Electronic Journal of Plant Breeding, 7(3): 505-513 (September 2016)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2016.00065.X

Research Article

Genetic Diversity, Character association and Path-Coefficient study in QPM inbreds

T.K. Mishra*, B. Pradhan and D. Mishra
Department of Plant Breeding and Genetics,
Orissa University of Agriculture & Technology, Bhubaneswar - 751003, India
E-mail: tkm.cuttack@gmail.com

(Received:24 Jan 2015; Accepted:21 Aug 2016)

Abstract
The thirty seven inbreds of quality protein maize of diverse origin, evaluated in RBD showed significant difference among the inbreds in respect of grain yield and its component traits. The characters like days to 50 % tasseling, days to 50 % silking and days to 75% dry husk were less influenced by the environmental factors because of lower differences in magnitudes between GCV and PCV. On the contrary, the characters like cob girth, number of kernels per row, number of kernel rows per cob and grain yield per plant were much influenced by the environmental factors as evidenced from higher differences in magnitude of PCV and GCV. High heritability with low genetic advances for characters like days to 50% tasseling, days to 50 % silking and days to 75 % dry husk indicated the predominance of non-additive gene action whereas high heritability with high genetic advance was reported for cob weight indicating the role of additive gene action. The characters *viz.*, cob weight, 100- kernel weight, plant height, ear height, and no. of kernels per row were highly and positively correlated with grain yield per plant at genotypic and phenotypic levels. Ear height (0.837), days to 50 % silking (0.526) and number of kernels/rows per cob (0.455) in that order had large positive direct effect on grain yield per plant at genotypic level. Similar trend was also observed at phenotypic level. The indirect effects were generally small with only a few exceptions. A close examination of all the direct and indirect effects of the components traits on yield indicated the presence of enough scope for yield improvement through selection for no of leaves per plant, cob length, no. of kernels per row, cob weight and 100-kernel weight. Based on 14 quantitative characters, the 37 quality protein maize inbreds were grouped into13 clusters following D^2 analysis and Tocher™s method of grouping. Among the yield traits, days to 50 % silking, days to 50% tasseling, days to 75% dry husk, cob weight, 100 kernel weight and grain yield per plant were found to be the major contributor towards genetic divergence. The overall clustering pattern indicated that QPM 3-7, QPM 9-18, and QPM 1110-7-2 were much divergent from rest of the inbreds in the experiment. Similarly, the inbreds of cluster III and XI and inbreds of clusters IX, III and X were distantly and distinctly related to each other. The pattern of clustering as stated above further indicated that there was no strict association between inbreds developed from diverse base populations.

Key words
QPM inbred, Genetic diversity, Character association, Path-Coefficient analysis.

Introduction

Maize is one of the staple food crops and ranks third next to wheat and paddy in production in India. Maize is a highly cross pollinated crop and this phenomenon has been successfully exploited and several hybrids and composite had been developed. However most of the hybrids/composites developed was low in protein content. Breeding methods to improve yield along with increased protein levels may develop quality protein in maize. The invention of heterosis phenomenon, the development of hybrid breeding technology and successful commercial exploitation of heterosis in maize have led to development of a number of genotypes e.g. single crosses, double crosses, varietal hybrids, multiple hybrids, composites, synthetics in different categories of maize including quality protein maize. And the success of hybrid development in maize involving the selected inbred lines depends of the extent of recombination, the extent to which a character is heritable and the genetic control of the characters. Information on genetic parameters of yield and component traits, genetic diversity among the inbred lines and character association among the component traits would help the breeders in selection of desirable inbreds. The present investigation was primarily focussed on studying the genetic divergence in multivariate traits in a selected set of QPM inbreds and to evaluate the association among the yield component traits and yield.

