Original Research Article

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Heterosis for Grain Yield and Component Traits in Quality Protein Maize

D. Singh* and P. N. Jagadev

Department of Plant Breeding and Genetics, Odisha University of Agriculture and
Technology, Bhubaneswar, India

*Corresponding author

ABSTRACT

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The present investigation was undertaken to study the heterosis manifested by the individual hybrids over mid-parent (relative heterosis) and over better parent (heterobeltiosis) for grain yield and component traits in quality protein maize (*Zea mays* L.). For relative heterosis (RH), the positive significant effects were observed in number of grains per ear, ear weight per plant, grains per row, ear girth, grain weight, harvest index and grain yield. The best three hybrids showing high magnitude of RH for grain yield were QPM 10-1 x QPM 8-5, QPM 8-5 x QPM 10-1 and QPM 8-5 x QPM 7-4. The best hybrids showing high magnitude of heterobeltiosis (HB) were QPM 8-5 x QPM 10-1 for ear length and QPM 10-1 x QPM 8-5 for number of grains, ear weight and grain yield. Hence, QPM 10-1 x QPM 8-5 was found to be the best hybrid exhibiting maximum RH and HB for number of grains, ear weight, grain weight and grain yield.

Introduction

Maize (*Zea mays* L.), the world's most widely grown cereal, occupies an important place in the food grain production scenario of Odisha. However, the productivity figure is very low due to the cultivation of landraces and composite varieties. Its nutritional qualities are superior to other cereals in most of the aspects. The maize kernel contains about 60-70 % carbohydrates, 9-11 % crude protein, 2-3 % crude fibre, 3-5 % lipids and 20 mg of Ca/100 g of kernel. It also contains carotene, a precursor of vitamin A and a rich source of phosphorous with 348 mg/100 g of kernel (Wright, 1987). Maize is a highly cross

pollinated crop and it has been successfully exploited for development of several hybrids and composites. However, most of the hybrids/composites developed were low in protein content. Breeding methods to improve yield along with increased protein level might develop quality protein in maize. The invention of heterosis phenomenon, the development of hybrid breeding technology and successful commercial exploitation of heterosis in maize are considered to be the significant achievements and landmarks in biological science. A number of genotypes like single cross, double cross, varietal hybrid, multiple hybrid, composite, synthetic etc., are feasible to the maize growing farmers for

commercial cultivation by virtue of crop being highly cross pollinated. The efficiency and success of hybrid maize breeding depends on the contribution of heterotic effects from the superior inbred lines. The superior cross combination may be exploited as a commercial single cross. Usually, the hybrid development programme in maize involves the development and evaluation of inbred lines, crossing of selected inbreds and production of hybrids. Heterosis of varying degrees for grain yield and other component traits in maize have been reported (Amiruzzaman *et al.*, 2010; Elmyhum *et al.*, 2013 and Singh *et al.*, 2013). Therefore, the present investigation was undertaken to assess the heterosis for grain yield and its components in a 5 x 5 diallel combination of quality protein maize genotypes to increase the production and productivity.

Materials and Methods

The experimental material comprised of five QPM inbreds (QPM 2-18, QPM 3-7, QPM 7-4, QPM 8-5, QPM 10-1) and 20 hybrids produced by 5 x 5 full diallel combination during the rabi season. Twenty hybrids produced from 5 x 5 full diallel combination and 5 parents were sown at EB-II Research Station of OUAT, Bhubaneswar following RBD with 3 replications in the following kharif season. Analysis of variance was carried out on mean values for all the 15 characters studied in F₁ generation (Table 1). The source of variation due to genotypes (i.e. parents and hybrids) was further analyzed into sources like parents, hybrids and parents vs. hybrids. Significance of differences among parents, hybrids and between hybrids and parents as groups was tested by F-test. Relative heterosis (RH) was estimated as per cent increase (or decrease) of hybrid mean over the mid parent value for grain yield and its components. Heterosis over better parent i.e., heterobeltiosis (HB) was estimated as per cent increase of the hybrid from higher or

lower parent mean (Turner, 1953). Heterosis was considered to be absent if the hybrid mean laid exactly at the mid-parental value of the two parents. The statistical significance of heterotic estimates was tested by t-test. The test was performed on the difference of the hybrid mean and the mid –parent value for RH and on the difference of the hybrid mean and higher or lower parent mean for HB before expressing them in percentage.

