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Studies on nutritional composition of quality protein and normal maize (*Zea mays*) genotypes

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ABSTRACT Chemical composition of quality protein maize (*Zea mays* L.) (QPM) was compared with that of normal maize genotypes. Study on nutritional traits indicated that protein and oil content were of higher magnitude in normal maize genotypes compared to QPM genotypes. However, protein quality was superior in case of QPM. Quality protein maize genotypes exhibited nearly two-fold increase in lysine and tryptophan content. In addition to that they had higher starch and fiber content compared to normal maize genotypes. The QPM genotypes *viz*. BQPML 5280 and BQPML 5175 were superior in nutritional parameters estimated for both quality and quantity. The normal maize lines, BML 40410 and BML 7 exhibited superior nutritional quality compared to other genotypes. The seed yield/plant showed significant positive correlation only with cob length and number of rows/cob, out of 9 yield-attributing traits. Starch and protein content of seed were negatively correlated, whereas oil and protein content were positively correlated. Seed protein content was negatively correlated with tryptophan and lysine.

Key words: Nutritional composition, quality protein maize, maize

Maize (*Zea mays* L.) is the third most important cereal in India after wheat and rice. Currently, it is cultivated over 8.12 million ha with 19.77 million tonnes, with an average productivity of 2,435 kg/ha [1]. Maize is a good source of carbohydrates, fats, proteins, vitamins and minerals, provide nutrients for humans and animals. However, it has an in-built drawback of being deficient in two essential amino acids namely lysine and tryptophan. This leads to poor net protein utilization and low biological value of traditional maize genotypes. To overcome this problem, maize breeders have developed quality protein maize (QPM) by incorporating *opaque*-2 mutant gene, which contains nearly twice the quantity of essential amino acids, namely lysine and tryptophan, thereby improving the protein quality. Quality protein maize tastes similar to normal maize with the same or higher yield potential and superior nutritional and biological value. The *opaque*-2 gene present in QPM lines was reported to have considerable degree of interference with regard to other nutritional parameters [2]. Hence, present investigation was planned to evaluate the seed yield and yield-contributing attributes, and nutritional parameters among QPM and normal maize genotypes in order to know the impact of nutritional parameters on seed yield and yield attributes.

MATERIALS AND METHODS

The field experiment was conducted at Maize Research Centre, Agricultural Research Institute, Acharya N. G. Ranga Agricultural University (ANGRAU), Hyderabad, during *kharif* 2010 in a randomized block design with three replications. Pure seed of ten maize inbred lines including six QPM (BQPML 5204, 5342, 5175, 5280, 5199 and 5232) and four normal maize genotypes (BML 40410, 9105, 5016 and 7) were used as the

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planting material in the study. Recommended package of cultural practices and plant-protection measures were taken up during the crop growth period. The data on days to 50% tasseling and silk emergence, plant height, cob length and girth, number of rows/cob and seeds/row, shelling capacity, test weight and seed yield/plant were recorded. Days to 50% tassel and silk emergence were recorded on plot basis, whereas data on rest of the parameters were recorded in 10 randomly selected plants/cob in each replication of the each genotype. The shelling capacity was calculated by the ratio of seed weight (g) after shelling and total weight of the ear (g) and test weight was recorded as weight of randomly collected 100 seeds from harvested seed in each genotype and replication.

Biochemical analyses for nutritional quality attributes were performed on freshly harvested seed at Department of Seed Science and Technology, College of Agriculture, ANGRAU, Hyderabad, and National Institute of Nutrition, Hyderabad. Moisture content of seed was determined as per ISTA rules [3]. Protein, oil and starch content were determined by using NIRT (Near Infra red Transmittance) grain analyzer (Model- Foss Infratech 1241). Fiber content of maize kernels was estimated by Automatic fiber analyzer (Model FT 12 Gerhardt) as per the method suggested by AOAC [4]. Tryptophan content in maize kernels was estimated Barytic hydrolysis method as described by Landry and Delhaye [5]. The lysine content was calculated by four times the value of tryptophan as relationship observed between tryptophan and lysine in maize endosperm protein (approximately 1-4) and tryptophan may be used as a single parameter for protein quality evaluation [6]. The field and laboratory data were analyzed by following randomized block design and completely randomized design, respectively and simple correlation coefficients were used to determine the relationship between seed yield and yield-attributing and nutritional traits of QPM and normal maize as per the procedure of Panse and Sukhatme [7].

