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Heterosis study for grain yield, protein and oil improvement in selected genotypes of maize (*Zea mays* L)

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Abstract: The extent and nature of heterosis was studied at College of Agricultural farm; Rajendranagar for thirteen important characters in Line x Tester mating design comprising of twenty four crosses from 6 lines and 4 testers in maize (*Zea mays* L.). It was carried out under irrigated condition in 2002-2003 using randomized block design with three replications. The results of this study indicated that the occurrence of non additive gene action for grain yield, oil and protein. B-QPM-117x B-QPM-128 was the only hybrid that recorded positive and highly significant standard heterosis for grain yield over DHM-105 with a value of 31.95%. Hence this cross can be a good substitute over the check DHM-105. Though it was not significant only hybrid B-QPM-114x B-QPM-118 showed the highest positive standard heterosis for oil content with the value of 0.71% and for grain yield per plot with value of 20% over the check Mandhuri. However, all the other crosses gave negative and significant standard heterosis for oil and protein contents over this check. This hybrid can be considered to improve oil content. Heterobeltiosis studies revealed that the five hybrids showed positive and significance performance for grain yield. Further three hybrids recorded positive and significant heterobeltiosis for protein content.

Keywords: Heterosis, Standard Heterosis, Heterobeltiosis

1. Introduction

Maize is a staple food crop for large population groups. Globally 67% of maize is used for live stock feed and 25% used for human consumption and industrial purpose [1].World maize production was estimated to be 950 million tons for the 2012/2013 season, an increase of 9% from 2011/2012. The United States is largest producer, responsible for about 40% of total output [2].

It was mentioned that maize endosperm contained approximately 75 percent of the total protein. The protein of Quality Protein Maize (QPM) has a nutritional quality almost equal of milk protein [3]. The presence of oil in maize was first reported in 1903 by studying structure of maize kernel and its chemical composition [4]. Later it was mentioned that maize endosperm contained approximately 15 percent of the total oil [5].Corn oil is good quality oil both from a nutritional standpoint and in terms of cooking quality. It is reach in the essential polyunsaturated fatty acid linoleic acid, so that it remains liquid at fairly low temperatures [6].It was suggested that genetic improvement could result in an improvement in the nutritional value of the grain [7].

The knowledge of gene action and hybrid vigor help in identification of superior F1 hybrids in order to use further in future breeding programs [1]. Information on this aspect is very important for improving the yield level in maize. The present study was under taken to select F1 hybrids in order to exploit heterosis for improvement of grain yield, protein and oil in maize (Zea mays L.).

2. Materials and Methods

2.1. The Genotypes, Study Area, Experimental Design and Data Collection

The present investigation, genetic analysis in full season inbred lines of maize were carried out with the objective of identifying high yielding lines and hybrids with high oil and protein content. The breeding material was obtained by crossing line and tester design, conducted at maize research station, Hyderabad, India. An experiment involving twenty four F1 hybrids with their parents six lines namely B-

QPM104, B-QPM 105, B-QPM 108, B-QPM 112, B-QPM 114 and B-QPM 117 and four testers namely B-QPM 118, B-QPM 122, B-QPM 124, 128 including two checks Madhuri and DHM-105 was laid out in randomized block design with three replication under irrigated condition in the year 2001-2002 (Table, 1) .Each entry was grown in 5m row with a spacing of 75cmx20cm. The line x tester mating design was used [8]. In each plot observation were recorded on five randomly selected plants for all important traits. Heterosis for various traits was estimated as percent increase or decrease of the hybrid over standard check (useful heterosis) Better parent (hetrobeltiosis) and over the mid parent (mid parent hetrosis).

