Pak. J. Agri. Sci
27 (4) 374, 1990

ESTIMATION OF HETEROSIS AND INHERITANCE OF SOME QUANTITATIVE CHARACTERS OF ECONOMIC IMPORTANCE IN SPRING WHEAT CROSSES

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Substantial heterosis was observed for plant height, grain yield and yield components in eight wheat crosses involving local and exotic wheat crosses. The F_1 hybrids exhibited heterosis due to partial dominance for plant height, dominance for number of fertile tillers and non–additive effects in the range of partial dominance and over dominance for the traits of spike density and grain yield. Varying degree of inbreeding depression was observed for the traits studied. Reciprocal differences between hybrids were found to being significant for number of fertile tillers and grain yield.

INTRODUCTION

Although new sophisticated approaches are being developed and tested to maximize wheat productivity, yet conventional procedures and practices continue to be employed by wheat breeders with emphasis on the development of short–statured wheats adapted to different production situations. One of the future possibility to boost wheat production is through the utilization of hybrid vigour. The other alternative of exploitation of hybrid vigour is the selection of pure lines in segregating generations showing a higher level of heterotic affects. Thus a number of parents have to be evaluated in various combinations to develop lines out–yielding their parents. In the present studies, two most widely adapted tall staturated local cultivars were crossed with three short statured wheat cultivars of Mexican origin to estimate heterosis and pattern of inheritance of some quantitative characters of economic importance.

There is a substantial evidence of quantitative inheritance and expression of varying degree of heterosis for the characters of plant height, grain yield and yield components in spring and winter wheats (Romero and Frey, 1973; Ghafoor, 1975; Rajki *et al.*, 1976; Vlach and Kren,1981 and Choudhry *et al* ., 1982). Spike length behaves as a complexily inherited character showing little heterosis (Mariani and Zetelli, 1973), however, marginal increase over better parent was reported by Din (1980). Partial dominance and dominance controlled the expression of plant height, spike length, number of spikelets per spike and grain yield as reported by Fedin (1976) and Prakash and Rao (1977), while other workers reported additive type of gene action for these traits (Verma *et al.*, 1984 and Cammock, 1984). Generally additive (Srivastava *et al.*, 1981) but in some cases dominance controlled the inheritance of number of fertile tillers (Fedin, 1976).

MATERIALS AND METHODS

The parental material used in developing crosses consisted of (i) two local cultivars of wheat namely, C273 and C271, characterized by tall stature and late heading and (ii) three short-statured and early maturing cultivars, AU49, Mexipak 65 and Sonora 64 belonging to the Mexican group of wheats introduced in Pakistan. The experimental material consisting of parents, all possible F_1 crosses including reciprocals and F_2 populations were planted in field in single rows of 6.5 metres length having row to row distance of 30 cm and plant to plant distance of 9 cm. The experiment was laid out in a randomized complete block design with three replications in 1987–88. For the purpose of recording observations, random selection of 80, 50 and 400 plants from parents, F_1 and F_2 populations were made, respectively. The data on characters of plant height (cm), number of fertile tillers, spike density and grain yield per plant were recorded. Spike density was calculated by the formula; $D = N/L \times 10$, where D is spike density, N is total number of spikelets per spike and L is length of spike (cm) of 10 normally developed spikes (cm).

Statistical observations like means and variances for all the populations were calculated on a plot mean basis. Heterosis or the superiority of the hybrids over its parents was quantitatively measured in relaction to the average of the parents as well as better parent. The relationship of heterosis and dominance was studied after Allards (1960) and Simmonds (1979). Inbreeding depression was measured by the formula $(100(F_1 - F_2))/F_1$ as decribed by Singh (1973). The significance of heterosis and inbreeding depression was tested by calculating cririical difference (CD) by the formula: CD = S.E. x t, where S.E. is standard error of the difference of the varietal means. Dominance estimates were determined for each trait by using potence ratio method (Griffing, 1950).

RESULTS AND DISCUSSION

The analysis of variance for different traits indicated that highly significant variation was present among wheat genotypes for plant height and grain yield while significant differences ($P < 0.05$) were revealed for number of fertile tillers, spike length and spike density.

