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HETEROSIS STUDIES FOR YIELD CONTRIBUTING AND QUALITY TRAITS IN EARLY MATURING QUALITY PROTEIN MAIZE (*ZEA MAYS* L.) USING LINE × TESTER

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ABSTRACT

Fourty-five hybrids of maize were developed through Line x Tester design using three male tester lines and fifteen female inbred lines as parental material along with four standard checks Pratap QPM hybrid-1, Vivek QPM-9, HQPM-1 and HQPM-5, to study heterosis in maize (*Zea mays* L.).The parents, hybrids and four standard checks were evaluated during *kharif* season 2014 for 15 characters. Analysis of variance for means revealed significant differences for all the fifteen characters studied. The ratio of **ó**^{2}sca / **ó**^{2}gca was greater than one for all the traits exhibiting preponderance of non-additive gene effects. Significant heterosis over relative heterosis was manifested by 40 hybrids, ranged from 10.46 (L_3 x T_3) to 117.57 percent (L_{13} x T_1). The estimates of significant heterobeltiosis was observed in 23 hybrids with the magnitude ranged from 7.84 (L_{11} x T_3) to 80.88 percent (L_{13} x T_1). Only eight hybrids magnitude ranged from 8.05 (L_9 x T_1) to 23.78 percent (L_{13} x T_1) exhibited significant economic heterosis over the best check HQPM-5. Hybrid L_{13} x T_1 also exhibited significant economic heterosis for starch content, lysine content, Protein content and tryptophan content.

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INTRODUCTION

The genetic basis of heterosis has been debated for over 100 years; however, it is still not fully understood. To explain this genetic phenomenon, dominance hypotheses (Jones 1917), over-dominance hypotheses (Shull 1908) and epistasis hypotheses (Powers 1944) have been proposed (Wei *et al.*, 2016). Now it is believed that dominance comprises more than one type of genetic effect. This information enables the breeders to explore heterosis from selected parental material for their utility as high yielding F_1 hybrids in maize where hybrids are being cultivated on commercial scale.

There is no other cereal crop which has such immense potential as maize and therefore maize occupies the unique place as "Queen of Cereals". Normal maize lacks in essential amino acids such as lysine and tryptophan, which are vital in the synthesis of proteins by the body (Vivek *et al.*, 2009). Lysine is the first limiting amino acid followed by tryptophan and threonine in the diets of non-ruminants and humans (Shimada and Cline, 1974). Seed storage protein of maize (Zein) constitute 50-60 percent fraction of the storage protein, which is completely devoid of lysine and tryptophan is the primary cause of poor protein quality in maize. Hence genetic manipu-lation for improved nutritional value, particularly, protein quality was considered as a noble goal for maize breeding.

This effort was stimulated with the discovery of mutant alleles, opaque-2 gene (Mertz et al., 1964) at Purdue University, which found to alter the amino acid profile and composition of maize endosperm protein and result in twice increase in the levels of lysine and tryptophan compared to proportion in normal maize genotypes. The discovery of this mutant and subsequently its modifier were considered remarkable and lead to the concept of Breeding for Quality Protein Maize (Vassal, 1999). Quality protein maize (QPM) is biofortified maize, contains higher amount of lysine and tryptophan in the endosperm ensuring higher biological value and availability of protein to human and animal. The lysine levels in normal and QPM maize average 2.0 percent and 4.0 percent of total protein respectively, but range across genetic back-grounds from 1.6 - 2.6 percent in normal maize and 2.7 - 4.5 percent in their opaque 2 maize converted counterparts (Moro *et al.*, 1996). Yet, it expresses negative pleiotropic effects on the grain quality such as lower density, susceptibility to pests and diseases and a floury appearance (Vassal, 2001). However, their cultivation has not been widespread. In order to improve current QPM production and quality, cultivars that are adapted to the diverse agro-ecologies of the province need to be developed.

The extent of heterosis has been measured as a superiority of hybrids over their mid parent (relative heterosis), superiority of hybrids over their better parent (Heterobeltiosis) and superior over standard parent (standard heterosis). Among the three heterosis, standard heterosis is given importance for the exploitation of heterotic vigour. The heterosis has been widely used in maize and other allied species by several workers like Pratap *et al.* (2013), Thakare *et al.* (2013) and Ulaganathan *et al.* (2015) continues to be applied in quantitative genetic studies.

Further basic research on heterosis pattems should be conducted to obtain information on the development of single-cross hybrids that maximize the expression of heterosis with high amount of lysine and tryptophan content. Thus breeders need to develop such maize hybrids which have high nutrient (lysine and tryptophan) without lowering their yield potential.

MATERIALS AND METHODS

The present investigation was carried out in Quality protein maize (*Zea mays* L.)"at Instructional farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, India during *Kharif,* 2014.The experimental material consisting of 15 female parents (Lines) and 3 male parents (Tester) presented in Table 1. In this experiment, 15 QPM inbred lines were crossed with three testers viz., EIQ-104, EIQ-103 and EIQ-130 during Rabi -2013-14 to develop a total of 45 hybrids. These 45 F_1 hybrids along with 18 parents and 4 checks viz., Pratap QPM hybrid-1, Vivek QPM-9, HQPM-1 and HQPM-5 were evaluated in randomized block design with three replications during *Kharif* 2014. The experimental material consisting of a total of 67 entries (45 F_1 hybrids, 18 parents and 4 checks) were sown in randomized block design with three replications with a single row plot of four meter length, maintaining crop geometry of 60 x 25 cm. Observations for all traits were recorded on five randomly selected competitive plants of each entry in each replication except for days to 50 percent tasseling, days to 50 percent silking and days to 75 percent brown husk where observations were recorded on plot basis. Data recorded were subjected to analysis of variance according to Panse and Sukhatme (1985) to determine significant differences among genotypes.

Estimation of Relative heterosis (Ha), heterobeltiosis (Hb) and economic heterosis (Hc) by Shull (1908), Fonseca and Patterson (1968) and Briggle (1963), respectively were calculated for each character using the following formula

$$\text{Heterosis over mid parent (relattive heterosis)} = \frac{F1-MP}{MP} \times 100$$

$$\text{Heterosis over better parent (heterobeltiosis)} = \frac{F1-BP}{BP} \times 100$$

$$\text{Heterosis over check (Standard heterosis} = \frac{F1-CC}{CC} \times 100$$

Where: F_1 = mean performance of F_1, MP = mean midparental value = $(P_1 + P_2)/2$, P_1 = mean performance of parent one, P_2 = mean performance of parent two, BP = mean performance of better parent, CC = mean performance of the best commercial check.