Results and Discussion

The mean squares of variation for parents, hybrids and parents vs. Hybrids revealed significant differences among the genotypes (Table 1). Variations due to parents vs. hybrids were significant for all the traits except days to 50 % tasseling and silking and shelling % indicating presence of heterotic responses. The range of heterosis and number of crosses showing desirable heterotic responses for the characters over mid-parent (MP) as well as corresponding better parent (BP) were studied and the heterosis for grain yield ranged from -25.41 to 155.39 % over MP (relative heterosis) and -0.01 to 148.62 % over BP (heterobeltiosis) (Table 2). Out of 20 hybrids, all were having more number of grains per ear than MP, while only 18 were superior to their corresponding BP. For shelling %, ear length and number of rows/ear, heterosis was exhibited by a few crosses. No cross showed BP heterosis for days to 50 % silking.

For plant height, 10 hybrids each over MP and BP showed positive heterosis. Of the 7 hybrids having more number of rows/ear than MP, only 4 were superior to their corresponding BP. Heterosis for number of grains/ear was to the extent of 78.81 % over MP and 69.25 % over BP. For shelling %, number of rows/ear, ear length and days to 50 % tasseling, heterosis was exhibited by a few crosses.

Table.1 Analysis of variance of parents and hybrids for 15 characters in maize

Character/ source	d.f.	Days to 50 % tasseling	Days to 50 % silking	Days to 75 % dry husk	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear girth (cm)	No. of rows/ ear	No. of grains/ row	No. of grains/ ear	100- grain weight (g)	Shelling (%)	Harvest index	Ear weight / plant (g)	Grain yield (q/ha)
Replication	2	0.52	0.41	2.02	1660.29**	52.59	32.79**	2.59*	4.03**	20.56*	656.04	9.61**	2.31	0.77	11.06	6.68
Genotype	24	6.25**	6.32**	23.18**	633.45**	141.49**	9.45**	1.53*	2.36**	56.58**	15031.46**	29.26**	2.48**	528.58**	2084.79**	595.45**
Parent	4	18.10**	15.10**	37.40**	151.63	93.48**	13.28**	0.67	1.14	48.02**	7710.14**	33.10**	1.66*	920.41**	1598.97**	382.37**
Hybrid	19	4.08**	4.76**	16.28**	196.00*	81.44**	6.11**	1.04*	2.26**	40.98**	6038.53**	181.16**	2.63**	457.72**	1836.09**	505.44**
Parent vs. hybrid	1	0.01	0.85	97.48**	10872.14**	1474.55**	57.55**	4.09**	9.16**	387.14**	215182.60**	224.87**	2.92	307.65**	8753.27**	3158.03**
Error	48	1.15	1.64	1.56	95.34	22.98	1.58	0.51	0.65	5.55	221.97	0.49	0.82	1.27	4.95	4.03
CVe (%)		2.27	2.56	1.45	6.48	8.57	8.43	5.47	6.14	8.10	3.48	3.00	1.15	2.19	2.38	4.11

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

Table.2 Range, significant crosses and best three hybrids for each trait based on significant heterotic responses over mid-parent (relative heterosis) and corresponding better parent (heterobeltiosis) for 15 morpho-economic traits in maize