Plant height: The estimates of mid-parent and better parent heterosis for plant height (Table 1) ranged from 0.43 to 14.31 and –3.48 to –15.12 percent, respectively. Thus F_1 means for plant height of all the crosses were higher than their respective mid parent but fell short of their respective better parent. The differences in height between F_1 and their reciprocal crosses were non-significant except for the F_1 crosses arising from crossing C273 and C271 with Mexipak 65. Seven out of 12 F_1 crosses expressed significant mid parent heterosis, while all the croses showed negative heterosis over better parent. The potence ratios for plant height were positive and ranged from 0.03 to 0.77 show-

Table 1. Mean performance of parental, F_1 and F_2 crosses between indigenous and exotic wheat cultivars for various traits

Cross	Plant height (cm)				No. of fertile tillers				Spike density				Grain yield/plant (g)			
	P_1	P_2	F_1	F_2	P_1	P_2	F_1	F_2	P_1	P_2	F_1	F_2	P_1	P_2	F_1	F_2
C273 x AU49	115.98	76.55	100.65	97.22	26.69	28.14	36.00	31.00	19.41	17.50	23.70	18.60	41.88	35.79	50.64	41.50
AU49 x C273			98.44	95.15			31.30	30.53			22.40	16.91			48.19	43.75
C273 x Mexipak 65	115.98	82.24	107.00	103.00	26.69	29.33	35.50	28.12	19.41	19.80	24.16	19.00	41.88	60.65	58.00	49.57
Mexipak 65 x C273			103.32	100.70			34.00	25.51			24.60	19.31			57.18	49.62
C273 x Sonora 64	115.98	88.75	104.60	96.45	26.69	27.81	40.22	26.04	19.41	18.42	23.50	19.00	41.00	45.32	61.19	50.34
Sonora 64 x C273			102.80	93.65			38.00	26.76			23.00	18.92			59.98	46.44
C271 x AU49	110.65	76.55	106.80	99.50	23.19	28.14	32.00	26.00	17.40	17.50	20.00	17.50	44.44	35.79	58.00	48.70
AU49 x C271			101.35	94.70			36.30	19.16			23.20	19.50			56.81	44.73
C271 x Mexipak 65	110.65	82.24	105.60	100.60	23.19	29.35	32.70	30.92	17.40	19.80	23.00	18.30	44.44	60.65	55.25	49.50
Mexipak 65 x 271			101.35	94.70			36.30	19.16			23.20	19.50			56.81	44.73
C271 x Sonora 64	110.65	88.75	100.50	98.00	23.19	27.81	29.00	26.00	17.40	18.42	22.50	18.00	44.44	45.32	48.00	43.70
Sonora 64 x C271			104.00	97.90			32.50	28.60			22.00	18.65			48.75	44.00

ing that the tallness behaved as partial dominance. Heterosis for semi–dwarfness has been indicated in several wheat crosses by Romero and Frey (1973). However, crosses involving indigenous and exotic wheat cultivars, the heterosis was reported by Ghafoor (1975) and Din (1980), while non–additive effects and different degree of dominance was reported by Fedin (1976).

Two–third of the wheat crosses showed significant inbreeding depression (Table 2). Ghafoor (1975) reported no inbreeding depression while Chowdhry *et al.* (1982) observed inbreeding depression in F_2.

Number of fertile tillers: It is evident from the data on fertile tillers that indegenous tall–statured cultivars had comparatively fewer tillers compared to the short–statured cultivars. About fifty per cent of the F_1 crosses showed significant differences from the mean of their respective reciprocals and were in agreement with Fedin (1976). The potence ratios were positive and ranged from 1.51 to 23.16 showing the involvement of large number of dominant plus genes. The means of all the F_1 crosses exceeded the respective mid and better parent exhibiting heterosis due to dominance and over–dominance. The number of fertile tillers shwed heterotic effects deriving from over–dominance, complete and partial dominance (Fedin, 1976). However, Srivastava *et al.* (1981) reported additive effects for this trait. Significant inbreeding depression was observed for all the crosses except C273 x AU49, AU49 x C273, Mexipak 65 x C271 and C271 x Sonora 64.

Spike density: The percentage of heterosis over mid–parent and better parent ranged from 14.61 to 28.45 and 14.28 to 26.85, respectively. The differences between the means of F_1 and reciprocal crosses were non–significant except for F_1 of cross C271 x AU49 and its reciprocal. The potence ratios were positive for all the crosses and ranged from 3.67 to 95.00 showing a preponderance of dominant plus genes effects in determining differences for spike density.

All the F_1 crosses showed a significant increase over their respective mid–parents as well as substantial increase over the respective better parent. It was evident that over–dominance effects were predominant in contributing to existing genetic variation for spike density. The results are in confirmity with Ghafoor (1975), Fedin (1976) and Din (1980).

Inbreeding depression for spike density ranged from 12.50 to 24.51 per cent and all the crsses differed statistically.