Estimation of oil content, starch content and protein content were done as per method suggested by Soxhlet's Ether Extraction method developed by A.O.A.C. (1965), Anthrone Reagent method and Micro kjeldahl's method given by Lindner (1944), respectively. Tryptophan was estimated through calorimetric method designed by Hernandez and Bates (1969). Lysine was estimated according to the calorimetric method designed by Tsai *et al.* (1972) and modified by Villegas and Mertz (1971).

RESULTS AND DISCUSSION

Analysis of variance showed that mean squares were highly significant for all the traits such as days to 50 percent tasseling, days to 50 percent silking, anthesis silking interval, days to 75 percent brown husk, plant height, ear height, ear length, 100-grain weight, grain yield per plant, harvest index, oil content, starch content, protein content, tryptophan content and lysine content. Highly significant mean squares due to parents vs. crosses indicated presence of average heterosis for all the characters. Mean squares due to crosses were highly significant for all the charecters. This indicated that the crosses were sufficiently different from each other for these traits and hence, selection is possible to identify the most desirable hybrids (Table 2). Similar trends for variance and its components were also reported by Ofori *et al.* (2015).

The phenomenon of heterosis has provided the most important genetic tool improving yield potential of crop plant. The aim of heterosis in the present investigation was identification of parent and their cross combinations capable of producing the highest level of transgressive segregates. The magnitude of heterosis depends on the extent of genetic diversity between parents and helps in choosing the parents for superior F_1s.

In the present investigation, the magnitude of relative heterosis/ mid parent heterosis (Ha), heterobeltiosis/ better parent heterosis (Hb) and economic heterosis/ standard heterosis (Hc) have been calculated. The magnitude of heterosis have been expressed as percent increase or decrease of F_1 value over mid parent (relative heterosis), over better parent (heterobeltiosis) and over standard check (standard or economic heterosis). The character wise results of mid parent, better parent and economic heterosis are presented in Table 3 to 9. For all the characters, positive values were considered desirable whereas, for days to 50 percent tasseling, days to 50 percent silking, days to 75 percent brown husk, plant height and ear height negative values were considered desirable for calculating heterosis, heterobeltiosis and economic heterosis. The trait wise results and discussion are summarized as under:

Days to 50 percent Tasseling

The estimates of relative heterosis for days to 50 percent tasseling revealed that out of 45 hybrids, 43 hybrids exhibited negative significant relative heterosis, 27 hybrids exhibited negative significant heterobeltiosis and only five hybrids depicted negative significant economic heterosis with the magnitude ranged from -8.82 (L_{14} x T_1) to -5.15 (L_1 x T_1) over the best check Vivek QPM-9. (Table 3) Similar finding for identification of superior early hybrid in maize were also reported by Ofori *et al.* (2015).

Days to 50 percent Silking

Out of 45 hybrids, 43 hybrids showed negative significant relative heterosis for days to 50 percent silking, 34 hybrids exhibited negative significant heterobeltiosis and only five hybrids depicted negative significant economic heterosis for this trait with ranged from -8.45 (L_{14} x T_3) to -5.63 percent (L_1 x T_1 and L_3 x T_1) in relation to the best check Vivek QPM-9. (Table 3) Similar finding for identification of superior early hybrid in maize were also reported by Ofori *et al.* (2015).

Anthesis silking Interval (ASI)

The estimates of relative heterosis for anthesis silking interval revealed that out of 45 hybrids, 34 hybrids exhibited negative

Table 1: Details of Inbred lines used as parents

S.N.	Symbol/Code	Pedigree	Origin
1	L_1 (EIQ-115)	NP-06-07R-58-3-2-1-2-1	AICRP on maize, Udaipur
2	L_2 (EIQ-116)	NP-06-07R-58-3-2-1-3-1	AICRP on maize, Udaipur
3	L_3 (EIQ-117)	NP-06-07R-74-19-1-1-1	AICRP on maize, Udaipur
4	L_4 (EIQ-118)	NP-06-07R-76-11-3-2-1	AICRP on maize, Udaipur
5	L_5 (EIQ-119)	NP-06-07R-76-9-1-1-2-2	AICRP on maize, Udaipur
6	L_6 (EIQ-120)	NP-06-07R-74-2-2-1-1	AICRP on maize, Udaipur
7	L_7 (EIQ-121)	NP-06-07R-77-1-2	AICRP on maize, Udaipur
8	L_8 (EIQ-122)	NP-06-07R-74-3-1-1-2-1	AICRP on maize, Udaipur
9	L_9 (EIQ-123)	NP-06-07R-74-3-1-1-3-2	AICRP on maize, Udaipur
10	L_{10} (EIQ-124)	NP-06-07R-16-3	AICRP on maize, Udaipur
11	L_{11} (EIQ-125)	NP-06-07R-76-8-3-3-1-8-2	AICRP on maize, Udaipur
12	L_{12} (EIQ-126)	NP-06-07R-80-16-1-1-1-1-1	AICRP on maize, Udaipur
13	L_{13} (EIQ-127)	NP-06-07R-89-12-1-1-1-1	AICRP on maize, Udaipur
14	L_{14} (EIQ-128)	HO6R-6136-64-1-2-1-1	CIMMYT
15	L_{15} (EIQ-129)	HO6R-64-1-4-1-1-2	CIMMYT
16	T_1 (EIQ-104)	NP-60	AICRP on maize, Udaipur
17	T_2 (EIQ-103)	NP-76	AICRP on maize, Udaipur
18	T3 (EIQ-130)	NP-86	AICRP on maize, Udaipur
19	Pratap QPM hybrid-1		AICRP on maize, Udaipur
20	Vivek QPM-9		VPKAS, Almora
21	HQPM-1		CCS, HAU
22	HQPM-5		CCS, HAU

Where, AICRP - All India Coordinated Research Project; CSS HAU - Chaudhary Charan Singh Haryana Agricultural University; CIMMYT - International Wheat and Maize Improvement Centre; VPKAS - Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora

Table 2: Analysis of variance for fifteen traits in maize

SN	Source	Replication [2]	Genotype [66]	Parent [17]	P v/s C [1]	Crosses [44]	Error [132]
1	Days to 50% tasseling	33.23**	34.75**	16.36**	691.24**	22.89**	1.73
2	Days to 50% silking	33.01**	38.72**	14.18**	890.06**	24.09**	1.63
3	Anthesis silking interval	0.06	0.76**	0.59**	14.58**	0.53**	0.13
4	Days to 75% brown husk	10.27*	51.32**	29.29**	1190.48**	30.87**	2.96
5	Plant height (cm)	4.94	565.33**	383.29**	6228.44**	482.54**	33.63
6	Ear height (cm)	197.97**	444.23**	853.68**	3024.8**	177.25**	25.7
7	Ear length (cm)	1.39**	5.86**	4.44**	57.13**	5.7**	0.09
8	100 Grain weight (g)	6.71**	75.82**	45.34**	3298.85**	19.95**	0.69
9	Grain yield per plant (g)	28.56*	1515.8**	769.93**	37059.53**	1030.65**	8.86
10	Harvest index (%)	0.62	32.27**	22.3**	432.01**	29.58**	0.57
11	Oil content (%)	0.01*	1.64**	1.06**	10.91**	1.78**	0
12	Starch content (%)	0.05	30.65**	16.33**	295.94**	31.57**	0.06
13	Protein (%)	0	2.85**	1.29**	36.99**	2.86**	0
14	Tryptophan Content (%)	0.02**	0.04**	0.03**	0.18**	0.05**	0
15	Lysine Content (%)	0.01	0.57**	0.31**	3.75**	0.64**	0.01

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

significant relative heterosis, only 14 hybrids exhibited negative significant and only two hybrids depicted negative significant economic heterosis with the magnitude -33.33 percent (L_3 x T_1 and L_{14} x T_1) over the best check Vivek QPM-9 (Table 4). Similar finding for ASI in maize were also reported by Ofori *et al.* (2015).

Days to 75 percent brown husk

A perusal of estimates of heterosis revealed that all the 45 hybrids exhibited negative significant relative heterosis for days to 75 percent brown husk, 28 hybrids exhibited negative significant heterobeltiosis and only 3 hybrids exhibited negative significant economic heterosis with magnitude varied from -6.03 (L_4 x T_2) to -3.88 percent (L_1 x T_1) over the best check Vivek QPM-9 (Table 4). Alam *et al.* (2008) also reported similar results related to maturity.

Plant height

The negative significant relative heterosis for plant height was exhibited by 29 hybrids. It ranged from -25.47 (L_{12} x T_2) to -5.08 percent (L_6 x T_1). Twenty three hybrids exhibited negative significant heterobeltiosis with magnitude varied from -22.88 (L_{12} x T_2) to -5.33 percent (L_3 x T_3). Only five hybrids ranged from -10.89 (L_4 x T_1) to -5.94 percent (L_3 x T_2, L_6 x T_2 and L_{12} x T_3) depicted negative significant economic heterosis for this trait over the best check HQPM-1 (Table 5). These results are generally analogous to the findings of Frascaroli et al. (2007).

Ear height

Table 3: Percent relative heterosis (Ha), heterobeltiosis (Hb) and economic heterosis (Hc) for days to 50% tasseling and days to 50% silking

SN.	Crosses	Days to 50 % tasseling			Days to 50 % silking		
		Ha	Hb	Hc	Ha	Hb	Hc
1.	L1 x T1	-18.61**	-11.64**	-5.15*	-19.28**	-12.99**	-5.63*
2.	L2 x T1	-9.54**	-4.55*	-	-9.73**	-4.97*	-
3.	L3 x T1	-21.23**	-16.88**	-5.88*	-21.41**	-17.79**	-5.63*
4.	L4 x T1	-6.75**	-1.94	-	-7.06**	-2.47	-
5.	L5 x T1	-7.36**	-2.58	-	-7.65**	-3.09	-
6.	L6 x T1	-7.36**	-2.58	-	-8.19**	-4.27*	-
7.	L7 x T1	-8.31**	-3.25	-	-9.09**	-4.91*	-
8.	L8 x T1	-9.03**	-2.67	-	-9.79**	-4.40*	-
9.	L9 x T1	-21.60**	-16.99**	-6.62**	-22.81**	-19.51**	-7.04**
10.	L10 x T1	-5.81**	-1.28	-	-7.29**	-3.64	-
11.	L11 x T1	-9.79**	-8.43**	-	-9.71**	-8.14**	-
12.	L12 x T1	-10.39**	-9.04**	-	-10.29**	-8.72**	-
13.	L13 x T1	-11.78**	-8.75**	-	-12.97**	-10.65**	-
14.	L14 x T1	-27.06**	-26.63**	-8.82**	-26.97**	-26.97**	-8.45**
15.	L15 x T1	-10.71**	-9.09**	-	-11.43**	-9.88**	-
16.	L1 x T2	-11.33**	-8.90**	-2.21	-11.11**	-9.09**	-1.41
17.	L2 x T2	-11.69**	-11.69**	-	-9.94**	-9.94**	-
18.	L3 x T2	-8.44**	-8.44**	-	-9.88**	-9.32**	-
19.	L4 x T2	-19.09**	-18.83**	-8.09**	-18.89**	-18.63**	-7.75**
20.	L5 x T2	-10.68**	-10.39**	-	-11.46**	-11.18**	-
21.	L6 x T2	-7.44**	-7.14**	-	-8.31**	-7.45**	-
22.	L7 x T2	-5.84**	-5.84**	-	-6.79**	-6.21**	-
23.	L8 x T2	0.66	-	-	-0.62	0.00	-
24.	L9 x T2	-9.45**	-9.15**	-	-9.54**	-8.70**	-
25.	L10 x T2	-6.45**	-5.84**	-	-7.36**	-6.21**	-
26.	L11 x T2	-6.25**	-2.60	-	-6.31**	-3.11	-
27.	L12 x T2	-7.50**	-3.90	-	-7.51**	-4.35*	-
28.	L13 x T2	-8.92**	-7.14**	-	-9.70**	-7.45**	-
29.	L14 x T2	-6.50**	-1.95	-	-7.37**	-2.48	-
30.	L15 x T2	-5.33**	-1.95	-	-4.50**	-1.24	-
31.	L1 x T3	-2.58	-	-	-3.09	-	-
32.	L2 x T3	-7.55**	-4.55*	-	-8.16**	-5.59**	-
33.	L3 x T3	-6.29**	-3.25	-	-6.91**	-4.91*	-
34.	L4 x T3	-5.33**	-2.58	-	-3.61*	-1.23	-
35.	L5 x T3	-7.84**	-5.16*	-	-7.83**	-5.56**	-
36.	L6 x T3	-5.96**	-3.23	-	-8.38**	-6.71**	-
37.	L7 x T3	-4.40*	-1.30	-	-3.30*	-1.23	-
38.	L8 x T3	-8.28**	-4.00	-	-8.81**	-5.66**	-
39.	L9 x T3	-7.89**	-4.58*	-	-8.98**	-7.32**	-
40.	L10 x T3	-5.00**	-2.56	-	-5.67**	-4.24*	-
41.	L11 x T3	-6.06**	-5.49**	-	-4.09*	-3.53	-
42.	L12 x T3	-7.88**	-7.32**	-	-7.60**	-7.06**	-
43.	L13 x T3	-8.02**	-6.87**	-	-7.37**	-7.10**	-
44.	L14 x T3	-7.51**	-6.10**	-	-8.05**	-5.88**	-
45.	L15 x T3	-9.42**	-9.15**	-	-9.36**	-8.82**	-