RESULTS AND DISCUSSION

Analysis of variance showed significant differences in QPM and normal maize genotypes for seed yield and yield-contributing traits except cob length and number of seeds/row, which indicated sufficient variability in material under study (Table 1). The data recorded with respect to mean and range are presented in Tables 1 and 2 and correlations are presented in Table 3

The mean plant height of normal maize lines (115.95 cm) was higher compared to QPM lines (103.08 cm). Among QPM lines, plant height was maximum in BQPML 5232 and in normal maize lines BML 9105 has exhibited the highest plant height. Interestingly both highest and lowest values for plant height were observed in normal maize lines. Plant height is a quantitative trait which can be influenced by management practices and genetic background of parental lines. The study showed that plant height was negatively correlated with seed yield and association was not significantly similar to the observation of Prakash *et al.* [8], who reported a negative association in sweet corn. On the contrary, plant height was positively associated with seed yield as reported [9].

The days to 50% tasseling was observed with a range from 62-69 days and a general mean of 65 days among QPM and normal maize genotypes. Among QPM lines, BQPML 5280, BQPML 5342 and BQPML 5232 took minimum number of days for 50% tasseling compared to other QPM and normal maize genotypes. Similarly, quality protien and normal maize genotypes took 67 and 69 days, respectively for 50% silking, indicating that QPM lines were early to flower. The results indicated that days to 50% tasseling had negative and non-significant association with seed yield. The negative correlation of plant height, days to 50% tasseling and silking with seed yield indicated the possibility of identifying high-yielding, short and early maturing hybrids using QPM inbred lines.

It is evident from the mean data on cob length that no significant differences were found among the genotypes for cob length except in BML 7 which had very long cob length. In QPM genotypes cob length ranged from 10.06 to 12.20 cm, whereas in normal maize lines it was 10.37-14.80 cm. Significant differences were found for

Table 1. Mean performance of QPM and normal maize genotypes for seed yield and yield parameters

Genotype	Plant height (cm)	Days to 50% tasseling	Days to 50% silking	Cob length (cm)	Cob girth (cm)	No. of rows/ cob	No. of seeds/ row	Shelling (%)	100-seed weight (g)	Seed yield/ plant (g)
BQPML 5204	94.56	66.00	69.00	11.83	11.49	14.00	22.00	78.25	21.88	58.62
BQPML 5342	101.03	62.00	65.00	11.83	10.73	14.00	24.00	78.20	19.01	58.10
BQPML 5175	106.82	69.00	73.00	10.43	9.38	12.00	25.00	63.65	17.47	50.58
BQPML 5280	101.84	62.00	65.00	10.83	9.39	14.00	24.00	77.65	17.97	54.44
BQPML 5199	103.31	65.00	68.00	10.06	9.29	16.00	17.00	77.98	24.12	62.50
BQPML 5232	110.93	62.00	65.00	12.20	10.72	14.00	25.00	82.11	18.88	60.43
BML 40410	124.29	67.00	70.00	10.37	9.98	12.00	14.00	75.52	32.57	56.03
BML 9105	137.45	62.00	65.00	11.40	10.64	12.00	15.00	81.27	33.06	51.42
BML 5016	89.57	69.00	72.00	13.10	8.28	12.00	21.00	78.15	24.13	53.49
BML 7	112.50	65.00	68.00	14.80	11.90	14.00	22.00	84.21	27.51	81.16
Mean	108.23	65.00	68.00	11.69	10.18	14.00	21.00	77.69	23.66	58.68
S Em ±	0.68	0.99	1.13	0.38	0.27	0.63	1.30	0.27	0.68	4.19
CD (0.05)	2.02	2.95	3.37	1.12	0.79	1.86	3.85	0.79	2.00	12.57

cob girth between QPM and normal maize genotypes, it ranged from 9.38 to 11.49 cm and 8.28 to 11.90 cm in QPM and normal maize genotypes, respectively. Among cob length and girth, cob girth plays a vital role as girth of cob is supposed to give room for more number of rows which exponentially increases total number of seeds/cob. The study showed that cob length and ear diameter were positively correlated with seed yield as indicated by previous researchers [8] which could be confirmed by the affirmative results obtained in the present investigation.

