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Development and evaluation of quality protein maize (QPM) hybrids for Eastern Uttar Pradesh

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ABSTRACT

This study was conducted with the purpose of developing QPM hybrids for Eastern Uttar Pradesh. In this effort 10 locally adaptable maize inbreds were selected keeping in view of their past history as they were good combiners and exhibited good heterosis including for QPM traits when they were crossed with adoptable QPM donors such as CML141,CML193, DMRQPM58, HKI164-7-6, HKI162, CML169, CML176, CML161. About 80 hybrids were developed involving 8 QPM donors and 10 maize inbreds. Out of these eighty hybrids 30 hybrids were selected for their evaluation your yield and yield component in two environments i.e, *Rabi* as well as *Kharif* seasons during 2013-14 and 2014-15. In the present study as many six hybrids viz., HUZM185 X CML193, HUZM478 X CML193, V341 X CML141, V341 X HKI162, V341 X DMRQPM58, V335 X CML161, CML141 X CML169 exhibited standard heterosis ranging from 20 to 155 percent in *Kharif* as well as *Rabi* Season.

Key Words: *Heterosis, Hybrid, Kharif maize, Non QPM inbreds, QPM, QPM inbreds, Rabi maize*

INTRODUCTION

Maize belongs to the family of grasses (*Poaceae*.) Maize is grown from 58°N to 40°S, from below sea level to altitudes higher than 3000 m and in areas with 250 mm to more than 5000 mm of rainfall per year and with a growing cycle ranging from 3 to 13 months (CIMMYT 2000). India has 5% of corn acreage and contributes 2% of world production. The maize grain accounts for about 15 to 56% of the total daily calories in diets of people in about 25 developing countries, particularly in Africa and Latin America. In approximately 20 developing counties, maize is a staple food crop and meets the protein and caloric requirements of its human population. Unfortunately, maize protein is of poor nutritional quality as it is deficient in two essential aminoacids, lysine and tryptophan and thus has to be supplemented. Improving nutritional quality of staple food crops including maize is, therefore, a noble goal. The quality protein maize (QPM) has about twice the levels of lysine and tryptophan as compared to normal maize. It was developed by combining the genetic systems of the gene mutant opaque 2 and modified O_2 endosperm (Prasanna *et al* 2001, Vasal 2001, Babu *et al* 2005, Krivanek *et al* 2007 and Sofi *et al* 2009). The people eating QPM had significantly higher nitrogen retention than those who eat normal maize. QPM is primarily developed for tropical and sub-tropical regions but it could also have many advantages in human nutrition and animal feed in other parts of the world. QPM can significantly improve the nutritional status of groups whose main staple is maize and who cannot afford protein-rich foods to supplement their diet. . The utility of QPM as animal feed is greater in the parts of the world which have high per capita meat supply. Utilization of QPM could substitute protein additives which are used in animal feed

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composites, reducing its cost (Scott *et al* 2009). Keeping this in view we are reporting development of QPM hybrids for Eastern Part of Uttar Pradesh

MATERIALS AND METHODS

Plant Materials: Ten Non Quality Protein Maize (HUZM185, HUZM97-1-2, HKI287, HUZM478, HUZM509, HUZM88, V335, V351, V336, V341, CM141) obtained from BHU, Varanasi; VPKAS, Almora were used as female parent. Many of these lines were early and medium duration .Eight tropical and subtropical Quality Protein Maize (QPM) donar lines *viz.*, CML141, CML193, DMRQPM58, HKI164-7-6, HKI162, CML169, CML176, CML161 were obtained from DMR, New Delhi, but originally introduced from CIMMYT, Mexico and Karnal, India were used as testers (males). The tester used in present study is widely used QPM donors in many national breeding programme to convert local lines into QPM version. These testers also have good ability to discriminate the inbred lines into different heterotic group. The details of inbreds along with its source, feature characteristics have been listed in Table 1.

