	0.01-36.08	-5.58-36.08	14(15)	11(15)
Spikelets per spike	-5.26-24.14	-10.34-24.15	12(15)	14(15)
Grain yield per plant	9.85-194.10	7.34-193.97	13(15)	14(15)
1000 grain weight	-21.86-0.29	-20.50-27.92	-(15)	12(15)

BP = Better Parent, SV = Standard Variety

Table 2: Analysis of variance among parents and hybrids and estimates of additive and non-additive components for eight different characters in bread wheat

Source	d.f	Days to 50 % flowering	Days to maturity	Tillers per plant	Plant height (cm)	Spikelets per spike	Grain yield per plant	1000 grain weight (g)	Spike length (cm)
Parents	5	11.83	57.02**	10.36	77.70*	3.16*	112.55	87.65**	0.63
Hybrids	14	66.34**	26.21**	108.42**	269.71**	7.50**	731.64**	33.40**	4.42**
Error	40	7.13	2.85	5.12	25.82	1.01	331.88	2.10	0.41
δ^2A		1.79	7.17	10.26	23.71	0.58	33.00	9.16	0.33
δ^2D		17.82	3.83	93.70	61.52	2.46	38.74	9.96	1.63

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

Table 3: Heterosis of grain yield and yield components over better parents in bread wheat

Crosses showing significant positive heterosis and negative heterosis over better parent	Grain yield per plant	Days to 50% flowering	Days to maturity	Tillers Per Plant	Plant Height	Spike Length	Spikelets per Spike	1000 Grain Weight
HD2888 X C306	50.36**	-	-4.05**	152.35**	-	9.09**	9.63**	-3.43**
HD2888 X DBW39	61.02**	-	-9.99**	92.85**	-9.14*	15.18**	9.45**	-21.86**
HD2888 X PBW343	33.70**	-	-	84.62**	-	15.18**	9.62**	-12.64**
HD2888 X K8027	88.88**	-	-	95.69**	-	-	-3.41**	-15.55**
HD2888 X HD3083	89.41**	-	-	146.15**	-	6.09**	-3.51**	-7.72**
C306 X DBW39	69.18**	-	-9.46**	109.50**	-	9.09**	7.58**	-8.98**
C306 X PBW343	37.93**	-13.76**	-5.67**	78.57**	-16.57**	21.18**	5.88**	-15.26**
C306 X K8027	194.10**	-	-4.05**	173.97**	-	36.08**	24.14**	-11.02**
C306 X HD3083	150.30**	-	-	169.07**	-	3.00**	-5.26**	-9.22**
DBW39 X PBW343	90.88**	-	-	84.61**	-23.58**	21.18**	18.91**	-21.76**
DBW39 X K8027	129.40**	-	-	117.41**	-12.50**	13.91**	8.62**	-
PBW343 X HD3083	-	-	-	100.00**	-25.29**	9.09**	12.26**	-21.66**
PBW343 X K8027	96.53**	-15.80**	-3.19**	45.66**	-10.39**	8.33**	3.46**	-14.87**
PBW343 X HD3083	-	-	-	94.84**	-14.89**	18.18**	5.26**	-21.35**
K8027 X HD3083	91.26**	11.20**	-	63.07**	-7.43**	13.91**	1.75*	-3.82**

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

Table 4: Heterosis of grain yield and yield components over standard variety in bread wheat

Hybrids	Days to 50% flowering	Days to maturity	Tillrs per plant	Plant height	Spike length	Sppikelet per spike	Grain yield per plant	1000 grain weight
HD 2888X C 306	6.03**	4.41**	130.46**	5.65	0.00	-1.70*	48.26**	27.92**
HD 2888X DBW 39	-3.01	-2.02	76.12**	-8.33**	5.50**	0.00	58.77**	3.49**
HD 2888X PBW343	1.29	1.47	56.55**	0.89	5.50**	-1.70*	31.83**	15.72**
HD 2888X K8027	-0.86	0.88	95.69**	-0.59	0.00	-3.46**	88.87**	11.86**
HD 2888X HD3083	0.00	2.64**	108.74**	-1.78	-2.83**	-5.17**	86.73**	22.24**
C306 X DBW39	3.01	-1.47	91.32**	-2.98	0.00	-1.70*	61.83**	11.99**
C306 X PBW343	-8.18**	2.64**	63.07**	-11.60**	11.08**	-6.88**	34.79**	9.38**
C306 X 8027	2.58	4.41**	173.97**	5.35	36.08**	24.15**	193.97**	9.3**
C306 X 3083	10.34**	7.05**	145.66**	-5.66	-5.58**	-6.88**	139.38**	13.77**
DBW39 X PBW343	-0.86	1.47	56.55**	-19.05**	11.08**	8.63**	86.53**	0.98
DBW39 X K8027	0.42	-1.47	117.41**	-12.50**	13.83**	8.63**	129.28**	3.85**
DBW39 X HD 3083	5.59**	-0.88	43.50**	-25.30**	0.00	10.34**	11.73**	-1.82
PBW343 X K8027	3.87*	-1.76	45.66**	-5.06	8.33**	3.46**	96.53**	12.42**
PBW343 X HD3083	-10.34**	0.59	65.23**	-9.82*	13.83**	1.70*	7.34	1.49
K8027 X HD3083	-10.34**	0.29	63.07**	-7.44*	-8.33**	-10.34**	91.22**	20.56**

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

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