Materials and Methods

Thirty seven quality protein maize inbreds of diverse geographic and genetic origin were obtained from Winter Maize Nursery, Hyderabad. These inbreds were grown in AICRP on Maize, Department of Plant Breeding and Genetics, OUAT, Bhubaneswar during *Rabi*, 2013 in RBD with three replications. Each inbred lines was represented by 2 lines of 4 meter row length with 60 cm spacing between line to line and 30 cm spacing between plant to plant. Fertilizers were applied @ 20 kg N, 40 kg P_2O_5, 40 kg K_2O per Farm Yard Manure per hectare and recommended package of practices were followed as per the scheduled programme for maize crop. Observations on days to 50 % tasseling, 50 % silking and days to 75 % dry husk were recorded on plot basis and rest eleven quantitative traits were recorded on the basis of five randomly chosen plants at appropriate stage. Genetic parameters like PCV, GCV, h^2, GA of the traits were estimated. Genetic divergence among inbreds was estimated as multivariate measure of D^2 (Al-Jibouri *et al.,* 1958). The associations among the traits were estimated in terms of r_p and r_g (Dewey and Lu, 1959) and the r_p estimates of component traits with yield were partitioned into direct and indirect effects by path-coefficient analysis (Rao, 1952).

Results and Discussion

Genetic parameters of Traits: The inbreds showed wide differences in the traits and analysis of variance revealed significant differences among the inbreds for all the characters studied. The phenotypic coefficients of variations (PCV) ranged from 3.96 % for days to 75 % dry husk to 22.92 % for cob weight (Table 1).

The PCV estimates showed that the phenotypic variability was low (< 10 %) for days to 50% tasseling, days to 50 % silking, days to 75 % dry husk, number of leaves/plant, cob length, cob girth, number of kernel rows/cob, number kernels/row and shelling %, moderate (10 to 20 %) for plant height, ear height and 100-kernel weight and high (> 20 %) for cob weight and grain yield per plant. The genotypic coefficient of variation (GCV) ranged between 3.86 %for days to 75 % dry husk to 20.78 % for grain yield/plant and followed almost a similar trend as phenotypic coefficient of variation except for the character plant height which fell under low (below 10 %) for GCV. The heritability (h_{bs}) estimates were high (>90%) for 50 % tasseling, days to 50 % silking, days to 75 % dry husk and cob weight, moderate (75 - 90%) for shelling %, 100-kernel eight and grain yield/plant and low (<75%) for characters like plant height, ear height, number of leaves/plant, cob length, cob girth, number of kernel rows/cob and number of kernels/cob. High heritability coupled with high genetic advance (expressed as per cent of mean) was observed for cob weight, which indicated that this character controlled by additive gene action and phenotypic selection for this character would be effective (Ojha *et al.,* 2006 and Bharathiveeramani *et al.*, 2012). High heritability with low genetic advance were found in case of days to 50 % silking, days to 50 % tasseling and days to 75 % dry husk that suggested predominant gene action in their inheritance reported earlier (Bharathiveeramani *et al.*, 2012).

Genetic Divergence: Multivariate measure of genetic divergence (D^2) among the inbreds based on all the characters was estimated. D^2 among 37 quality protein maize inbreds ranged from 5.297(QPM5-2 and QPM10-1) to 23.501 (QPM 2-4 and QPM 3-7) indicating that some genotypes were close to each other genetically while the rest were strongly diverse in nature. Using Tocher's method of clustering, 37 quality protein maize inbreds were grouped on the basis of genetic affinity or diversity measured by D^2 values which resulted into thirteen groups or clusters consisting 1 to 10 inbreds and the cluster composition was as follows:

Cluster I	QPM 5-2, QPM 10-1, QPM 1-3, QPM 1131-8-1, QPM 8-15, QPM 7-4, QPM 10-13, QPM 8-2, QPM 9-2, QPM 9-4
Cluster II	QPM 9-16 , QPM 3-5 , QPM 8-12
Cluster III	HK 1-164-7, QPM 2-4
Cluster IV	QPM 2-7 , QPM 1130-7-1, QPM 2-18, QPM 8-11
Cluster V	QPM 9-10, QPM 1-6, QPM 11-7 QPM 7-14
Cluster VI	QPM 8-7 , QPM 6-4 , QPM 8-1
Cluster VII	HK 1-191-1, HK 1-164-4
Cluster VIII	QPM 1-7 , QPM 2-1
Cluster IX	HK 1-193-2, HK 1-193-1
Cluster X	QPM 8-3 , QPM 8-5
Cluster XI	QPM 3-7
Cluster XII	QPM 9-18
Cluster XIII	QPM 1110-7-2