***Table 1.** Pedigree history and morphological characters of QPM inbreds*

line	Pedigree Origin	Days to 50% tasseling	Days to 50% silking	Protein (%)	Oil (%)
1	B-QPM-104 CML*-162xCML-165 QPM [1] hybrids	49.33	54.33	9.26	10.42
2	B-QPM-105 CML-162xCML-165 QPM [1] hybrids	50.00	55.00	10.24	11.24
3	B-QPM-108 CML-164xCML-166 QPM [1] hybrids	49.57	55.00	8.64	10.24
4	B-QPM-112 CML-164xCML-166 QPM [1] hybrids	48.67	55.67	8.54	10.05
5	B-QPM-114 CML-164xCML-120 QPM [1] hybrids	53.33	58.00	8.34	10.44
6	B-QPM-117 CML-162xCML-165 QPM [1] hybrids	53.67	58.33	10.61	9.89
7	B-QPM-118 Line derived from Shaki composite (QPM)	53.00	58.00	7.94	11.10
8	B-QPM-122 Line derived from Shaki composite (QPM)	53.67	58.67	9.84	10.52
9	B-QPM-124 CML-166xCML-211 QPM hybrids	53.33	58.67	9.28	9.76
10	B-QPM-128 CML-166xCML-211 QPM hybrids	52.67	58.00	8.63	10.25

Note: *CML=CIMMYT maize lines[1] QPM= Quality protein maize Shakati composite= QPM varieties Line 1. 2 and 3 are QPM high yielding hybrids

2.2. Statistical Analysis

2.2.1. Estimation of Heterosis

Heterosis for various traits was estimated as percent increase or decrease of the hybrid over standard check (useful heterosis) and better parent (better parent heterosis). Their values were mathematically calculated by using the following formula. The significance was tested using t-test.

$$\text{Heterobeltiosis}= \frac{\overline{F1}-\overline{B.P.}}{\overline{B.P.}} \times 100 \quad (1)$$

$$\text{Standard heterosis} = \frac{\overline{F1}-\overline{SC}}{\overline{SC}} \times 100 \quad (2)$$

Where $\overline{F1}$=mean value of F1, $\overline{B.P}$=mean value of better parent, $\overline{SC}$=mean value of standard check.

3. Result and Discussion

Standard heterosis refers to the superiority of F1 over the standard commercial check variety and indicates the usefulness of the hybrid when composed to checks. Though it was not significant only hybrid B-QPM 114 x B-QPM 118 showed the highest positive standard heterosis for oil content (0.71%) over the check Madhuri. However, all the other crosses gave negative and significant heterosis for oil and protein percentage over this check. Even though it has not seen significant difference the cross B-QPM 114 x B-QPM 118 recorded positive standard heterosis for grain yield per plot with value 20% over Madhuri (Table, 2).

***Table 2.** Standard heterosis over madhuri for yield, yield component characters, oil and protein in maize*

F1 Hybrids	Days Of 50% tasseling	Days of 50% silking	Days Of 50% maturity	Plant Height (cm)	Ear Height (cm)	Ear Length (cm)	Ear Girth (cm)	No. of Seeds Per row	No. of seed rows Per cob	100 seed weight (g)	Oil content (%)	Protein content (%)	Grain yield per Plot (kg)
B- qpm-104xb-qpm-118	-3.8	-3.5	2.6	15.0*	9.2	11.0	9.6	3.7	-13.9	58.9**	-14.3*	-19.7*	42.0
B- qpm-104xb-qpm-122	0.8	0.5	6.7	11.0	13.7	20.4	11.0	15.7	2.7	46.2**	-18**	-12.7**	74.3**
B- qpm-104xb-qpm-124	1.3	0.5	2.6	5.1	36.0*	6.8	7.3	13.1	10.7	27.8	-11.3	-8.3**	60.2*
B- qpm-104xb-qpm-128	-3.1	-2.2	3.3	10.4	13.0	22.1	4.9	11.4	7.7	43.5**	-19**	-18.8**	71.1*
B- qpm-105xb-qpm-118	0.8	-1.2	3.3	13.8*	22.1	5.6	6.0	6.2	4.2	38.2*	-12.5*	17.3**	48.6*
B- qpm-105xb-qpm-122	-2.5	-1.7	1.5	17.6*	10.8	-0.5	4.1	2.8	2.2	37.1*	-10.8	-8.9**	45.3
B- qpm-	0.0	-1.7	2.2	-24**	-52**	-18.3	-14.3	-28.0*	-17.6	27.6	-16**	-13.7**	-12.0