Among all genotypes, BQPML 5199 exhibited highest number of rows/cob. Number of rows in QPM genotypes ranged from 12 to 16, whereas in normal maize lines the range was 12 to 14. Thus, QPM lines exhibited more number of rows/ cob compared to normal maize lines. The study indicated that number rows/cob was positively correlated with seed yield, whereas data on number of seeds/row indicated a non-significant differences among maize genotypes. Number of seeds/row exhibited positive relation with yield but may be negatively correlated with test weight and seed size. As long as there is no competition among the traits like seed number, seed size, seed weight and row length, this trait influences the yield positively as it has been reported [8].

With respect to shelling per cent, it is evident that normal maize genotypes exhibited high mean shelling per cent compared to QPM genotypes. The shelling per cent is positively correlated with yield hence the genotypes having more shank girth are generally not preferred. If shelling per cent is less, it can be very clearly understood that the plant has spent more of its energy for shank development than for the seed. In present study, positive and significant association between shelling percentage and seed yield/plant

Table 2. Mean performance of QPM and normal maize genotypes for seed nutritional parameters

Genotype	Moisture content (%)	Protein content (%)	Starch content (%)	Oil content (%)	Fiber content (%)	Tryptophan content (g/100 g protein)	Lysine content (g/100g protein)
BQPML 5204	10.16	9.90	70.87	3.73	1.72	0.93	3.73
BQPML 5342	12.17	9.70	71.40	3.72	1.62	0.93	3.72
BQPML 5175	10.57	10.50	70.43	3.33	1.89	0.83	3.33
BQPML 5280	11.47	11.67	70.90	3.20	2.30	0.80	3.20
BQPML 5199	11.00	10.83	72.10	2.81	1.63	0.69	2.81
BQPML 5232	11.03	11.23	70.53	3.02	1.96	0.76	3.02
BML 40410	12.37	12.80	67.00	2.12	1.71	0.53	2.12
BML 9105	12.73	13.57	66.80	1.76	1.66	0.44	1.76
BML 5016	11.63	11.93	69.10	1.81	1.47	0.45	1.81
BML 7	11.43	12.10	66.13	6.20	1.55	0.39	1.57
Mean	11.45	11.42	69.53	5.08	1.75	0.68	2.71
S Em ±	0.56	0.05	0.23	0.05	0.10	0.08	0.08
CD (0.05)	0.19	0.13	0.68	1.42	0.30	0.22	0.22

suggested that maize genotypes with high shelling percentage may record high seed yield.

The data on 100-seed weight showed that BML 9105 had maximum 100-seed weight and BQPML 5175 had lowest 100-seed weight (Table 2). Seed number parameters indicated that higher number of rows/cob and higher number of seeds/row have definitely interfered with seed weight and size in QPM lines. The QPM lines have registered lower 100-seed weight compared to normal maize lines. Seed yield/plant was positively correlated with number of seeds/cob ($r = 0.50$) and shelling per cent ($r = 0.51$). However, 100-seed weight was negatively correlated with seed yield/plant and number of seeds per row ($r = -0.88$) in the present study. The implication is that high 100 seed weight may not necessarily mean high seed yield per plant in maize [10]. This observation was at variance with the report of Manivannan [11] who reported positive and significant association between 1,000-seed weight and seed yield in maize. For seed yield/plant, of all the genotypes, BML 7 (81.16 g) exhibited highest seed yield/plant, followed by BQPML 5199 (62.50 g). Seed yield is a rather complex product of a number of its attributing traits.

The cob length, cob girth and number of seed rows/cob were most important yield-contributing traits for corn. The performance of QPM lines like BQPML 5199 and BQPML 5232 was comparable to normal maize. However, normal maize lines, BML 7 and BML 40410, performed well. Even though many researchers reported the poor agronomic performance of high lysine maize but the results obtained in the present study may be attributed to hard endosperm of QPM cultivars which contain *Opaque-2* genes along with endosperm modifiers.