Layout: The 10 normal maize inbreds taken as female were crossed with eight testers used as male to develop 80 F_1 involving Non QPM vs QPM crosses. Only 30 hybrids based on heterosis and past history were selected for evaluation. The 30 F_1s, 18 parental lines along with check (Malviya Makka-2) were planted during *Kharif* 2013-14 and *Rabi* 2014-15 in RBD with three replication at Institute of Agricultural Sciences, BHU, Varanasi, UP.

Raising of the crop: An experiment of thirty hybrids including ten Non QPM and five QPM along with check (Malviya Makka 2) were grown in Randomized Block Design with three replications. Each genotype was planted in two row plot of 3 m length having a uniform inter and intra row spacing of 60 and 25 cm, respectively. Two seed per hill were planted and later one plant was thinned from each hill to maintain the optimum plant population. Border rows were maintained at end of each replication to minimize border effect. The recommended agronomic packages of practices were adopted. Methods of handling to raise a good and healthy crop. The fertilizer nitrogen, phosphorus, potash were applied @ 160, 80 and 60 Kg per hectare, respectively. Proper and timely irrigation as per need were provided with suitable drainage system at seedling, knee height and grain filling stages. For proper control of weeds and less competition at early stage of crop growth, Atrazine (50%WP) were sprayed just after the sowing @1.25 kg/hectare. The check variety Malviya Makka-2 is a medium duration single cross hybrid. The purpose of growing check was to compare the performance of F_1 crosses and for calculation of standard heterosis.

Observation: Ten competitive plants in each plot were randomly selected prior to tasseling and tagged to record the observation for height, yield and yield related trait. However, on days to 50 percent tasseling, days to 50 percent silking, days to 75 percent brown husk and grain yield per plot were recorded on plot basis. Details of procedure for each trait are given below:

Days to 50% tasseling: Number of days taken from date of sowing to 50% plant showing tassel emergence in a plot was recorded as Days to 50% tasseling.

Days to 50%* silkig*: Days to 50% silkig Number of days taken from date of sowing to 50% plant showing silk emergence in a plot was recorded as Days to 50% tasseling.

Days to 75% brown husk: Number of days taken from date of sowing to 75% plants in a plot got first husk cover on the ear dried and turned brown was recorded as days to 75% brown husk.

Plant height (cm): Plant height was recorded in centimeter by measuring the plant stalk from ground level to the base of the last leaf sheath of mature plant

Table 1 Characteristic feature of Non QPM and QPM lines used in present study.

Inbred Name	Source	Feature Characteristics
HUZM185 (Non QPM)	BHU, Varanasi	Yellow, Flint kernel, Medium duration, Tassels and Leaf angle is small, Tall height and Good grain yield.
HUZM97-1-2 (Non QPM)	BHU, Varanasi	Yellow kernel, Early duration, Wide leaf angle
HUZM509 (Non QPM)	BHU, Varanasi	Yellow kernel, Late duration, Leaf angle small with narrow tassel angle
HKI287 (Non QPM)	Karnal	Yellow kernel, Late duration, Leaf and Tassel angle is wide, Tall height with high grain yield.
HUZM478 (Non QPM)	BHU, Varanasi	Yellow, Flint kernel, Late duration, Leaf angle is wide with narrow tassel angle
V336 (Non QPM)	VPKAS, Almora	Yellow, Flint kernel, Medium duration, Leaf and Tassel angle is small, Straight leaf attitude.
V341 (Non QPM)	VPKAS, Almora	Yellow, Flint kernel, Early duration, Tall with drooping leaf attitude, straight tassel.
V351 (Non QPM)	VPKAS, Almora	Orange yellow, Flint kernel, Early duration, Straight leaf attitude and better grain yield.
CM141 (Non QPM)	DMR, New Delhi	Yellow kernel, Late duration, Curved tassel
V335 (QPM)	DMR, New Delhi	Orange, Flint kernel, Medium duration, Straight tassel.
CML141 (QPM)	CIMMYT	White, Flint kernel, Late duration, Dwarf height.
CML193 (QPM)	CIMMYT	Yellow, Flint, Medium to late duration, Medium height
DMRQPM58 (QPM)	DMR	Orange yellow, Flint kernel, Early duration, Tall height
HKI 164-7-6 (QPM)	Karnal	Yellow, Semi Dent, Late duration, Medium height green plant, Sparse tassel.
HKI 162 (QPM)	Karnal	Yellow, Flint kernel, Late duration, Tall plant, Small tassel, Erect and Narrow leaves.
CML 169 (QPM)	CIMMYT	Yellow, Flint kernel, Medium duration, Curved tassel
CML 176 (QPM)	CIMMYT	White kernel, Medium to Late duration.
CML 161 (QPM)	CIMMYT	Orange yellow, Flint kernel, Late duration, Dwarf height with small leaf angle and straight leaf attitude.