F1 Hybrids	Days Of 50% tasseling	Days of 50% silking	Days Of 50% maturity	Plant Height (cm)	Ear Height (cm)	Ear Length (cm)	Ear Girth (cm)	No. of Seeds Per row	No. of seed rows Per cob	100 seed weight (g)	Oil content (%)	Protein content (%)	Grain yield per Plot (kg)
105xb-qpm-124													
B- qpm-105xb-qpm-128	-2.5	-0.5	3.3	17.9**	-0.5	1.9	3.0	8.3	2.7	32.3*	-6.7	-18.5**	47.1
B- qpm-108xb-qpm-118	-2.5	-2.2	2.6	14.3*	-0.46	3.3	13.0	3.1	4.1	62.0**	-10.3	-20.3**	75.1**
B- qpm-108xb-qpm-122	-3.8	-2.9	1.1	20.1**	22.4	1.4	14.8	7.9	7.4	64.5**	-22**	-27.5**	91.2**
B- qpm-108xb-qpm-124	-4.4	-2.9	1.5	8.2	-3.3	-8.5	6.3	1.2	-2.5	35.9**	-13.0*	-19.7**	34.9
B- qpm-108xb-qpm-128	0.8	-0.5	3.0	12.8	-3.4	-0.7	7.4	1.4	5.5	41.1**	-7.3	-7.5**	49. 8*
B- qpm-1112xb-qpm-118	-1.9	-2.2	0.7	8.8	3.2	7.3	-6.2	14.3	-1.2	42.6**	-15.5*	-23.5**	63.3**
B- qpm-112xb-qpm-122	-3.8	-1.7	1.9	8.2	-12.4	18.8	7.8	24.8	12.4	43.2**	-9.1	-21.7**	100.6**
B- qpm-112xb-qpm-124	0.0	-0.5	3.0	10.9	-2.6	-5.9	6.3	-2.5	10.2	37.1*	-21**	-10.9**	48.2*
B- qpm-112xb-qpm-128	0.8	0.0	1.5	15.9*	22.4	-2.1	7.4	-7.9	-1.2	30.1*	-10.6	-12.4**	19.6
B- qpm-114xb-qpm-118	2.7	1.2	3.7	6.3	-11.2	-14.8	3.4	-22.7	-2.0	55.0*	0.2	-22.8**	20.0
B- qpm-114xb-qpm-122	7.1**	3.4	7.4	-1.9	-28.71	-21.1	-18.4*	-19.7	-7.7	7.4	-9.1	-17.4**	-30.6
B- qpm-114xb-qpm-124	0.0	-1.7	0.0	-11.0	-28.3	-9.6	-15.7	-19.5	6.2	16.0	-7.9	-19.8**	1.2
B- qpm-114xb-qpm-128	-2.5	-1.7	5.2	7.0	46.9*	6.1	2.2	13.0*	1.7	31.1*	-16**	-25.3	50.4*
B- qpm-104xb-qpm-118	3.8	2.2	6.7	3.5	19.0	12.9	30.9**	17.9	0.0	55.8**	-8.1	-19.4**	85.9**
B- qpm-104xb-qpm-122	0.0	0.0	4.4	4.2	4.1	2.6	3.0	-1.5	5.2	65.9**	-16**	-19.2**	74.9**
B- qpm-104xb-qpm-124	-1.1	-1.2	24.8**	10.7	7.5	1.2	14.0	9.2	10.4	23.5	-15.1*	-10.7**	53.5*
B- qpm-104xb-qpm-128	-1.1	-1.2	12.6*	11.8	9.3	12.0	15.9	8.9	7.7	77.7**	-13.2*	-21.6**	108.2**

Note: - *significantat5%level. **significantat1%level. qpm= QPM (Quality Protein Maize)

Table 3. *Standard heterosis over DHM-105 for yield, yield component characters, oil and protein in maize*

F1 Hybrids	Days Of 50% tasseling	Days of 50% silking	Days Of 50% maturity	Plant Height (cm)	Ear Height (cm)	Ear Length (cm)	Ear Girth (cm)	No. of Seeds Per row	No. of seed rows Per cob	100 seed weight (g)	Oil content (%)	Protein content (%)	Grain yield per Plot (kg)
B- qpm-104xb-qpm-118	-2.6	-2.3	1.1	1.4	6.3	10.8	-2.0	-2.0	-15.2	7.9	6.1	-11.3**	-10.0
B- qpm-104xb-qpm-122	1.9	1.7	5.1	-4.8	10.6	20.1	-0.8	9.3	1.2	-0.7	2.0	-3.62**	10.5
B- qpm-104xb-	2.6	1.7	1.1	-9.9	32.4	6.6	-4.1	7.0	9.1	-13.2	9.9	1.2	1.4

