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Heterosis in early maturing high yielding quality protein maize (*Zea mays*) hybrids

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Abstract
The present investigation was undertaken in F_1 population of 14 crosses, obtained by crossing 7 inbred lines of maize with two diverse testers in line x tester mating design during *Rabi* 2016. The 14 hybrids along with 9 parents (7 lines x 2 testers) and standard check were evaluated in Randomised Block Design with three replications at Field Experimentation Centre of the Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Naini Agricultural Institute, Allahabad (U.P) during the year *kharif* 2017. Crosses L_4 X T_1 and L_4 X T_2 exhibited maximum negatively significant economic heterosis for days to maturity followed by L_2 X T_2 and L_2 XT_1. The crosses L_7 X T_1, L_7 X T_2 and L_4 X T_1 exhibited significant positive standard heterosis over the check for yield and other attributes in maize.

Keywords: Line x tester, heterosis and quality protein maize

Introduction

Maize (*Zea mays*) belonging to the family *Poacea* is the third most important cereals grown in India after wheat and rice. It is a versatile crop grown over a wide range of agro climatic zone, they are grown during Kharif, Rabi and Spring. Maize acreage and production have an increasing tendency with the introduction of hybrids due to their high yield potentials. Maize can play an important role in increasing food production of India.

Quality protein Maize (QPM) is a genotype with *Opaque* 2 gene along with associated modifiers. Although the uses of maize are many, however, its protein quality is deficient in amino acids mainly lysine and tryptophan. The QPM contains twice the amount of lysine and tryptophan than normal maize.

Hybrid varieties are the first generations of (F1) from crosses between two pure lines, inbred lines, open pollinated varieties, clones or population that are genetically dissimilar. The development of hybrid breeding is one of the greatest accomplishment in Plant breeding to increase food security in the world. Breeding strategies based on selection of hybrids require expected level of heterosis (Hundera N.B. *et al*, 2017) [2]. Heterosis refers to the superiority of F_1 hybrids in one or more characters over its parents. The term was coined by Shull. Standard heterosis is estimated over standard commercial hybrid.

Heterosis is an important factor in deciding the direction of future breeding programme and to identify the cross combinations which are promising for hybrid breeding programme. In the present study, heterosis over better parent as well as standard check (SHAKTIMAN 5) were estimated for grain yield, maturity characters and quality parameters.

Materials and Methods

The experiment was conducted during Rabi and Kharif season of 2016- 2017 at Field Experimentation Centre of the Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (U.P). The experimetal materials used were made up of seven inbred lines *viz.*, NBPGR 32809 (T_1), NBPGR 31899 (T_2), POP 31Q-18211 (L_1), JP25- W95 (L_2), CML-41 (L_3), YHP-Panth (L_4), CML 358 (L_5), CML-470 B×15 (L_6) and VIVEK-33VF$_2$ (L_7). These lines were crossed in line x tester mating design (Kempthorne, 1957**)** [7] during *Rabi*- 2016 to form 14 F_1 hybrids. F_1 single crosses were made by hand pollination using bulk pollen from each line. The harvested ear were dried and shelled manually and in the major season *Kharif*-2017 field evaluation of 14 F_1 single crosses and their parents along with one check Shaktiman QPM-5 was conducted.

The entries were arranged in Randomized Block Design with three replications. Each genotype was planted in three rows of 5 meters length with row-to-row and plant-to-plant spacing of 60 cm and 20 cm respectively. Cultural practices such as fertilization, weeding, pest and diseases control were accompanied using normal field management practices for raising a good crop.

The data were recorded from five randomly selected plants from each replication.

The following traits that were evaluated from five randomly selected plants from each replication are days to 50% tasseling, days to 50% silking, anthesis-silking interval, days to maturity, cob width (cm), cob length (cm), number of grains per row (cm), number of grains row, test weight (100 seed weight) and grain yield per plant (g). The data were subjected to line x tester analysis as per the method given by Kempthrone (1957) [7].

Results and Discussion

Analysis of Variance: The analysis of variance showed that mean squares due to crosses were highly significant for all the traits except for anthesis-silking interval. This indicates that the crosses were sufficiently different from each other for these traits and hence, selection is possible to identify the most desirable crosses. Highly significant mean squares due to parents vs. crosses indicated presence of average heterosis for all the characters.

Maturity: Maturity is an important attribute of a given genotype, which directly or indirectly affects economic yield. Maturity itself is expressed by several components such as days to 50% tasseling, 50% silking, Anthesis – silking interval, days to maturity etc.