Sl. No.	Character	Relative heterosis			Heterobeltiosis		
		Range	No. of significant crosses	Best three hybrids	Range	No. of significant crosses	Best three hybrids
1	Days to 50 % tasseling	-4.70 to 7.75	4	QPM-8-5 x QPM 2-18, QPM 3-7 x QPM 8-5, QPM 8-5 x QPM 3-7	-4.05 to 5.04	1	QPM 8-5 x QPM 3-7
2	Days to 50 % silking	-5.01 to 6.21	2	QPM 8-5 x QPM 3-7, QPM 8-5 x QPM 2-18	-4.49 to 3.35	0	No significant cross
3	Days to 75 % dry husk	-1.20 to 8.64	14	QPM 8-5 x QPM 10-1, QPM 10-1 x QPM 7-4, QPM 7-4 x QPM 8-5	1.18 to 8.64	6	QPM 8-5 x QPM 10-1, QPM 10-1 x QPM 7-4 QPM 7-4 x QPM 8-5
4	Plant height (cm)	17.63 to 36.74	10	QPM 8-5 x QPM 10-1, QPM 3-7 x QPM 8-5, QPM 3-7 x QPM 7-4	12.52 to 30.56	10	QPM 8-5 x QPM 10-1, QPM 3-7 x QPM 7-4, QPM 3-7 x QPM 8-5
5	Ear height (cm)	5.80 to 45.93	16	QPM 8-5 x QPM 10-1, QPM 8-5 x QPM 2-18, QPM 8-5 x QPM 7-4	2.04 to 36.13	10	QPM 8-5 x QPM 10-1, QPM 7-4 x QPM 10-1, QPM 10-1 x QPM 3-7
6	Ear length (cm)	1.60 to	6	QPM 8-5 x QPM 10-1, QPM 7-4 x QPM	6.01 to	3	QPM 8-5 x QPM 10-1 QPM 7-4 x

		36.53		10-1, QPM 2-18 x QPM 8-5	36.13		QPM 10-1, QPM 7-4 x QPM 8-5
7	Ear girth (cm)	-5.46 to 17.07	12	QPM 8-5 x QPM 2-18, QPM 2-18 x QPM 8-5, QPM 2-18 x QPM 10-1	-1.87 to 16.01	8	QPM 8-5 x QPM 2-18, QPM 2-18 x QPM 8-5, QPM 2-18 x QPM 10-1
8	No. of rows/ear	-4.12 to 22.40	7	QPM 10-1 x QPM 3-7, QPM 7-4 x QPM 3-7, QPM 8-5 x QPM 2-18	-1.06 to 21.73	4	QPM 10-1 x QPM 3-7, QPM 7-4 x QPM 3-7, QPM 10-1 x QPM 2-18
9	No. of grains/row	-9.36 to 54.04	13	QPM 10-1 x QPM 8-5, QPM 8-5 x QPM 2-18, QPM 8-5 x QPM 10-1	-0.54 to 49.21	9	QPM 10-1 x QPM 8-5, QPM 8-5 x QPM 10-1, QPM 10-1 x QPM 7-4
10	No. of grains/ear	15.92 to 78.81	20	QPM 8-5 x QPM 2-18, QPM 2-18 x QPM 8-5, QPM 8-5 x QPM 10-1	1.04 to 69.25	18	QPM 8-5 x QPM 2-18, QPM 2-18 x QPM 8-5, QPM 7-4 x QPM 8-5
11	100-grain weight (g)	-1.47 to 53.99	18	QPM 10-1 x QPM 8-5, QPM 8-5 x QPM 10-1, QPM 8-5 x QPM 7-4	1.54 to 44.92	13	QPM 10-1 x QPM 8-5, QPM 7-4 x QPM 10-1, QPM 8-5 x QPM 10-1
12	Shelling (%)	-1.76 to 3.37	5	QPM 7-4 x QPM 10-1, QPM 8-5 x QPM 7-4, QPM 3-7 x QPM 7-4	-1.55 to 3.13	4	QPM 8-5 x QPM 7-4, QPM 7-4 x QPM 10-1, QPM 7-4 x QPM 8-5
13	Harvest index	-33.37 to 61.87	12	QPM 10-1 x QPM 2-18, QPM 8-5 x QPM 3-7, QPM 10-1 x QPM 8-5	-32.30 to 53.29	7	QPM 2-18 x QPM 3-7, QPM 10-1 x QPM 2-18, QPM 3-7 x QPM 10-1
14	Ear weight/plant (g)	-30.71 to 151.71	16	QPM 10-1 x QPM 8-5, QPM 8-5 x QPM 10-1, QPM 8-5 x QPM 7-4.	-8.10 to 141.41	14	QPM 10-1 x QPM 8-5, QPM 8-5 x QPM 10-1, QPM 8-5 x QPM 7-4
15	Grain yield (q/ha)	-25.41 to 155.39	16	QPM 10-1 x QPM 8-5, QPM 8-5 x QPM 10-1, QPM 8-5 x QPM 7-4	-0.01 to 148.62	15	QPM 10-1 x QPM 8-5, QPM 8-5 x QPM 10-1, QPM 7-4 x QPM 8-5