F1 Hybrids	Days Of 50% tasseling	Days of 50% silking	Days Of 50% maturity	Plant Height (cm)	Ear Height (cm)	Ear Length (cm)	Ear Girth (cm)	No. of Seeds Per row	No. of seed rows Per cob	100 seed weight (g)	Oil content (%)	Protein content (%)	Grain yield per Plot (kg)
qpm-124													
B- qpm-104xb-qpm-128	-1.9	-1.2	1.8	-5.3	9.4	21.8	-6.2	5.3	6.1	-2.5	0.2	-10.4**	8.7
B- qpm-105xb-qpm-118	1.9	0.0	1.8	-2.3	18.8	5.4	-5.2	0.4	2.7	-6.2	8.4	-8.7**	-5.8
B- qpm-105xb-qpm-122	-1.3	-0.6	0.0	0.8	7.8	-0.7	-6.9	-2.8	0.7	-6.9	10.5	0.5	-7.9
B- qpm-105xb-qpm-124	1.3	0.6	0.7	-35.1**	-52.9**	-18.5	-23.4**	-32.0**	-18	-13.4	3.5	-4.7	-44.2**
B- qpm-105xb-qpm-128	-1.3	0.6	1.8	1.1	-3.1	1.6	-7.9	2.3	1.2	-10.2	15.6*	-10.1**	-6.7
B- qpm-108xb-qpm-118	-1.3	-1.2	1.1	-2.0	-3.1	3.0	1.0	-2.60	3.4	10.0	11.1	-12.0**	11.0
B- qpm-108xb-qpm-122	-2.6	-1.7	0.4	3.0	9.1	1.2	2.5	2.0	5.9	11.7	-3.9	-19.9**	21.2
B- qpm-108xb-qpm-124	-3.2	-1.7	0.0	-7.2	-5.9	-8.7	-4.90	-4.3	-3.9	-7.8	7.7	-11.4**	-14.5
B- qpm-108xb-qpm-128	1.9	0.6	1.5	-3.3	-6.0	-0.9	-4.0	-4.2	3.9	-4.2	14.8*	2.2	-5.1
B- qpm-1112xb-qpm-118	-0.7	-1.2	-0.7	-6.7	0.4	7.0	-16.1*	8.0	-2.7	-3.2	4.7	-15.5*	3.5
B- qpm-112xb-qpm-122	-2.6	-0.6	0.4	-7.2	-14.8	18.5	-3.6	18.0	10.8	-2.8	12.6	-13.5**	27.2
B- qpm-112xb-qpm-124	1.3	0.6	1.5	-4.90	-5.2	-6.1	-5.0	-7.9	8.6	-6.9	-2.6	-1.7	-6.1
B- qpm-112xb-qpm-128	1.9	1.2	0.0	-0.6	19.1	-2.3	-4.0	-13.0	-2.7	-11.6	10.7	-3.3**	-24.2
B- qpm-114xb-qpm-118	3.9	2.3	2.2	-8.8	-13.6	-15.0	-7.5	-26.9*	-3.4	5.2	24.1**	-14.8**	-23.9
B- qpm-114xb-qpm-122	8.4**	4.7**	5.8	-15.9**	30.6	-21 .3	-27.1**	-24.1*	-9.1	-37**	12.6	-8.8**	-56.0**
B- qpm-114xb-qpm-124	1.3	-0.6	-1.5	-23.7**	-30.2	-9.8	-24.7**	-23.9	4.7	-21**	14.1	-11.4**	-35.8**
B- qpm-114xb-qpm-	-1.3	0.6	3.7	-8.2	43.0*	5.9	-8.6	6.8	0.2	-11.0	3.1	-17.6**	-4.7