For maturity characters like days to 50% tasseling, eleven crosses showed significant heterosis over better parent and thirteen crosses showed standard heterosis (Table 2), for days to 50% tasseling heterosis ranged from -6.34% to -14.74% over better parent and-4.03% to -12.75% over standard check. For days to 50% silking ten crosses showed significant heterosis over better parent and thirteen crosses showed standard heterosis. Heterosis ranged from -6.08% to -14.72% over better parent and -3.23% to -11.61% over standard Heterosis. For anthesis – silking interval two and one crosses showed significant heterosis over better parent and standard check respectively. And totally eleven crosses showed significant heterosis over better parent and standard check in days to maturity. Crosses L_4 X T_1 and L_4 X T_2 exhibited maximum negatively significant economic heterosis for days to maturity followed by L_2 X T_2 and L_2 XT_1. These crosses can be exploited further in breeding program for developing early maturing varieties. Genotypes which showed early maturity can be of immense use in future breeding program. These findings are in conformity with the findings of Shah *et al*. (2016) [8] and Matin *et al.* (2016) [6].

Yield and yield attributes**:** Grains, the ultimate economic product from the maize plant are the net result of various components. The yield is attributed by various characters of the plant and the total yield in maize is influenced by several grain component characters.

Percentage of heterosis over standard check (SHAKTIMAN QPM 5) for grain yield and other related characters are presented in Table 3 and 4. The degree of heterosis varied from cross to cross and from character to character. Standard heterosis ranged from -0.65 to -13.8%; -15.32 to 44.69%; -24.04 to 18.31%; -28.33 to 20.83%, -14.96 to 5.69% and -24.42 to 19.18% for cob width, cob length, number of grains per row, number of grains row, test weight (100 seed weight) and grain yield per plant. Overall perusal estimates of heterosis revealed that cross L_4 X T_1, L_7 X T_1 and L_7 X T_2 exhibited positive significant standard heterosis for grain yield and other yield attributing characters like cob length and number of grains per row. Positive significant heterosis for grain yield and other attributes in maize were also reported by Khan *et al*. (2014) [4], Kumar *et al*. (2014) [5] and Birhaine *et al.* (2017) [1].

The study showed appreciable amount of heterobeltiosis and economic heterosis for certain characters. The desirable crosses combination L_4 X T_1, L_7 X T_1 and L_7 X T_2 showed high magnitude of heterosis (4.0 to 19.0 %) over the check variety Shaktiman QPM-5 for grain yield along with other yield attributing characters. The study of heterotic response revealed that we can adopt the option of developing single cross QPM hybrids from the materials under study that belong to high quality protein maize.

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Table 1: Analysis of variance for different characters in Quality Protein Maize Parents, Hybrids and Parents vs Hybrids

Mean Sum of squares							
Characters	**Replications d.f=2**	**Treatments d.f=22**	**Hybrids d.f= 13**	**Parents d.f= 8**	**Parents vs. Hybrids d.f=1**	**Error d.f= 44**	**Total d.f= 68**
Days to 50% tasseling	1.58	15.10**	10.53**	13.00**	91.31**	0.79	5.44
Days to 50% silking	2.14	17.33**	11.75**	15.12**	107.55**	0.97	6.30
Anthesis-silking interval	0.04	0.45	0.38	0.54	0.66	0.13	0.23
Days to maturity	0.44	22.05**	23.72**	20.17**	15.49**	0.24	7.30
Cob width	0.16	7.46**	1.21**	7.22**	90.75**	0.21	2.55
Cob length	0.10	32.99**	13.44**	8.62**	482.22**	0.64	11.09
Number of grain/ rows	1.17	206.62**	53.19**	88.13**	3149.23**	2.98	68.81
Number of grain row	0.07	10.27**	2.51**	12.80**	90.84**	0.42	3.60
Test weight	0.61	8.80**	6.62**	10.99**	19.64**	0.85	3.42
Grain yield	1.55	1178.36**	300.09**	310.46**	19539.10**	13.83	390.23

*,** Significant at 5 % and 1 % level of significance respectively

Table 2: Range of heterobeltiosis and standard heterosis for yield and quality traits in maize