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

Seven hybrids magnitude ranged from -19.93 (L_7 x T_2) and -7.47 (L_7 x T_1) percent exhibited negative significant relative heterosis for ear height. Two hybrids L_2 x T_2 (-13.21 %) and L_1 x T_2 (-11.54 %) exhibited negative significant heterobeltiosis. None of the hybrid exhibited negative significant economic heterosis (Hc) for this trait (Table 5). These results are generally analogous to the findings of Devi *et al.* (2007) for this trait.

Ear length

The estimates of significant positive relative heterosis were exhibited by 28 hybrids Significant positive heterobeltiosis was depicted by 20 and eleven hybrids magnitude ranged from 3.28 (L_4 x T_1) to 10.87 percent (L_{13} x T_1) exhibited positive significant economic heterosis over the best check HQPM-5 (Table 6).

100-grain weight

Forty four hybrids exhibited positive significant relative heterosis for this trait. The positive significant heterobeltiosis was observed in 38 hybrids and hybrid L_{14} x T_1 (43.07 %) exhibited positive significant economic heterosis over the best check HQPM-5 (Table 6). Devi *et al.* (2007) also reported economic heterosis for this trait in maize.

Grain yield per plant

The estimates of significant heterosis over relative heterosis was manifested by 40 hybrids, significant positive heterobeltiosis was observed in 23 hybrids and only 8 hybrids magnitude ranged from 8.05 (L_9 x T_1) to 23.78 (L_{13} x T_1)

Table 4: Percent relative heterosis (Ha), heterobeltiosis (Hb) and economic heterosis (Hc) for anthesis silking interval and days to 75% brown husk

SN.	Crosses	Anthesis silking interval			Days to 75 % brown husk		
		Ha	Hb	Hc	Ha	Hb	Hc
1.	L1 x T1	-37.50**	-37.50**	-16.67	-14.89**	-8.98**	-3.88*
2.	L2 x T1	-20.00*	-14.29	0.00	-8.21**	-4.28*	-
3.	L3 x T1	-52.94**	-50.00**	-33.33*	-14.34**	-9.56**	-2.16
4.	L4 x T1	-20.00*	-14.29	0.00	-8.41**	-4.30*	-
5.	L5 x T1	-20.00*	-14.29	0.00	-7.87**	-3.53*	-
6.	L6 x T1	-29.41**	-25.00*	0.00	-7.69**	-3.15	-
7.	L7 x T1	-29.41**	-25.00*	0.00	-6.99**	-1.60	-
8.	L8 x T1	-29.41**	-25.00*	0.00	-7.40**	-1.61	-
9.	L9 x T1	-47.37**	-37.50**	-16.67	-14.83**	-9.31**	-3.45
10.	L10 x T1	-41.18**	-37.50**	-16.67	-6.37**	-1.96	-
11.	L11 x T1	-14.29	0.00	0.00	-6.54**	-2.34	-
12.	L12 x T1	-14.29	0.00	0.00	-8.69**	-5.73**	-
13.	L13 x T1	-41.18**	-37.50**	-16.67	-10.58**	-7.31**	-
14.	L14 x T1	-52.94**	-50.00**	-33.33*	-19.34**	-17.84**	-4.74*
15.	L15 x T1	-20.00*	-14.29	0.00	-8.55**	-5.02**	-
16.	L1 x T2	-6.67	-	-	-12.96**	-8.16**	-3.02
17.	L2 x T2	28.57**	-	-	-12.29**	-9.73**	-0.00
18.	L3 x T2	-37.50**	-28.57*	-16.67	-10.90**	-7.17**	-
19.	L4 x T2	-28.57**	-28.57*	-16.67	-17.42**	-14.84**	-6.03**
20.	L5 x T2	-28.57**	-28.57*	-16.67	-14.23**	-11.37**	-2.59
21.	L6 x T2	-25.00**	-14.29	0.00	-9.13**	-5.91**	-
22.	L7 x T2	-25.00**	-14.29	0.00	-7.28**	-3.20	-
23.	L8 x T2	-25.00**	-14.29	0.00	-4.23**	-	-
24.	L9 x T2	-11.11	-	-	-9.83**	-5.26**	-
25.	L10 x T2	-25.00**	-14.29	0.00	-14.23**	-11.37**	-2.59
26.	L11 x T2	-7.69	0.00	0.00	-6.44**	-3.52*	-
27.	L12 x T2	-7.69	0.00	0.00	-8.61**	-6.87**	-
28.	L13 x T2	-25.00**	-14.29	0.00	-9.40**	-7.31**	-
29.	L14 x T2	-25.00**	-14.29	0.00	-9.06**	-8.55**	-
30.	L15 x T2	28.57**	-	-	-6.59**	-4.25*	-
31.	L1 x T3	-20.00*	-14.29	0.00	-5.04**	-	-
32.	L2 x T3	-28.57**	-28.57*	-16.67	-7.95**	-5.45**	-
33.	L3 x T3	-25.00**	-14.29	0.00	-4.60**	-0.80	-
34.	L4 x T3	28.57**	-	-	-5.88**	-3.13	-
35.	L5 x T3	-14.29	-14.29	0.00	-7.22**	-4.31*	-
36.	L6 x T3	-37.50**	-28.57*	-16.67	-4.76**	-1.57	-
37.	L7 x T3	12.50	-	-	-4.80**	-0.80	-
38.	L8 x T3	-25.00**	-14.29	0.00	-7.51**	-3.23	-
39.	L9 x T3	-33.33**	-14.29	0.00	-5.41**	-0.81	-
40.	L10 x T3	-25.00**	-14.29	0.00	-5.70**	-2.75	-
41.	L11 x T3	38.46**	-	-	-3.61*	-0.78	-
42.	L12 x T3	-7.69	0.00	0.00	-4.69**	-3.05	-
43.	L13 x T3	-0.00	-	-	-8.85**	-6.92**	-
44.	L14 x T3	-25.00**	-14.29	0.00	-5.93**	-5.58**	-
45.	L15 x T3	-14.29	-14.29	0.00	-6.04**	-3.86*	-