In the present study classification of 37 quality protein maize inbreds developed at two centres led to the formation of 13 clusters with varying number of inbreds in each cluster. The genotypes falling in the same cluster are more closely related and possess narrow genetic diversity. The result of the present investigation is in good agreement with the previous findings (Hepziba *et al*. (2013); Chen *et al*. (2007), Singh *et al*. (2009) and Shrestha, 2013).The clustering pattern revealed that the tendency of inbreds developed from diverse populations might be due to similarity in requirement and selection approaches followed under domestic cultivation. The estimates of average intra- and inter-cluster distances (D^2 values) indicated that the highest intra-cluster distance was reported in case of cluster X, revealing the maximum genetic diversity among two inbreds (QPM8-3and QPM8-5), closely followed by Cluster IX which indicated lower magnitude of genetic diversity among different constituent inbreds *i.e.* HK 1-193-2 and HK 1-193-1 (Table 2). The least intra-cluster distance was reported in case of cluster III comprising of two different inbreds i.e. HK 1-164-7 and QPM 2-4. The spectrum of inter-cluster distance ranged between 37.567(Cluster I and Cluster II) and 310.176 (Cluster III and Cluster XI).The higher inter-cluster distance (average D^2 value) was between cluster III and cluster XI followed in order by between cluster III and cluster X (277.815) and between cluster VIII and cluster XI (263.994). This indicated that the inbred of clusters III and XI and inbreds of clusters III, VIII and X are distantly and distinctly related to each other. On the other hand, the minimum inter-cluster average D^2 value observed between cluster I and II (37.587) indicated less divergence between the inbreds of respective clusters. Among the thirteen clusters identified, cluster I which included 10 inbreds was not superior with respect to any of the characters studied (Table 3). However, the mean recorded with respect to shelling % (81.596 %) was more than the respective general mean of 81.375 %. The cluster II, containing three different inbreds was not superior with respect to any of the characters studied. Cluster III comprised of two inbreds was characterized by longer maturity duration i.e. days to 75 % dry husk, higher plant and ear height, possessing more number of leaves/plant and larger cob girth. The cluster VII with two genotypes (HK 1-191-1 and HK 1-164-4) were identified as late flowering while cluster XI with a single genotype (QPM 3-7) was the best for early maturity.In view of the above discussion, it may be concluded that the inbreds from cluster VIII i.e., QPM 1-7 and QPM 2-1 should be selected for developing high yielding hybrid while QPM 3-7 should be selected for early maturity in maize. Among the thirteen clusters identified, cluster I which included 10 inbreds was not superior with respect to any of the characters studied. However, the mean recorded with respect to shelling % (81.596 %) was more than the respective general mean of 81.375 %. The cluster II, containing three different inbreds was not superior with respect to any of the characters studied. Cluster III comprised of two inbreds was characterized by longer maturity duration i.e. days to 75 % dry husk, higher plant and ear height, possessing more number of leaves/plant and larger cob girth. The cluster VII with two genotypes (HK 1-191-1 and HK 1-164-4) were identified as late flowering while cluster XI with a single genotype (QPM 3-7) was the best for early maturity. In view of the above discussion, it may be concluded that the inbreds from cluster VIII i.e., QPM 1-7 and QPM 2-1 should be selected for maturity in maize.