F1 Hybrids	Days Of 50% tasseling	Days of 50% silking	Days Of 50% maturity	Plant Height (cm)	Ear Height (cm)	Ear Length (cm)	Ear Girth (cm)	No. of Seeds Per row	No. of seed rows Per cob	100 seed weight (g)	Oil content (%)	Protein content (%)	Grain yield per Plot (kg)
128													
B- qpm-104xb-qpm-118	5.2	3.5	5.1	-11.3	15.9	12.7	17.0*	11.5	-1.5	5.8	13.8	-10.1**	17.9
B- qpm-104xb-qpm-122	1.3	1.2	2.9	-10.7	1.3	2.3	-8.0	-6.9	3.7	12.6	3.6	-10.6**	10.9
B- qpm-104xb-qpm-124	0.0	0.0	23.0**	-5.1	4.7	0.9	1.9	3.3	8.8	-16.1	5.2	-1.5	-2.7
B- qpm-104xb-qpm-128	0.0	0.0	12.0*	-4.1	6.4	11.7	3.6	2.9	6.1	20.6*	7.5	-13.5**	31.0

Note:- *significantat5%level. **significantat1%level qpm= QPM (Quality Protein Maize)

Heterosis was maximum and positively significant in the hybrid B-QPM 117 x B-QPM 128 for grain yield with a value of 108.16 over Madhuri and it is the only hybrid that recorded positive and highly significant standard heterosis over DHM 105 with 31.95% (Table, 3). Hence the hybrid B-QPM 117 x B-QPM 128 can be considered in order to obtain high grain yield. The hybrid was followed by B-QPM 112 x B-QPM 122 and B-QPM 117 x B-QPM 118 for grain yield. The latter two crosses also had greater oil content than earlier one.

Heterobeltiosis studies revealed that five hybrids namely B-QPM 117 x B-QPM 118, B-QPM 117 x B-QPM 128, B-QPM 117x B-QPM 122, B-QPM 108 x B-QPM 122 and B-QPM 108 x B-QPM 118 showed positive and highly significant performance for grain yield. Among the yield components plant height, ear height, ear length, number of seeds per row, showed positive and significant heterosis in some crosses (Table, 4). Earlier it was also reported promising cross combination in terms of yield heterosis and heterobeltiosis [9].

Three hybrids namely B-QPM 104 x B-QPM 124, B-QPM 108 x B-QPM 128 and B-QPM 112 x B-QPM 128 showed positive and significant heterobeltiosis for protein content. However, most hybrids showed negative heterobeltiosis for this character. In addition no hybrid revealed positive and significant hetrobeltiosis for oil percentage. Though not significant, eight hybrids gave positive heterobeltiosis for oil percent (Table, 4). Similar research indicated that occurrence of hetrobeltiosis in positive and negative direction for protein and oil content [10].

Table 4. *Heterobeltiosis for grain yield, yield component characters, oil and protein in maize*

F1 Hybrids	Days Of 50% Tasseling	Days of 50% silking	Days of 50% maturity	Plant Height (cm)	Ear Height (cm)	Ear Length (cm)	Ear Girth (cm)	No. of Seeds Per row	No. of seed rows Per cob	100 seed weight (g)	Oil content (%)	Protein content (%)	Grain Yield per Plot (kg)
B- qpm-104xb-qpm-118	-5.0	-3.5	-0.4	21.0**	0.8	17.1	6.7	4.8	-13.3	16.0	-9.4	-3.1*	5.0
B- qpm-104xb-qpm-122	-1.9	-0.6	2.1	16.8*	16.3	29.7*	8.0	17.0	3.5	6.7	-8.2	-0.9	28.8
B- qpm-104xb-qpm-124	-0.6	-0.6	-0.4	10.2	39.2*	12.6	4.4	14.4	3.7	-6.7	-0.1	10.3**	18.4
B- qpm-104xb-qpm-128	-3.8	-2.3	-0.4	0.3	15.2	28.7*	-2.0	12.6	-3.3	4.7	-9.0	-2.1	26.7
B- qpm-105xb-qpm-118	-0.6	-1.2	-1.8	19.3**	12.7	9.2	6.0	20.1	5.0	3.4	-8.7	-9.8**	41.9
B- qpm-105xb-qpm-122	-5.0	-2.8	-3.5	23.2**	74.7**	2.9	6.4	16.3	7.9	9.5	-6.9	-0.7	38.8
B- qpm-105xb-qpm-124	-1.9	-1.7	-2.8	-21**	-44.7*	-15.5	-12.4	-18.6	-22.8*	-3.3	-12.8**	-5.8**	-23.6