Table 5: Percent relative heterosis (Ha), heterobeltiosis (Hb) and economic heterosis (Hc) for plant height and ear height

SN.	Crosses	Plant height			Ear height		
		Ha	Hb	Hc	Ha	Hb	Hc
1.	L1 x T1	-4.27	-2.77	-	-5.84	-3.85	-
2.	L2 x T1	5.82**	-	-	-4.10	-3.02	-
3.	L3 x T1	-6.07**	-4.78	-	28.76**	-	-
4.	L4 x T1	-18.48**	-17.43**	-10.89**	12.11*	-	-
5.	L5 x T1	-5.94**	-3.92	-	17.98**	-	-
6.	L6 x T1	-5.08*	-	-	4.65	-	-
7.	L7 x T1	-1.09	-	-	-7.47*	-	-
8.	L8 x T1	-5.69*	-4.74	-	16.77**	-	-
9.	L9 x T1	-8.90**	-7.51**	-	2.37	-	-
10.	L10 x T1	3.70	-	-	27.61**	-	-
11.	L11 x T1	-2.15	-1.80	-	15.55**	-	-

Table 5: Cont......

SN.	Crosses	Plant height			Ear height		
		Ha	Hb	Hc	Ha	Hb	Hc
12.	L12 x T1	-12.61**	-6.98**	-	21.97**	-	-
13.	L13 x T1	-9.14**	-5.72*	-	-0.21	-	-
14.	L14 x T1	-9.09**	-7.87**	-	-7.94*	-3.69	-
15.	L15 x T1	0.80	-	-	6.58	-	-
16.	L1 x T2	-11.66**	-7.75**	-0.99	-12.71**	-11.54*	-
17.	L2 x T2	-11.59**	-10.43**	-	-13.53**	-13.21**	-
18.	L3 x T2	-16.23**	-12.68**	-5.94*	3.90	-	-
19.	L4 x T2	-13.30**	-9.72**	-2.57	-2.71	-	-
20.	L5 x T2	-3.20	-	-	8.41	-	-
21.	L6 x T2	-13.24**	-5.94*	-5.94*	-8.20	-4.08	-
22.	L7 x T2	-10.95**	-7.63**	-	-19.93**	-8.24	-
23.	L8 x T2	-3.16	-	-	-7.92	-	-
24.	L9 x T2	-11.66**	-10.59**	-	-2.39	-	-
25.	L10 x T2	-0.99	-	-	22.72**	-	-
26.	L11 x T2	6.55**	-	-	16.53**	-	-
27.	L12 x T2	-25.47**	-22.88**	-9.90**	-9.50	-	-
28.	L13 x T2	-8.48**	-7.63**	-	19.91**	-	-
29.	L14 x T2	-10.65**	-9.41**	-	-9.41*	-4.49	-
30.	L15 x T2	-12.33**	-10.14**	-	21.28**	-	-
31.	L1 x T3	-11.90**	-10.52**	-3.96	-3.92	-2.00	-
32.	L2 x T3	-3.00	-1.61	-	8.74*	-	-
33.	L3 x T3	-6.62**	-5.33*	-	16.85**	-	-
34.	L4 x T3	-5.62*	-4.40	-	-5.88	-	-
35.	L5 x T3	17.81**	-	-	37.93**	-	-
36.	L6 x T3	1.50	-	-	3.03	-	-
37.	L7 x T3	-12.99**	-7.16**	-	-14.29**	-	-
38.	L8 x T3	-6.05**	-5.11	-	11.11*	-	-
39.	L9 x T3	-3.96	-2.50	-	11.75**	-	-
40.	L10 x T3	-2.78	-	-	14.63**	-	-
41.	L11 x T3	-2.15	-1.80	-	26.15**	-	-
42.	L12 x T3	-20.17**	-15.03**	-5.94*	15.29**	-	-
43.	L13 x T3	-8.97**	-5.55*	-	13.33**	-	-
44.	L14 x T3	-14.39**	-13.24**	-3.96	-13.92**	-6.00	-
45.	L15 x T3	-9.90**	-9.66**	-	26.19**	-	-

Table 6: Percent relative heterosis (Ha), heterobeltiosis (Hb) and economic heterosis (Hc) for ear length and 100 grain weight

SN.	Crosses	Ear length			100 Grain weight		
		Ha	Hb	Hc	Ha	Hb	Hc
1.	L1 x T1	4.90**	2.31	2.31	58.37**	37.58**	7.66**
2.	L2 x T1	12.32**	6.37**	6.37**	61.64**	36.52**	6.83**
3.	L3 x T1	14.90**	8.27**	8.27**	38.40**	22.06**	-
4.	L4 x T1	15.12**	3.28*	3.28*	20.67**	10.98**	-
5.	L5 x T1	12.90**	-	-	37.02**	19.09**	-
6.	L6 x T1	5.10**	-	-	15.68**	9.20**	-
7.	L7 x T1	-13.21**	-	-	10.04**	4.89*	-
8.	L8 x T1	14.76**	7.39**	7.39**	60.76**	44.86**	13.36**
9.	L9 x T1	14.03**	5.89**	5.89**	52.50**	41.54**	10.76**
10.	L10 x T1	-9.76**	-	-	32.66**	13.38**	-
11.	L11 x T1	-1.69	-	-	24.03**	23.18**	-
12.	L12 x T1	6.49**	-	-	44.73**	26.15**	-
13.	L13 x T1	15.19**	10.87**	10.87**	66.74**	48.57**	16.26**
14.	L14 x T1	8.99**	-	-	52.86**	43.07**	11.96**
15.	L15 x T1	-2.92*	-	-	12.85**	8.85**	-
16.	L1 x T2	-8.34**	-	-	36.13**	14.82**	-
17.	L2 x T2	1.43	1.34	-	44.21**	18.38**	-
18.	L3 x T2	-4.17**	-	-	23.70**	5.85*	-
19.	L4 x T2	26.51**	19.36**	6.88**	40.77**	25.41**	5.37*
20.	L5 x T2	20.19**	3.93*	-	41.48**	19.39**	0.31
21.	L6 x T2	-1.15	-	-	19.53**	9.19**	-
22.	L7 x T2	1.14	-	-	12.10**	10.60**	-
23.	L8 x T2	-0.64	-	-	29.51**	13.14**	-
24.	L9 x T2	19.30**	16.75**	4.54**	33.59**	20.06**	0.88

Table 6: Cont.......