Character Association: The Phenotypic (r_p) and genotypic (r_g) correlation estimates among the traits followed almost similar trend, though r_g estimates in most cases little higher (Table 4). In case of genotypic level with a deviation in case of shelling %. A close corresponds between genotypic and phenotypic correlations indicate lesser masking effect of environment of character expression. In general genotypic correlation coefficients were higher than corresponding phenotypic one for most of the character combinations and this was the most agreement with earlier findings (Singh *et al.* (2009), Shrestha (2013), Khorasani *et al.* (2011), Ravi *et al.* (2012) and Kumar and Satyanarayana (2001). It appeared from the overall picture of associations between yield and other traits that the group of inbreds evaluated present a wide array of character combinations. This means, there is substantial diversity in the material offering ample scope for improvement of yield by manipulative breeding. And in doing so, selection for cob weight, 100- kernel weight, plant height and ear height perhaps, receive much greater attention than other characters. At phenotypic level, similar trend was also noticed irrespective of direct and indirect effects of component traits on grain yield per plant. The analysis had high R^2 (89.529) value and residual effect of 0.324. Cob weight (0.575), shelling % (0.236), 100-kernel weight (0.163), number of leaves per plant (0.143) and ear height (0.107) in that order, had positive direct effects on grain yield per plant. The direct effects of days to 50% silking (0.096), plant height (0.021), cob length (0.097), cob girth (0.085) and number of kernel rows per cob (0.006) were of smaller magnitude but positive while direct effects of remaining three characters i.e. days to 50% tasselling (-0.121), days to 75 per cent dry husk (-0.145) and number of kernels per row (-0.001) were negative.

The indirect effects were mostly small with only a few exceptions. For example cob weight had negative indirect effect via days to 50 per cent tasseling, (-0.018), days to 75 per cent dry husk (0.079) and number of kernels per row (-0.001) on grain yield. Days to 50% tasseling and days to 50 % silking, both had negative indirect effects on grain yield via days to 75 % dry husk and shelling%. Plant height and ear height had positive indirect correlations via all the characters except via two traits *viz.*, days to 50 per cent tasseling and days to 75 % dry husk. Similarly cob length, number of leaves per plant, cob girth followed the same results like plant height and ear height. It is revealed from the study that days to 50% tasseling and days to 75% dry husk had negative indirect effect through most of yield attributing characters. The trait, number of kernels per row and number of kernel rows per cob had very small indirect effects via most of the yield contributing traits at the phenotypic level. Similar results were also reported earlier by Singh *et al.* (2009), Ravi *et al.* (2012) and Kumar and Satyanarayana (2001).

Path–Coefficient analysis: The phenotypic correlation estimates of component traits with yield were partitioned into direct and indirect effects by path coefficient analysis (Table 5). The analysis had high R^2 (89.529) value and residual effect of 0.324. Cob weight (0.575), shelling % (0.236), 100-kernel weight (0.163), number of leaves per plant (0.143) and ear height (0.107) in that order, had positive direct effects on grain yield per plant. The direct effects of days to 50% silking (0.096), plant height (0.021), cob length (0.097), cob girth (0.085) and number of kernel rows per cob (0.006) were of smaller magnitude but positive while direct effects of remaining three characters i.e. days to 50% tasseling (-0.121), days to 75 per cent dry husk (-0.145) and number of kernels per row (-0.001) were negative. The indirect effects were mostly small with only a few exceptions. For example cob weight had negative indirect effect *via* days to 50 per cent tasseling, (-0.018), days to 75 per cent dry husk (0.079) and number of kernels per row (-0.001) on grain yield. Days to 50% tasseling and days to 50 % silking, both had negative indirect effects on grain yield via days to 75 % dry husk and shelling%. Plant height and ear height had positive indirect correlations via all the characters except *via* two traits *viz*., days to 50 per cent tasseling and days to 75 % dry husk. Similarly cob length, number of leaves per plant, cob girth followed the same results like plant height and ear height. It is revealed from the study that days to 50% tasseling and days to 75% dry husk had negative indirect effect through most of yield attributing characters. The trait, number of kernels per row and number of kernel rows per cob had very small indirect effects via most of the yield contributing traits at the phenotypic level. Results were also in agreement with the reports of Singh *et al.* (2009), Ravi *et al.* (2012) and Kumar and Satyanarayana (2001). Days to 50% tasseling and days to 50 % silking, both had negative indirect effects on grain yield via days to 75% dry husk and shelling%. Plant height and ear height had positive indirect correlations via all the characters except *via* two traits *viz*., days to 50 per cent tasseling and days to 75 % dry husk. Similarly cob length, number of leaves per plant, cob girth followed the same results like plant height and ear height.