There were significant differences among maize genotypes for nutritional parameters such as protein, starch, oil, fibre, tryptophan and lysine contents (Table 2). In QPM lines, protein content

Table 3. Correlation coefficients among seed yield, yield attributing and nutritional parameters of quality protein and normal maize genotypes

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PH	1															
DTT	-0.33	1														
DTS	-0.32	0.99**	1													
CL	-0.16	-0.06	-0.06	1												
CG	0.30	-0.42	-0.46	0.45	1											
NORPC	-0.30	-0.28	-0.31	-0.04	0.28	1										
NOSPR	-0.61	-0.18	-0.15	0.34	0.08	0.27	1									
Shelling per cent	0.15	-0.59*	-0.62	0.59*	0.48	0.27	-0.10	1								
100-seed weight	0.70**	0.07	0.05	0.09	0.17	-0.37	-0.88**	0.35	1							
SYPP	-0.25	-0.28	-0.26	0.70**	0.50	0.58*	0.50	0.51	-0.20	1						
Protein content	0.72**	-0.09	-0.08	0.11	-0.09	-0.51	-0.64*	0.32	0.79**	-0.23	1					
Starch content	-0.66**	-0.12	-0.09	-0.45	-0.31	0.57**	0.49	-0.30	-0.80**	-0.30	-0.81**	1				
Oil content	0.33	0.22	0.19	0.70**	0.26	-0.23	-0.29	0.41	0.61**	0.66**	0.60*	-0.84**	1			
Fiber contnet	-0.02	-0.38	-0.34	-0.41	-0.11	0.11	0.43	-0.23	-0.53*	-0.31	-0.10	0.37	-0.52*	1		
Tryptophan	-0.47	-0.19	-0.15	-0.43	0.07	0.37	0.58*	-0.39	-0.78**	-0.30	-0.86**	0.84**	-0.87**	0.49	1	
Lysine	-0.48	-0.18	-0.14	-0.44	0.06	0.38	0.57*	-0.39	-0.78**	-0.30	-0.86**	0.84**	-0.87**	0.48	0.98**	1

*Significant at 5% level; **Significant at 1% level

PH: Plant height; DTT: days to 50% tasseling; DTS: days to 50% silking; CL: cob length; CG: cob girth; NORPC: number of rows/cob; NOSPR: number of seeds/row; SYPP: seed yield/plant

varied from 9.70 to 11.23%, whereas in normal maize lines it was 11.93- 13.57% (Fig. 1). The protein content (13.57%) in BML 9105 was significantly higher than other genotypes. Endosperm protein content, however, is not major criterion in comparing QPM and normal maize genotypes, as it does not indicate protein quality in terms of lysine and tryptophan concentration in protein [12].

The mean tryptophan and lysine content in QPM genotypes were 0.82 and 3.30 g/100 g protein, whereas in normal maize genotypes they were 0.45 and 1.81 g/100 g protein, respectively (Fig. 1). The QPM genotypes had nearly two times higher tryptophan content over the normal maize genotypes. Tryptophan content obtained was in accordance with the reports [12] who reported 0.78-1.09% tryptophan in QPM and 0.43-0.45% in normal maize.

The QPM genotypes exhibited high starch content than normal maize genotypes. These results were in agreement with those mentioned [13] that QPM tended to have higher carbohydrates (starch) compared to normal maize. The oil content of 4.77% for QPM and 5.53% for normal maize, obtained in this study agrees with the reports of other workers [14. The genotype BML 7