SN.	Crosses	Ear length			100 Grain weight		
		Ha	Hb	Hc	Ha	Hb	Hc
25.	L10 x T2	27.12**	21.95**	9.19**	47.51**	22.49**	2.91
26.	L11 x T2	20.97**	18.69**	6.28**	14.13**	10.96**	-
27.	L12 x T2	13.17**	11.92**	0.21	32.64**	12.23**	-
28.	L13 x T2	7.56**	5.84**	-	34.51**	16.24**	-
29.	L14 x T2	-2.65	-	-	28.48**	16.41**	-
30.	L15 x T2	15.68**	13.16**	5.94**	10.36**	10.22**	-
31.	L1 x T3	2.11	0.70	-	15.93**	-	-
32.	L2 x T3	-7.45**	-	-	34.12**	6.44**	-
33.	L3 x T3	5.01**	2.76	-	8.65**	-	-
34.	L4 x T3	-1.68	-	-	11.73**	-	-
35.	L5 x T3	-0.68	-	-	40.05**	14.08**	4.77*
36.	L6 x T3	-8.18**	-	-	23.04**	8.07**	-
37.	L7 x T3	-18.23**	-	-	4.32*	1.19	-
38.	L8 x T3	9.95**	6.82**	-	34.22**	12.98**	3.76
39.	L9 x T3	6.48**	2.62	-	24.89**	8.01**	-
40.	L10 x T3	14.39**	8.09**	-	29.35**	3.77	-
41.	L11 x T3	4.94**	1.39	-	-0.09	-	-
42.	L12 x T3	9.63**	6.75**	-	27.06**	3.77	-
43.	L13 x T3	7.59**	7.55**	-	32.93**	10.75**	1.71
44.	L14 x T3	13.58**	6.98**	-	37.73**	20.03**	10.23**
45.	L15 x T3	6.44**	5.77**	-	11.75**	7.12**	-

Table 7: Percent relative heterosis (Ha), heterobeltiosis (Hb) and economic heterosis (Hc) for grain yield per plant and harvest index

SN.	Crosses	Grain yield per		plant	Harvest index		
		Ha	Hb	Hc	Ha	Hb	Hc
1.	L1 x T1	93.89**	52.86**	4.61	17.30**	12.35**	0.62
2.	L2 x T1	101.09**	53.16**	4.81	20.45**	8.70**	-
3.	L3 x T1	104.78**	57.96**	8.10**	23.35**	14.71**	2.74
4.	L4 x T1	-25.33**	-	-	21.06**	17.53**	5.27**
5.	L5 x T1	57.75**	21.87**	-	15.72**	6.42**	-
6.	L6 x T1	70.56**	43.73**	-	25.16**	21.19**	15.89**
7.	L7 x T1	47.40**	27.37**	-	16.67**	15.45**	5.62**
8.	L8 x T1	104.89**	72.76**	18.22**	8.80**	8.69**	-
9.	L9 x T1	100.57**	57.89**	8.05**	19.83**	10.44**	-
10.	L10 x T1	27.83**	18.36**	-	12.84**	8.53**	-
11.	L11 x T1	20.02**	2.52	-	14.18**	9.97**	-
12.	L12 x T1	51.30**	20.23**	-	18.99**	18.67**	6.86**
13.	L13 x T1	117.57**	80.88**	23.78**	21.36**	19.04**	6.62**
14.	L14 x T1	124.14**	65.35**	13.15**	18.28**	8.77**	-
15.	L15 x T1	16.45**	3.23	-	12.79**	6.90**	6.90**
16.	L1 x T2	43.78**	5.50	-	34.42**	31.73**	12.51**
17.	L2 x T2	15.08**	-	-	16.79**	7.68**	-
18.	L3 x T2	34.03**	-	-	15.56**	9.88**	-
19.	L4 x T2	68.94**	34.11**	13.23**	21.90**	21.15**	3.47
20.	L5 x T2	28.07**	-	-	15.64**	8.71**	-
21.	L6 x T2	4.15	-	-	-2.42	-	-
22.	L7 x T2	12.52**	-	-	-1.78	-	-
23.	L8 x T2	26.43**	-	-	-7.38**	-	-
24.	L9 x T2	88.03**	37.79**	16.34**	27.88**	20.48**	2.91
25.	L10 x T2	56.30**	32.10**	11.54**	22.49**	20.55**	2.96
26.	L11 x T2	-29.95**	-	-	3.06	1.59	-
27.	L12 x T2	17.76**	-	-	-0.12	-	-
28.	L13 x T2	12.18**	-	-	-4.05*	-	-
29.	L14 x T2	15.68**	-	-	5.22**	-	-
30.	L15 x T2	-13.40**	-	-	-2.37	-	-
31.	L1 x T3	52.75**	19.92**	-	19.92**	13.82**	-
32.	L2 x T3	56.65**	18.85**	-	19.91**	18.63**	-
33.	L3 x T3	43.24**	10.05**	-	17.89**	15.32**	-
34.	L4 x T3	35.67**	16.46**	-	4.69*	-	-
35.	L5 x T3	10.46*	-	-	10.71**	9.59**	-
36.	L6 x T3	29.46**	8.59*	-	0.32	-	-

Table 7: Cont........