References

Al-Jibouri, H.A., Miller, P.A. and Robinson, H.F. 1958. Genotypes and environmental variances and co-variances in a upland cotton cross of inter specific origin. *Agron. J.*, **50**: 633-636.

Bharathibveeramani, B., Prakash, M. and Sestharam, A. 2012. Variability studies of quantitative characters in Maize (*Zea mays* L.). *Electronic Journal of Plant Breeding*, **3**(4): 995-997.

Chen, F., Yang KeCheng, Rong Ting Zhao and Pan Guang Tang. 2007. Analysis of genetic diversity of maize hybrids in the regional tests of Sichuan and Southwest China. *Acta Agronomica Sinica*, **33**(6): 991-998.

Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.*, **51**:515-518.

Hepziba, S.J., Keetha, K. and Ibrahim, S.M. 2013. Evaluation of genetic diversity, variability, character association and path analysis in diverse inbreds of maize (ZeamaysL.). *Electronic Journal of Plant Breeding* **4**(1): 1067-1072.

Khorasani, K., Mostafavikh, S., Zondipour, E. and Heidarian, A. 2011. Multivariate analysis of agronomic traits of new corn hybrids (*Zea mays* L.) *International J. of Agri Sci*., **1**(6): 314-322.

Kumar, P. and Satyanarayana, E. 2001. Variable and correlation studies of full season inbred lines of maize. *Journal of Research, ANGARU*, **29**: 71- 75.

Ojha, D.K., Omikunle, O.A., Oduwaye, Ajala, M.O. and Ogunbayo, S.A. 2006. Heritability, character correlation and path coefficient analysis among six inbred-lines of Maize. (*Zea mays* L.) *World Journal of Agricultural Sciences*, **2**(3): 352-358.

Rao, C.R. 1952. *Advanced statistical methods in biometrical research*.1st Edn. John Wiley and Som, New York.

Ravi, V., Murali; Chikkalingaiah and Shailaja Hittalmani. 2012. Correlation study for protein content, Grain yield and yield contributing traits in Quality Protein Maize (QPM) (Zea Mays L.). *Electronic Journal of Plant Breeding*, **2**(1): 649-651.

Shrestha, J. 2013. Agro-morphological characterization of maize inbred lines. *Weed pecker Journal of Agri. Res*. **2** (7): 209-211.

Singh, S.B., Gupta. B.B. and Singh, A.K. 2009. Genetic Divergence for Morpho-Physiological Traits and Yield Components Associated with Drought Tolerance in Maize (*Zea mays* L.) inbreds. *Indian J. Plant Gent. Resour.*, **22**(2): 102-107.

Electronic Journal of Plant Breeding, 7(3): 505-513 (September 2016)
ISSN 0975-928X

Table 1. Genetic parameters of different characters of quality protein maize inbreds

Sl. No.	Character	Range	Mean	CVe (%)	GCV (%)	PCV (%)	h^2 (%)	GA	GA as % of mean
1.	Days to 50 % tasseling	55.00-67.33	60.57	1.91	4.30	4.44	93.82	5.193	8.57
2.	Days to 50 % silking	55.33-69.67	62.51	2.18	4.37	4.55	92.34	5.406	8.65
3.	Days to 75 % dry husk	99.67-115.00	107.36	**1.37**	**3.86**	**3.96**	**95.98**	8.402	7.83
4.	Plant height (cm)	111.17-193.72	156.96	12.42	9.49	11.85	63.41	24.302	15.48
5.	Ear height (cm)	45.53-97.93	72.86	12.69	13.44	15.31	77.11	17.719	24.32
6.	No. of leaves/plant	10.73-14.47	12.87	6.85	5.99	7.18	69.68	1.296	10.07
7.	Cob length (cm)	13.80-22.50	16.21	9.59	8.19	9.88	68.65	2.266	13.98
8.	Cob girth (cm)	11.80-15.79	14.04	6.57	4.61	5.97	59.62	**1.029**	7.33
9.	No. of kernel rows/cob	12.27-16.53	14.22	7.59	6.84	8.13	70.95	1.688	11.87
10.	No. of kernels/row	25.33-36.53	30.58	11.99	5.15	8.63	**35.62**	1.936	**6.33**
11.	Cob weight (g)	89.80-244.63	151.35	9.19	22.30	**22.92**	94.64	**67.640**	**44.69**
12.	Shelling %	76.14-96.03	81.38	3.04	3.63	4.03	81.06	5.477	6.73
13.	100-kernel weight (g)	21.58-35.24	27.04	9.53	11.27	12.54	80.75	5.641	20.86
14.	Grain yield/ plant (g)	76.12-166.84	114.70	**14.87**	**20.78**	22.49	85.42	45.387	39.57