Grain yield: The F_1 crosses C271 x Sonora 64 and C273 x Sonora 64 produced the minimum (48.0 gm) and maximum (61.18 g) grain yield per plant, respectively (Table 1). The F_1 crosses showed 5.16 to 44.60 and – 8.90 to 34.99 per cent heterosis over mid–parent and better parent, respectively. The degrees of dominance (potence ratio) were positive and ranged from 0.33 to 10.22 showing the contribution of dominant plus genes towards higher parent. Heterosis for grain yield and yield components were reported by Rajki *et al.*, 1976. Two–third of the F_1

Table 2. Estimation of heterosis, potence ratio and inbreeding depression in crosses between indigenous and exotic wheat cultivars for various traits

Cross	Plant hight (cm)				No. of fertile tillers				Spike density				Grain Yield/Plant (g)			
	Heterosis				Hetrosis				Hetrosis				Hetrosis			
	MP	BP	PR	ID[1]	MP	BP	PR	ID	MP	BP	PR	ID	MP	BP	PR	ID
C273 x AU49	+ 4.56*	−13.22**	+0.22	3.41	+31.34**	+27.93**	+11.77	+13.89	+28.45**	+22.10**	+55.47	+21.52**	+30.41**	+20.92**	+3.87	+18.50**
AU49 x C273	2.26	−15.12**	+0.11	3.34	+14.19	+11.23	+ 5.33	+ 2.49	+21.41**	+15.40**	+ 4.11	+24.51**	+24.10**	+15.07	+3.07	+ 9.21**
C273 x Mexipak65	+ 7.96**	− 7.74**	+0.47	3.74*	+26.64**	+20.95**	+ 5.62	+20.79**	+23.26**	+22.02**	+22.80	+21.36**	+13.15**	− 4.37**	+0.72	+14.53**
Mexipak65 x C273	+ 4.25*	−10.91**	+0.25	2.53**	+21.34**	+15.84*	+ 4.50	+24.97**	+25.51**	+24.24**	+25.00	+21.50**	+11.55**	− 5.72**	+0.63	+13.22
C273 x Sonora64	+ 2.19	− 9.81**	+0.16	7.79**	+47.60**	+44.62**	+23.16	+35.26**	+24.27**	+21.07**	+ 9.18	+19.15**	+40.32	+34.99**	+10.22	+17.72**
Sonora64 x C273	+ 0.43	−11.36**	+0.03	8.90**	+39.45**	+36.64**	+19.20	+29.58**	+21.63**	+18.49	+ 8.18	+17.74**	+37.57**	+32.35**	+9.52	+22.53**
C271 x AU49	+14.10*	− 3.48*	+ 00.77	6.03**	+24.71**	+13.72	+ 2.56	+18.75**	+14.61*	+14.28*	+51.00	+12.50*	+44.60**	+30.51**	+4.13	+16.03**
AU49 x C271	+13.25*	− 4.20*	+0.73	5.00**	+52.84**	+39.37**	+ 5.47	+19.61**	+27.22	+26.85**	+95.00	+16.66**	+40.26**	+26.60**	+3.73	+19.66*
Mexipak65 x C271	+ 9.50**	− 4.56**	+0.64	4.73**	+24.48**	+11.41	+ 2.09	+ 5.44	+23.65**	+16.16**	+ 3.67	+20.43**	+ 5.16**	− 8.90**	0.33	+10.40**
C271 x Mexipak65	+ 5.09	− 8.40**	+0.34	6.56	+38.18**	+23.68**	+ 3.26	+14.67**	+24.73**	+17.17**	+ 3.83	+15.95**	+8.13**	− 6.33**	0.52	+21.26**
C271 x Sonora64	+ 0.80	− 9.17**	+0.07	2.49	+13.72*	+ 4.28	+ 1.51	+10.34	+23.63**	+22.15**	+ 9.00	+20.00**	+6.95**	+ 5.91**	+7.09	+ 8.96**
Sonora64 x C271	+14.31*	− 6.10	+0.39	5.86**	+27.45	+16.86**	+ 3.03	+12.00*	+22.84**	+19.45**	+ 8.02	+15.23**	+8.62**	+ 7.57**	+8.79	+ 9.74**

crosses of C273 with AU49 and Sonora 64 and their reciprocal were heterotic and their means exceeded corresponding mid–parent and better parent. While the remaining one–third crosses derived from by crossing cultivar C271 and C273 with Mexipak 65 and their reciprocals showed a significant increase over the corresponding mid–parent, thereby showing heterotic effects and non–additive gene action due to over–dominance and partial dominance for higher yielding parents. Heterosis for grain yield influenced by non–additive gene effects and dominance was reported by Prakash and Rao (1977) whereas additive and non–additive and both additive and dominance affects controlling grain yield were observed by Cammack (1984).

Inbreeding depression for grain yield was significant for all the crosses. Ghafoor (1975) reported no inbreeding depression while Chowdhry *et al.* (1982) reported inbreeding depression for grain yield.

CONCLUSIONS

Significant heterosis and inbreeding depression was expressed for plant height with both additive and non–additive effects. Significant estimates for heterosis and inbreeding depression was also observed for fertile tillers, spike density and grain yield. Thus improved selections can be developed from hybridization of cultivars that produce the best combination of traits followed by selection in segregating generations. Selection for transgressive segregates also seems possible from the crosses C273 with each AU49 and Sonora 64.

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