SN.	Crosses	Grain yield per plant			Harvest index		
		Ha	Hb	Hc	Ha	Hb	Hc
37.	L7 x T3	20.46**	3.59	-	6.15**	-	-
38.	L8 x T3	41.74**	18.97**	-	2.02	-	-
39.	L9 x T3	35.17**	5.97	-	19.99**	18.50**	-
40.	L10 x T3	-13.72**	-	-	6.77**	0.93	-
41.	L11 x T3	26.85**	7.84*	-	10.63**	4.42*	-
42.	L12 x T3	-0.44	-	-	7.83**	-	-
43.	L13 x T3	24.63**	3.14	-	3.69	-	-
44.	L14 x T3	50.42**	10.57**	-	15.96**	14.80**	-
45.	L15 x T3	-3.97	-	-	-4.31*	-	-

Table 8: Percent relative heterosis (Ha), heterobeltiosis (Hb) and economic heterosis (Hc) for oil content and starch content

SN.	Crosses	Oil content			Starch content		
		Ha	Hb	Hc	Ha	Hb	Hc
1.	L1 x T1	40.84**	29.19**	3.61**	11.96**	11.89**	2.65**
2.	L2 x T1	32.81**	21.04**	-	14.36**	12.44**	3.03**
3.	L3 x T1	42.29**	32.73**	2.63**	17.66**	14.66**	5.06**
4.	L4 x T1	13.37**	11.81**	-	-0.79**	-	-
5.	L5 x T1	-11.43**	-	-	-1.75**	-	-
6.	L6 x T1	26.92**	8.17**	2.75**	1.48**	-	-
7.	L7 x T1	-0.71	-	-	-0.63*	-	-
8.	L8 x T1	34.12**	17.42**	4.65**	18.40**	15.72**	6.04**
9.	L9 x T1	65.37**	62.11**	12.96**	10.81**	9.85**	2.44**
10.	L10 x T1	22.19**	19.98**	-	5.09**	4.42**	-
11.	L11 x T1	-8.42**	-	-	5.56**	3.55**	-
12.	L12 x T1	5.50**	-	-	2.21**	1.23**	-
13.	L13 x T1	26.72**	14.22**	-	11.80**	10.90**	1.62**
14.	L14 x T1	34.68**	12.41**	12.41**	8.43**	4.96**	2.76**
15.	L15 x T1	20.07**	13.18**	-	0.00	-	-
16.	L1 x T2	17.13**	5.26**	-	-5.12**	-	-
17.	L2 x T2	11.57**	-	-	-0.79**	-	-
18.	L3 x T2	18.04**	7.83**	-	4.09**	-	-
19.	L4 x T2	71.18**	65.10**	13.63**	11.95**	8.14**	5.55**
20.	L5 x T2	-11.95**	-	-	-6.80**	-	-
21.	L6 x T2	5.46**	-	-	-7.61**	-	-
22.	L7 x T2	12.98**	-	-	-1.96**	-	-
23.	L8 x T2	9.50**	-	-	3.54**	-	-
24.	L9 x T2	62.21**	55.53**	8.37**	8.78**	6.36**	3.81**
25.	L10 x T2	67.19**	60.56**	11.49**	10.08**	6.06**	3.51**
26.	L11 x T2	11.95**	0.84	-	0.34	-	-
27.	L12 x T2	16.95**	2.83*	-	-1.74**	-	-
28.	L13 x T2	7.55**	-	-	2.37**	-	-
29.	L14 x T2	-12.83**	-	-	0.27	0.11	-
30.	L15 x T2	14.50**	5.66**	-	0.45	-	-
31.	L1 x T3	40.59**	22.10**	-	8.20**	4.28**	3.15**
32.	L2 x T3	36.38**	17.73**	-	9.91**	4.16**	3.03**
33.	L3 x T3	31.09**	15.65**	-	7.01**	0.54	-
34.	L4 x T3	23.17**	14.48**	-	-1.69**	-	-
35.	L5 x T3	-4.47**	-	-	-6.68**	-	-
36.	L6 x T3	7.26**	-	-	1.42**	-	-
37.	L7 x T3	55.81**	30.69**	14.00**	-2.75**	-	-
38.	L8 x T3	14.97**	-	-	10.67**	4.28**	3.15**
39.	L9 x T3	46.75**	35.61**	-	-6.92**	-	-
40.	L10 x T3	20.87**	11.88**	-	-0.09	-	-
41.	L11 x T3	10.65**	-	-	-0.60*	-	-
42.	L12 x T3	3.41**	-	-	0.12	-	-
43.	L13 x T3	57.27**	34.38**	12.04**	9.81**	4.95**	3.81**
44.	L14 x T3	7.26**	-	-	-1.41**	-	-
45.	L15 x T3	15.24**	2.67*	-	-4.91**	-	-

Table 9: Percent relative heterosis (Ha), heterobeltiosis (Hb) and economic heterosis (Hc) for protein content, tryptophan content and lysine content