Bold figures indicates maximum and minimum values

Electronic Journal of Plant Breeding, 7(3): 505-513 (September 2016)
ISSN 0975-928X

Table 2. Average intra-cluster (diagonal) and inter-cluster distance (D^2 values) among 13 clusters of 37 quality protein maize inbreds

Clusters	I(10)	II(3)	III(2)	IV(4)	V(4)	VI(3)	VII(2)	VIII(2)	IX(2)	X(2)	XI(1)	XII(1)	XIII(1)
I	21.084	**37.587**	146.136	39.322	80.235	39.411	86.715	116.072	48.830	49.959	60.282	78.784	85.148
II		25.109	112.539	44.977	47.639	69.600	59.696	108.212	45.346	77.075	104.699	50.877	75.318
III			**14.019**	76.009	85.428	155.982	53.893	39.142	152.823	277.815	**310.176**	140.291	95.726
IV				16.815	67.867	48.809	60.331	86.864	63.522	107.541	117.455	103.952	58.126
V					27.709	82.046	68.442	112.974	94.151	151.613	174.268	47.739	84.344
VI						24.801	131.962	130.509	99.451	83.668	58.512	85.567	105.399
VII							30.262	78.857	63.000	162.100	216.136	107.320	77.510
VIII								33.621	142.142	241.226	263.994	152.268	108.896
IX									34.589	68.251	122.146	99.587	111.023
X										**35.989**	42.035	120.261	151.416
XI											0.000	141.588	176.176
XII												0.000	141.816
XIII													.0.000

Figures in parentheses indicate number of inbreds in the respective clusters
Bold figures indicate maximum and minimum (inter-cluster/intra-cluster) values

Electronic Journal of Plant Breeding, 7(3): 505-513 (September 2016)
ISSN 0975-928X

Table 3. Cluster (D^2 based) means in 37 quality protein maize inbreds for 14 characters

Sl. No.	Characters	I(10)	II(3)	III(2)	IV(4)	V(4)	VI(3)	VII(2)	VIII(2)	IX(2)	X(2)	XI(1)	XII(1)	XIII(1)	Grand mean
1.	Days to 50 % tasseling	59.800	62.222	62.667	60.083	60.417	55.444	**65.833**	61.500	65.167	60.833	**55.333**	60.333	60.333	60.567
2.	Days to 50 % silking	62.067	63.889	64.667	61.583	62.667	57.444	**68.000**	63.500	67.333	61.500	**56.333**	62.333	62.667	62.513
3.	Days to 75 % dry husk	104.300	109.000	**114.833**	107.167	113.083	104.667	111.833	109.500	106.333	100.833	**99.667**	111.333	109.667	107.360
4.	Plant height (cm)	152.033	158.411	**186.066**	175.508	153.108	142.800	166.467	170.917	165.767	128.934	137.467	**122.533**	168.833	156.961
5.	Ear height (cm)	67.993	72.511	**95.367**	81.608	74.475	67.344	83.633	80.867	75.800	**54.183**	61.700	54.733	75.700	72.856
6.	No. of leaves/plant	12.280	12.533	**13.800**	12.550	13.267	**11.333**	13.600	13.533	13.366	11.433	10.933	11.933	13.133	12.571
7.	Cob length (cm)	15.725	18.378	17.284	16.617	15.750	**14.427**	16.840	**18.393**	14.934	14.800	17.000	16.227	16.033	16.211
8.	Cob girth (cm)	13.651	13.736	**15.420**	14.158	13.832	14.340	14.524	15.180	14.030	**13.050**	13.600	14.840	14.067	14.044
9.	No. of kernel rows/cob	14.153	13.689	15.933	**13.234**	13.450	14.133	15.534	13.934	14.333	14.800	14.933	**16.000**	14.267	14.216
10.	No. of kernels/row	30.520	31.933	32.400	31.350	30.617	28.000	28.200	**35.838**	27.400	30.034	**25.333**	29.533	33.000	30.580
11.	Cob weight (g)	141.013	141.711	219.867	169.383	142.566	144.578	157.000	**234.550**	116.933	**98.867**	101.067	150.133	177.333	151.345
12.	Shelling %	81.596	81.418	81.193	81.973	80.030	79.931	80.963	80.053	**79.398**	82.974	81.150	76.520	**96.033**	81.375
13.	100-kernel weight (g)	25.498	26.390	30.413	31.780	25.624	26.129	26.130	**33.223**	27.188	24.690	23.647	**21.583**	29.967	27.042
14.	Grain yield/ plant (g)	108.587	109.132	159.107	132.936	103.068	105.240	134.775	**165.493**	91.182	84.863	84.570	**76.120**	139.257	114.697