Ear height (cm): Ear height was recorded in centimeter from the base of plant to upper most ears bearing node.

Ear length (cm): Length of the ear was measured and recorded in centimeter at the time of harvest (from the base to the tip of the ear).

Ear diameter (cm): Ear diameter was measured and recorded in centimeter as the thickness of the ear at the middle of the dehusked cob.

Number of kernel row/ear: Number of row per ear was counted after harvesting of each cob.

Number of kernel /row: Number of kernels in each kernel row was counted after shelling cob.

100-seed weight (gm): The weight of one hundred grain drawn from random sundried sample of ten randomly selected ears in each plot was recorded with the help of electronic top pan balance.

Grain Yield per Plot: The grain yield per was estimated on basis of yield per plot in grams

Estimation of Nature and Magnitude of Heterosis: The nature and magnitude of heterosis were computed over mid parent, better parent and standard check variety. Heterosis was expressed as percent increase or decrease of F_1s over mid parent, better parent and standard check**.** Heterosis in F_1s will be calculated as the difference of F_1 hybrid performance from the mid parent, better parents (Heterobeltiosis) and standard checks (Standard heterosis) by using the formulae (Kempthorne 1957).

(a) Average heterosis (%) = $\frac{(\overline{F}_1 - \overline{MP})}{\overline{MP}} \times 100$

(b) Heterobeltiosis (%) = $\frac{(\overline{F}_1 - \overline{BP})}{\overline{BP}} \times 100$

(c) Standard heterosis (%) = $\frac{(\overline{F}_1 - \overline{C})}{\overline{C}} \times 100$

Where, $\overline{F_1}$ = mean performance of F_1. MP = mean performance of mid parent

$\overline{BP}$ = mean performance better parent, $\overline{C}$ = mean performance of check variety.

Test of significance of heterosis: To test the significance of heterosis, the formula proposed by Arunachalam (1976) was used.

SE (Diff.) for ($\overline{F_1}$ - $\overline{BP}$ or $\overline{C}$) = $(2MSe/3r)^{1/2}$

CD = SE (Diff.) × t value at 5 and 1 per cent significance at respective error degree of freedom. Where, MSe = Mean sum of squares due to error Heteorsis was estimated for all the eleven trait but presently it is being reported for only yield and 70% brawn husk in Tables due to shortage of space. It has been discussed in results and discussion.