SN.	Crosses	Protein			Tryptophan Content			Lysine Content		
		Ha	Hb	Hc	Ha	Hb	Hc	Ha	Hb	Hc
1.	T1 x L1	38.94**	29.85**	19.13**	29.14**	22.83**	-	48.91**	43.44**	8.97**
2.	T1 x L2	26.53**	22.02**	11.95**	27.32**	21.08**	4.22**	35.95**	34.54**	-
3.	T1 x L3	7.36**	7.28**	-	28.75**	21.05**	6.75**	22.13**	15.02**	-
4.	T1 x L4	20.48**	16.09**	6.51**	14.07**	6.07**	-	16.13**	2.38	-
5.	T1 x L5	2.35**	-	-	32.97**	32.61**	2.95*	40.86**	39.66**	-
6.	T1 x L6	-0.23	-	-	-4.92**	-	-	4.58*	-	-
7.	T1 x L7	-1.92**	-	-	-26.37**	-	-	-13.32**	-	-
8.	T1 x L8	35.66**	24.95**	14.63**	60.83**	47.28**	14.35**	39.63**	30.07**	6.08**
9.	T1 x L9	26.82**	26.08**	15.67**	46.18**	29.89**	0.84	40.51**	36.12**	2.19
10.	T1 x L10	21.94**	18.43**	8.66**	1.78	-	-	0.64	-	-
11.	T1 x L11	-1.41**	-	-	12.11**	-	-	24.97**	12.16**	-
12.	T1 x L12	-7.12**	-	-	8.20**	7.61**	-	-8.67**	-	-
13.	T1 x L13	28.04**	19.50**	9.63**	60.36**	47.28**	14.35**	38.99**	22.83**	12.66**
14.	T1 x L14	28.50**	24.58**	14.30**	36.81**	35.33**	5.06**	58.36**	58.36**	11.47**
15.	T1 x L15	17.87**	15.58**	6.04**	-4.06**	-	-	-3.34	-	-
16.	T2 x L1	22.32**	17.42**	1.78**	5.04**	3.51*	-	7.32**	4.86*	-
17.	T2 x L2	11.48**	10.53**	-	-23.20**	-	-	5.11*	4.68	-
18.	T2 x L3	-0.28	-	-	-17.37**	-	-	-2.36	-	-
19.	T2 x L4	25.52**	24.35**	7.79**	43.38**	28.97**	16.46**	39.10**	24.22**	14.56**
20.	T2 x L5	4.76**	-	-	-18.08**	-	-	11.75**	9.22**	-
21.	T2 x L6	0.11	-	-	13.88**	10.44**	-	7.11**	3.60	-
22.	T2 x L7	4.78**	4.72**	-	15.17**	2.75*	-	7.47**	-	-
23.	T2 x L8	3.83**	-	-	8.64**	2.92	-	-1.88	-	-
24.	T2 x L9	27.91**	25.09**	13.42**	57.96**	45.03**	4.64**	44.46**	41.97**	6.58**
25.	T2 x L10	27.17**	27.02**	10.10**	35.38**	28.65**	-	45.08**	42.09**	2.99
26.	T2 x L11	6.29**	1.23*	-	15.20**	-	-	16.78**	6.19**	-
27.	T2 x L12	3.43**	-	-	3.68*	0.55	-	-2.48	-	-
28.	T2 x L13	5.09**	0.74	-	5.85**	0.58	-	-6.13**	-	-
29.	T2 x L14	8.35**	8.01**	-	-11.11**	-	-	7.33**	5.78*	-
30.	T2 x L15	13.57**	12.60**	-	11.33**	-	-	25.55**	8.28**	8.28**
31.	T3 x L1	7.81**	5.03**	-	10.17**	3.72*	-	3.04	-	-
32.	T3 x L2	21.02**	20.20**	2.42**	-11.73**	-	-	2.40	-	-
33.	T3 x L3	4.45**	0.15	-	23.93**	17.70**	3.80**	25.91**	24.45**	1.50
34.	T3 x L4	6.47**	5.84**	-	-17.41**	-	-	-17.50**	-	-
35.	T3 x L5	10.99**	2.15**	2.15**	1.89	0.53	-	5.95**	-	-
36.	T3 x L6	-17.69**	-	-	23.24**	21.28**	-	13.41**	10.64**	-
37.	T3 x L7	1.24**	-	-	-16.26**	-	-	22.79**	14.48**	7.98**
38.	T3 x L8	28.69**	23.47**	3.79**	13.20**	2.66	-	-4.65*	-	-
39.	T3 x L9	5.78**	1.92**	-	8.76**	-	-	-6.56**	-	-
40.	T3 x L10	9.68**	8.15**	-	42.11**	29.26**	2.53*	32.81**	22.98**	0.30
41.	T3 x L11	-3.84**	-	-	-18.12**	-	-	-5.51**	-	-
42.	T3 x L12	3.01**	-	-	23.78**	21.81**	-	18.05**	17.11**	-
43.	T3 x L13	17.73**	14.53**	-	25.15**	13.83**	-	22.90**	16.09**	6.48**
44.	T3 x L14	13.68**	12.31**	-	22.28**	19.68**	-	21.39**	13.08**	-
45.	T3 x L15	15.41**	12.71**	-	-13.00**	-	-	-3.46*	-	-

exhibited positive significant economic heterosis over the best check HQPM-5. (Table 7) Ojo (2007) also obtained similar results for heterosis in maize.

Harvest index

The estimates of significant positive relative heterosis were exhibited by thirty four hybrids with the magnitude ranged from 4.69 (L_4 x T_3) to 34.42 percent (L_1 x T_2), Significant heterobeltiosis was depicted by 29 hybrids with the magnitude ranged from 4.42 (L_{11} x T_3) to 31.73 percent (L_1 x T_2) and 7 hybrids magnitude ranged from 5.27 (L_4 x T_1) to 15.89 (L_6 x T_1) exhibited positive significant economic heterosis over the best check HQPM-5 (Table 7).

Oil content

The estimates of positive significant relative heterosis for this trait were recorded in 39 hybrids, 27 hybrids showed significant positive heterobeltiosis and eleven hybrids exhibited positive significant economic heterosis over the best check HQPM-5. The maximum positive significant economic heterosis was depicted by the hybrid L_7 x T_3 (14.00 percent) over the best check HQPM-5 (Table 8). Singh *et al.* (2013) reported economic heterosis for seed oil content in maize.

Starch content

The estimates of significant relative heterosis in positive direction were observed in 23 hybrids. In case of heterobeltiosis 17 hybrids exhibited positive significant heterobeltiosis and 14 hybrids exhibited positive significant economic heterosis magnitude ranged from 1.62 (L_{13} x T_1) to 6.04 percent (L_8 x T_1) over the best check HQPM-1. (Table 8) These results are in accordance with the findings of Abuali *et al.* (2012).

Protein content

Positive significant relative heterosis for this trait were recorded in 37 hybrids, 39 hybrids showed significant positive heterobeltiosis and significant economic heterosis in positive direction was observed in 16 hybrids with the magnitude ranged from 1.78 (L_1 x T_2) to 19.13 percent (L_1 x T_1). The maximum positive significant economic heterosis was expressed by hybrid L_1 x T_1 (19.13 %) over the best check for this trait was Vivek QPM-9 (Table 9). Premlatha (2011) and Lahane *et al.* (2014) also reported economic heterosis for protein content in maize.

Tryptophan content

The estimates of significant relative heterosis in positive direction were observed in 31 hybrids for tryptophan content. In case of heterobeltiosis 23 hybrids exhibited positive significant heterobeltiosis. Ten hybrids exhibited positive significant economic heterosis magnitude ranged from 2.53 (L_{10} x T_3) to 16.46 percent (L_4 x T_2) over the best check Vivek QPM-9 (Table 9). Present results are in agreement with the findings of Amiruzzaman *et al.* (2011).

Lysine content

Significant relative heterosis in positive direction were observed in thirty hybrids In case of heterobeltiosis 24 hybrids exhibited positive significant values. Only 9 hybrids exhibited positive significant economic heterosis which ranged from 6.08 (L_8 x T_1) to 14.56 percent (L_4 x T_2) over the best check HQPM-1 (Table 9). These results are in accordance with the findings of Amiruzzaman *et al.* (2011).

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