Crosses	Days to 50% tasseling		Days to 50% silking		Anthesis-silking interval		Days to maturity	
	Hb	Hc	Hb	Hc	Hb	Hc	Hb	Hc
L1 X T1	3.40 *	2.01	2.56	3.23*	-11.11	33.33*	0.00	0.80
L1 X T2	-8.97 **	-4.70**	-7.98 **	-3.23**	-11.11	33.33*	-1.21 *	-1.61 **
L2 X T1	-13.07 **	-10.74**	-11.95 **	-9.68**	16.67	16.67	-5.98 **	-5.22 **
L2 X T2	-10.26 **	-6.04**	-10.43 **	-5.81**	-14.29	0.00	-6.45 **	-6.83 **
L3 X T1	-8.84 **	-10.07**	-10.26 **	-9.68**	-33.33 **	0.00	-0.78	2.41 **
L3 X T2	-12.82 **	-8.72**	-12.88 **	-8.39**	-33.33 **	0.00	0.00	3.21 **
L4 X T1	-8.45 **	-12.75**	-7.43 **	-11.61**	16.67	16.67	-7.97 **	-7.23 **
L4 X T2	-12.18 **	-8.05**	-11.66 **	-7.10**	0.00	16.67	-6.85 **	-7.23 **
L5 X T1	1.42	-4.03*	0.68	-3.87*	-14.29	0.00	-5.58 **	-4.82 **
L5 X T2	-11.54**	-7.38**	-12.27	-7.74**	-28.57 *	-16.67	-4.44 **	-4.82 **
L6 X T1	1.44	-5.37**	0.00	-6.45**	-33.33 *	-33.33*	-4.78 **	-4.02 **
L6 X T2	-10.90**	-6.71**	-11.04 **	-6.45**	-14.29	0.00	-3.23 **	-3.61 **
L7 X T1	-6.34**	-10.74**	-6.08 **	-10.32**	0.00	0.00	-5.58 **	-4.82 **
L7 X T2	-14.74**	-10.74**	-14.72 **	-10.32**	-14.29	0.00	-2.82 **	-3.21 **

*,** Significant at 5 % and 1 % level of significance respectively.

Table 3: Range of heterobeltiosis and standard heterosis for yield and quality traits in maize

Crosses	Cob width		Cob length		Number of grains per row		Number of grain rows	
	Hb	Hc	Hb	Hc	Hb	Hc	Hb	Hc
L1 X T1	9.25 *	-8.20 **	38.27 **	13.47 **	0.8	-24.04 **	0.13	20.83 **
L1 X T2	12.97 **	-5.08	21.49 **	0.57	67.27 **	-10.28 *	9.62 *	-13.33 **
L2 X T1	36.04 **	-0.65	41.62 **	16.22 **	49.45 **	12.63 **	16.67 **	-12.50 **
L2 X T2	20.57 **	-12.08 **	41.98 **	17.53 **	155.38 **	6.64	-1.85	-22.50 **
L3 X T1	17.52 **	-2.42	28.90 **	5.79	38.37 **	4.28	12.22 *	-15.83 **
L3 X T2	18.36 **	-1.71	19.43 **	-1.14	81.71 **	-15.95 **	11.87 **	-11.67 **
L4 X T1	18.02 **	-13.81 **	45.66 **	19.54 **	18.77 **	-10.49 *	17.22 **	-12.08 **
L4 X T2	24.40 **	-9.29 **	42.12 **	17.65 **	144.62 **	2.14	16.09 **	-8.33 *
L5 X T1	11.85 **	-4.73	30.06 **	6.74	26.15 **	-4.93	0.00	-12.50 **
L5 X T2	2.25	-12.91 **	2.29	-15.32 **	24.42 **	-22.27 **	-18.10 **	-28.33 **
L6 X T1	21.57 **	-11.22 **	28.61 **	5.55	19.19 **	-10.17 *	2.22	-23.33 **
L6 X T2	22.57 **	-10.62 **	35.67 **	12.31 *	99.20 **	-6.26	9.50 *	-13.54 **
L7 X T1	11.71 **	-1.08	63.23 **	36.36 **	47.63 **	18.31 **	16.67 **	-12.50 **
L7 X T2	10.12 **	-2.49	73.20 **	44.69 **	44.42 **	15.74 **	10.82 *	-12.50 **

*,** Significant at 5 % and 1 % level of significance respectively.

Table 4: Range of heterobeltiosis and standard heterosis for yield and quality traits in maize

Crosses	Test weight		Grain yield	
	Hb	Hc	Hb	Hc
L1 X T1	-9.44 **	-6.34	50.33 **	-13.39 **
L1 X T2	-14.25 **	-10.59 **	38.57 **	-9.07 *
L2 X T1	-3.07	5.56	95.30 **	5.68
L2 X T2	-12.75 **	-4.99	34.42 **	-11.79 **
L3 X T1	-1.22	2.23	95.32 **	5.69
L3 X T2	-13.22 **	-9.52 **	23.74 **	-18.80 **
L4 X T1	-7.07	-14.96 **	76.06 **	4.73**
L4 X T2	-17.12 **	-13.58 **	15.17 **	-24.42 **
L5 X T1	-13.66 **	-8.68 *	43.23 **	-1.33
L5 X T2	-8.36 *	-3.08	34.45 **	-7.37 *
L6 X T1	-3.61	-4.49	80.16 **	-2.51
L6 X T2	-5.39	-1.35	41.49 **	-7.16 *
L7 X T1	2.04	5.69	59.32 **	19.18 **
L7 X T2	-4.32	-0.23	41.34 **	5.73**

*,** Significant at 5 % and 1 % level of significance respectively

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