RESULTS AND DISCUSSION

Heterosis in present study was estimated as an increase or decrease of F_1 value over either mean parental value (average heterosis) or better parent (heterobeltiosis). But from practical point of view, increase of F_1 value over the best commercial variety (standard heterosis) is more relevant. Heterosis has been extensively utilized particularly in developing high yielding hybrids in commercially important allogamous crops. Taking this in view, in the present investigation the relative magnitude of heterosis over mid parent, better parent, standard check (Malviya Makka 2) has been estimated for ten characters in 30 crosses. The result suggested that the magnitude of hybrid vigour differ from character to character depending upon specific hybrid combination. The perusal of result revealed that among the 30 hybrids studied for days to 50% tasseling was exhibited toward negative direction in *Kharif* season except V341 X CML141 and V336 X CML193 but negative as well as positive direction in *Rabi* season, similarly days to 50% silking and days to 75% brown husk, heterosis was exhibited towards negative and positive direction in both *Kharif* and *Rabi* season. Overall rich manifestation of heterosis was registered for days to 50% tasseling in, while poor manifestation of heterosis for days to 50% silking and days to 75% brown husk in both kharif and Rabi. Heterobeltiosis and standard heterosis in negative direction for days to 50% tasseling have been reported by Debnath (1984), Sfakianakis *et al* (1996) and Dickert and Tracy (2002) as well as heterobeltiosis in negative direction for days to 50% silking and 75% brownhusk have been reported by Mohan lal *et al* (2011), Langade *et al* (2013). It may be mentioned here that negative heterosis for days to 50% tasseling , days to 50% silking and days to 75% brown husk is desirable. In the present study crosses viz., HKI287 X DMRQPM58, HUZM478 X DMRQPM58, HUZM185 X CMl169, HUZM509 X CMl169, HUZM478 X CMl169, HUZM478 X CMl176 and CM141 X CML176 exhibit negative heterosis over mid parent, better parent, check variety for days to 50% tasseling , days to 50% silking and days to 75% brown husk in season as well as crosses V341 X CML161 also exhibit negative heterosis over mid parent, better parent, check variety for days to 50% tasseling, days to 50% silking and days to 75% brown husk in *Rabi* season. It was observed that the majority of crosses recorded all the three types of positive heterosis for plant height and ear height in both *Kharif* and *Rabi* season. None of the crosses exhibit significant negative heterosis for plant height over mid parent as well as better parent and standard check in both *Kharif* and

Rabi season. Heterosis in negative direction is desirable as far as plant height is concerned. Present observations are in conformity with the finding of Anusheela *et al* (2013), who reported significant and positive heterosis over mid parent, better parent and standard check for plant height and ear height. Heterosis for ear length in general, was relatively low but overall lit was expressed in positive direction for mid parent and better parent whereas, it was expressed in negative direction for standard heterosis in both *Kharif* and *Rabi* season. High heterosis for ear length, ear length, ear girth, kernel per row and 100 grain weight, which might have contributed to high grain yield as observed.In present case in crosses *viz.*, HUZM185 X CML169, HUZM185 X CML176, HUZM509 X CML169 in *Kharif* season and cross CM141 X HKI164-7-6, V341 X CML141

Table 1 Extent of heterosis over mid parent (MPH), better parent (BPH), check (SH) in 30 maize hybrid for days to 75% Brown Husk, Grain yield/plant(gm) in *Kharif*.