F1 Hybrids	Days Of 50% Tasseling	Days of 50% silking	Days of 50% maturity	Plant Height (cm)	Ear Height (cm)	Ear Length (cm)	Ear Girth (cm)	No. of Seeds Per row	No. of seed rows Per cob	100 seed weight (g)	Oil content (%)	Protein content (%)	Grain Yield per Plot (kg)
B- qpm-105xb-qpm-128	-3.2	-0.6	-1.8	7.2	1.5	5.3	-3.7	18.3	-7.8	6.7	-2.6	-11.1**	14.4
B- qpm-108xb-qpm-118	-3.8	-2.3	0.0	11.0	-8.1	8.1	12.9	5.1	5.8	21.2	-5.2	3.05*	42.5*
B- qpm-108xb-qpm-122	-6.2*	-4.0	-3.2	16.7	41.6*	6.1	21.2*	10.1	14.9	24.6*	-13.5**	-17.**	55.7**
B- qpm-108xb-qpm-124	-6.3*	-4.0	0.0	5.1	10.5	-4.2	10.7	3.2	-8.6	2.9	-0.4	-3.4**	9.8
B- qpm-108xb-qpm-128	0.0	-0.6	-0.7	2.6	-1.5	3.9	0.3	3.4	-5.4	6.9	6.1	19.6**	16.5
B- qpm-112xb-qpm-118	-3.1	-2.3	-2.5	7.3	-4.7	13.1	-6.3	13.9	-0.5	-7.9	-10.7	0.2	11.6
B- qpm-112xb-qpm-122	-6.2*	-2.8	-2.5	6.7	5.3	25.3*	11.8	24.4	18.9	-7.5	1.4	-11.1**	37.1*
B- qpm-112xb-qpm-124	-1.9	-1.7	-0.4	9.4	11.3	-0.7	10.3	-2.8	3.3	-11.5	-8.2	7.2**	1.3
B - qpm-112xb-qpm-128	0.0	0.0	-2.1	5.3	24.8	3.2	0.4	-8.2	-11.4	-16.0	2.3	13.4**	-18.3
B- qpm-114xb-qpm-118	0.6	1.2	1.1	10.8	-18.0	-4.5	3.4	-0.3	-2.0	15.9	5.9	3.3*	23.5
B- qpm-114xb-qpm-122	4.4	2.3	2.8	2.3	-29.7	-11.6	-14.2	3.5	-7.7	-24.4	1.4	-6.2**	-20.4
B- qpm-114xb-qpm-124	-1.9	-2.8	-2.5	-7.2	-29.2	1.3	-12.2	3.8	-0.5	-12.1	3.5	-3.4**	-12.1
B- qpm-114xb-qpm-128	-4.4	-1.7	1.4	-2.7	44.9*	13.9	-4.5	23.5	-8.7	6.9	-6.5	-3.4*	17.0
B- qpm-117xb-qpm-118	1.2	1.7	4.0	11.1	9.9	9.8	30.8**	62.8**	-3.6	1.3	-2.9	-15.1**	68.7**
B- qpm-117xb-qpm-122	-2.5	-1.1	0.0	11.8	58.2*	-0.2	3.1	43.7*	1.4	7.9	-6.8	-14.8**	58.7**
B- qpm-117xb-qpm-124	-3.7	-2.3	23.0**	16.1*	22.9	-1.6	14.2	51.5**	3.5	-19.7*	0.7	-6.06**	33.3
B- qpm-117xb-qpm-128	-3.7	-1.7	8.6	1.6	11.5	8.9	8.3	19.0	-3.3	15.5	0.6	-17.5**	61.9**

Note: *significantat5%level. **significantat1% level qpm= QPM (Quality Protein Maize)

4. Conclusion

The results of heterosis suggested the presence of non additive gene action for grain yield, oil and protein. Hence exploitation of commercial heterosis would be the best method for utilizing such gene action. The superior hybrids over the two checks and that of better parent for grain yield, oil content and protein content can be exploited further in breeding programs for improving such important quantitative and qualitative traits.

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