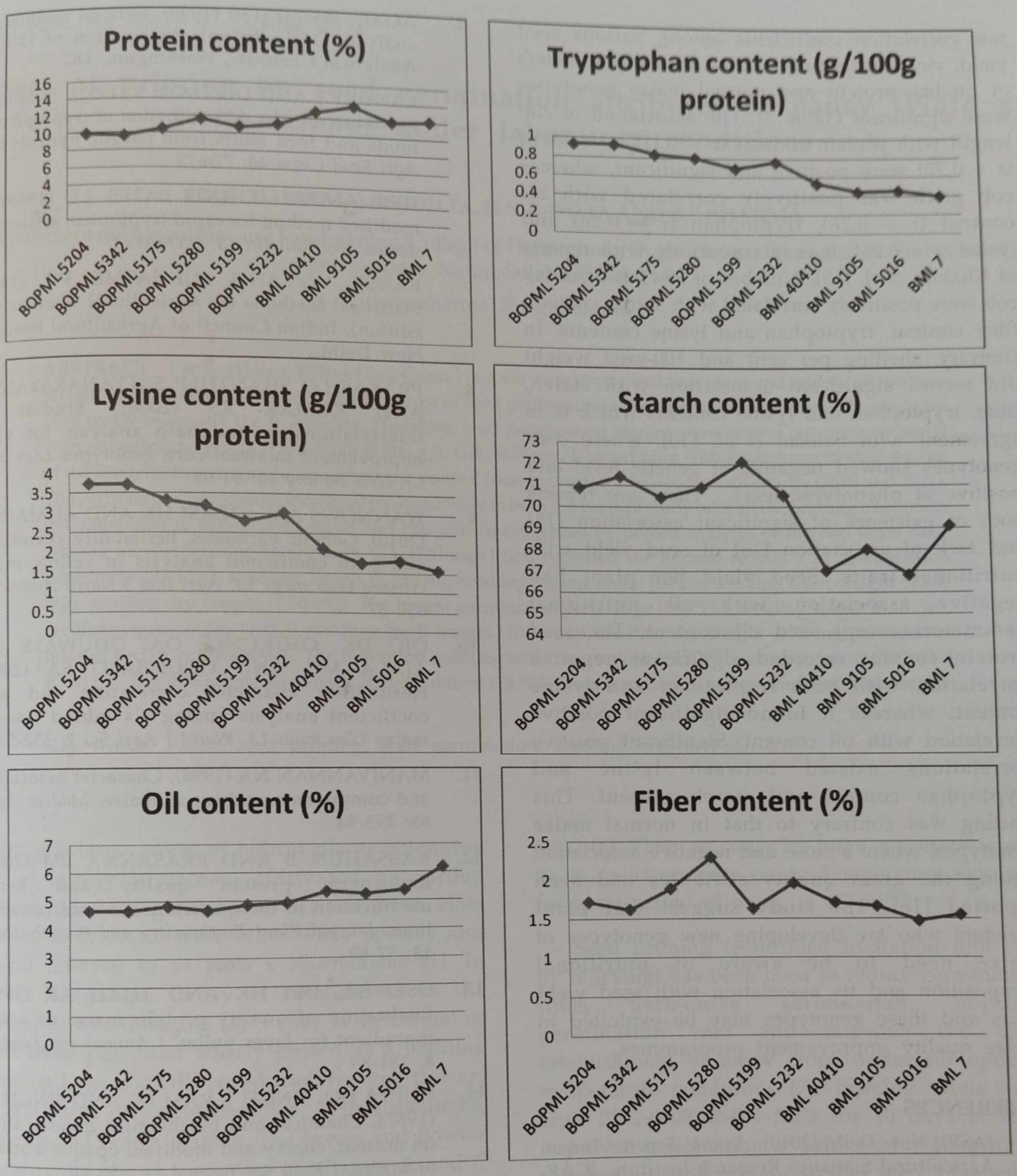

Fig. 1. Nutritional composition of quality protein maize (QPM) and normal maize genotypes

has exhibited significantly high oil content (6.20%) than others. Among all genotypes, BQPML 5280 exhibited high fiber content (2.32%) and BML 9105 exhibited low fiber content (1.49%) (Fig. 1).

The genotypes, BQPML 5280 and BQPML 5175, of QPM & BML 40410 and BML 7 of normal maize were found to be superior in all the nutritional parameters evaluated for both quality and quantity.

It was apparent in the present study that a

few correlation coefficients among various seed yield, yield-attributing and nutritional parameters of quality protein and normal maize genotypes were significant (Table 3). The association of cob length with protein content (r = 0.11) oil content (r = 0.70) were positive and significant, whereas cob girth was positively correlated with oil content (r = 0.26), tryptophan (r = 0.26) and lysine (r = 0.06). It is in conformity with reports of Khakim *et al.* [15]. Number of rows and seeds/ cob were positively correlated with starch content, fibre content, tryptophan and lysine contents. In contrary, shelling per cent and 100-seed weight did record significant association with starch, fibre, tryptophan and lysine contents which is in agreement with Saleem *et al.* [16], where corn genotypes showed negative at genetic level and positive at phenotypic level. There are reports both of existence of significant association [15] and lack of association [16] of seed yield with nutritional traits. Seed yield per plant had negative association with all nutritional parameters except seed oil content. The seed protein content recorded significant negative correlation with both tryptophan and lysine content, whereas it found significant positive correlation with oil content. Significant positive correlations existed between lysine and tryptophan content and starch content. This finding was contrary to that in normal maize genotypes, where a close and negative association among the grain quality attributes had been reported [16]. The study suggest that plant breeders who are developing new genotypes of maize need to be aware of nutritional composition and its association with seed yield traits and these genotypes may be exploited in maize quality improvement programmes.

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