Crosses	**75% Brown Husk**			**Grain yield/plant(gm)**		
	BPH(%)	**MPH(%)**	**SH(%)**	**BPH(%)**	**MPH(%)**	**SH(%)**
HUZM185 x CML141	-6.18 **	-8.83 **	-1.53	210.63 **	195.13 **	58.43
HUZM185 x CML193	-6.54 **	-6.72 **	-4.58	328.36 **	260.21 **	155.32 **
HUZM185xDMRQPM58	-0.96	-3.37	-1.53	148.73 **	89.17 **	75.44 *
HUZM185 x HKI162	-1.31	-1.5	0.38	88.96 *	40.39	39.61
HUZM185 x CML169	-10.04 **	-13.75 **	-4.2	307.85 **	224.13 **	165.74 **
HUZM185 x CML176	-8.15 **	-14.52 **	1.15	218.44 **	143.7 **	121.96 **
HUZM185 x CML161	3.31	-0.75	1.15	139.69 **	91.28 *	55.07
HUZM97-12 x DMRQPM58	1.56	0.38	-0.38	74.94 *	54.58	43.36
HUZM97-12 x CML161	1.58	-1.15	-1.91	291.86 **	267.9 **	198.26 **
HUZM509 x CML169	-5.86 **	-11.68 **	-1.91	167.06 **	146.64 **	102.21 **
HKI287 x CML193	1.71	0	2.29	124.35 **	106.16 **	74.41 *
HKI287 x DMRQPM58	-0.58	-1.54	-2.67	35.46	29.51	20.12
HKI287 x CML169	-3.64	-8.93 **	1.15	20.39	18.53	0.28
HUZM478 x CML193	-1.85	-2.92	1.53	253.09 **	162.3 **	85.92 **
HUZM478 x DMRQPM58	-1.52	-5.11 *	-0.76	40.84	-3.44	-10.44
HUZM478 x HKI162	-1.48	-2.92	1.53	16.99	-21.25	-21.69
HUZM478 x CML169	-7.61 **	-10.31 **	-0.38	194.46 **	109.06 **	71.4 *
HUZM478 x CML176	-7.19 **	-12.58 **	3.44	50.18	3.47	-5.75
V336 x CML141	-0.37	-4.95 *	2.67	107.23 **	67.19	46.28
V336 x CML193	6.29 **	4.1	6.49 *	121.97 **	100.89 **	75.77 *
V336 x DMRQPM58	7.24 **	6.61 *	4.58	25.78	22.22	13.35
V341 x CML141	-2.75	-6.36 **	1.15	298.54 **	256.89 **	91.59 **
V341 x HKI162	-0.76	-1.5	0	121.21 **	57.84	56.96
V341 x DMRQPM58	-0.78	-2.29	-2.29	99.4 *	45.34	34.8
V341 x CML161	3.54	0.38	0.38	58	20.38	-2.41
CM141 x DMRQPM58	4.33	4.33	1.15	107.63 *	21.88	13.04
CM141 x HKI164-7-6	-0.57	-4.36	0.38	142.89 *	48.92	6.25
CM141 xCML169	-2.75	-8.93 **	1.15	265.62 **	118.79 **	79.38 *
CM141 x CML176	-10.64 **	-18.71 **	-3.82	91.71	12.84	2.78
V335 x CML161	6.26 **	5.62 *	0.38	276.43 **	120.31 **	78.61 *
No. of hybrids with Positive heterosis	9(3)	7(1)	18(1)	30(22)	28(15)	26(13)
No. of hybrids with Negative heterosis	21(10)	23(13)	12(0)	0(0)	2(0)	4(0)
Range of heterosis	-10.64 to 7.24	-18.71 to 5.62	-4.58 to 6.49	16.99 to 328.36	-21.25 to 267.9	-21.69 to 198.26

* and ** indicates significant at 5 and 1 percent level of probability, respectively.

in *Rabi* season. It was also observed that in some of the crosses, where high positive and significant heterosis was observed for grain yield per plant, the same hybrid fail to show high positive and significant heterosis for ear length *viz,* HUZM478 X CMl169, HUZM478 X CML169, HUZM185 X CML141, HUZM185 X CML193, HUZM185 X CML169, V336 X CML193, V336 X DMRQPM58, CM141 X CML169 and CM141 X HKI164-7-6 in both *Kharif* and *Rabi* season. Therefore it can be concluded that ear length in general did not contribute much towards grain yield. The hybrid with positive heterosis is desirable for number of kernals per row. Six crosses in *Kharif* season *viz* HUZM185 X CML169, HUZM509 X CML169, HKI287 X CML169, HUZM478 X HKI162, V336 X CML193, V341 X HKI162 and two crosses *viz.*, HUZM185 X DMRQPM58, V341 X HKI162 and CM141 X CML169 in *Rabi* season expressed heterosis in desired direction with significant high value, when tested against mid parent, better parent. The present study of heterosis for grain yield per plant over mid and better parent exhibited a wide range, the value varied from 16.99% to 328.36% and -21.25% to 279.59% respectively in *Kharif* season and from -2.84 to 315.44% and -11.32% to 279.59% in *Rabi* season. However from the practical point of view of practical utility heterosis over the standard check for grain yield is more relevant. In the present study as many as 10 hybrids *viz* HUZM185 X CML193, HUZM185 X CML169, HUZM185 X CML176, HUZM509 X CML169, HUZM478 X CML193, V341 X CML141, HUZM9712 X CML161, HUZM478 X CML169, V335 X CML161 and CML141 X CML169 exhibit heterosis over mid parent, better parent and check is more than 80% in *Kharif* season and six crosses V341 X HKI162, V341 X DMRQPM58, V341 X CML161, CM141 X HKI164-7-6, CM141 X CML176, V335 X CML161 exhibit positive and significant heterosis in *Rabi* seas.

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