Table.3 Best five economic heterotic hybrids for grain yield over mid-parent (RH) and corresponding best parent (HB) and for other best five traits in maize

Sl. No.	Hybrid	Mean grain yield (q/ha)	Heterosis (%)		Significant heterosis for other best 5 traits (Sl. Nos.) #
			RH	HB	
1	QPM 10-1 x QPM 8-5	65.61	155.39*	148.62*	9,10,11,13,14
2	QPM 8-5 x QPM 10-1	57.09	122.23*	116.33*	5, 9, 10, 11, 14
3	QPM 8-5 x QPM 7-4	63.89	114.99*	93.35*	5,9,10,11,14
4	QPM 2-18 x QPM 8-5	70.27	82.18*	38.45*	5,9,10,11,14
5	QPM 8-5 x QPM 2-18	66.77	73.11*	31.56*	5,9,10,11,14

Best parent (QPM 2-18) mean yield = 50.75 q/ha

* Significant at 5 % level, RH = Relative heterosis, HB = Heterobeltiosis

#Sl. Nos. for other traits correspond to the characters at Table 2

Only four crosses each showed BP heterosis for number of rows/ear and shelling %. Heterosis up to 22.40 % over MP and 21.73 % over BP was recorded for number of rows/ear. Out of 20 hybrids, 15 had higher grain yield than their corresponding BP ranging the heterosis from -25.41 to 155.39 % over MP and -0.01 to 148.62 % over BP. The three best crosses selected for each trait based on significant heterotic response over MP and BP were presented in Table 2. The highest heterotic cross QPM 10-1 x QPM 8-5 was common in comparison for number of grains/row, 100-grain weight, harvest index, ear weight and grain yield.

Maximum heterosis was manifested in QPM 10-1 x QPM 8-5 for grain yield with high yield potential (Table 3). Cross of QPM 2-18 x QPM 8-5 with the highest *per se* performance showed 82.18 % relative heterosis (RH) with 38.45 % heterobeltiosis (HB). In the reciprocal cross, QPM 8-5 x QPM 2-18 showed high heterosis coupled with high mean performance being the best parent QPM 2-18 yielded 50.75 q/ha of grains. The reciprocal cross QPM 8-5 x QPM 10-1, the next highest heterotic cross was also common for days to 75 % dry husk, plant height, ear height, ear length, number of grains, grain weight and grain yield. The findings were supported by Shalimuddin *et al.*, (2006) and Kanagarasu *et al.*, (2010). Hence, the cross QPM 10-1 x QPM 8-5 resulted as the best hybrid exhibiting very high mean grain yield (65.61 q/ha, an increase of 77.35 % over the best parent QPM 2-18) with highest significant RH (155.39 %) and HB (148.62 %) accompanied by significant heterosis for number of grains, grain weight,

harvest index, ear weight and could be exploited for development of high yielding hybrids in quality protein maize.

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