Figures in parentheses indicate number of inbreds in the respective clusters
Bold figures indicate maximum and minimum (inter-cluster/intra-cluster) values

Electronic Journal of Plant Breeding, 7(3): 505-513 (September 2016)
ISSN 0975-928X

Table 4. Phenotypic (r_p) and genotypic (r_g) correlations among yield component trait in quality protein maize inbreds.

Characters		Days to 50 % silking	Days to 75 % dry husk	Plant height (cm)	Ear height (cm)	No. of leaves/ plant	Cob length (cm)	Cob girth (cm)	No. of kernel rows/cob	No. of kernels/ row	Cob weight (g)	Shelling (%)	100 kernel weight (g)	Grain yield/ plant (g)
Days to 50 % tasseling	r_g r_p	0.991** 0.972**	0.481** 0.466**	0.510** 0.409*	0.477** 0.477**	0.783** 0.663**	0.299 0.239	0.160 0.119	0.280 0.227	0.221 0.131	0.164 0.149	-0.082 -0.078	0.185 0.156	0.179 0.179
Days to 50 % silking			0.523** 0.510**	0.522** 0.419**	0.493** 0.493**	0.847** 0.694**	0.298 0.233	0.195 0.167	0.299 0.262	0.204 0.126	0.210 0.192	-0.062 -0.052	0.211 0.173	0.237 0.221
Days to 75 % dry husk				0.547** 0.478**	0.645** 0.645**	0.785** 0.645**	0.372* 0.320	0.560** 0.448**	0.131 0.115	0.366* 0.226	0.565** 0.543**	-0.470** -0.040	0.342* 0.300	0.462** 0.432**
Plant height (cm)					0.982** 0.982**	0.727** 0.607**	0.447** 0.372*	0.372* 0.282	-0.098 -0.082	0.494** 0.402*	0.763** 0.620**	0.074 0.100	0.680** 0.497**	0.807** 0.646**
Ear height (cm)						0.895** 0.693**	0.440** 0.344*	0.484** 0.312	-0.111 -0.099	0.690** 0.385*	0.708** 0.622**	-0.026 -0.006	0.604** 0.445**	0.787** 0.620**
No. of leaves/plant							0.270 0.233	0.373* 0.238	0.056 0.030	0.338* 0.295	0.526** 0.427**	0.017 0.015	0.230 0.206	0.546** 0.448**
Cob length (cm)								0.393* 0.394*	-0.029 0.025	0.496** 0.478**	0.560** 0.498**	-0.070 -0.011	0.405* 0.405*	0.505** 0.491**
Cob girth (cm)									0.514** 0.520**	0.145 0.215	0.802** 0.667**	0.015 0.082	0.771** 0.578**	0.707** 0.633**
No. of kernel rows/ cob										-0.618** -0.265	0.085 0.097	0.044 0.068	0.037 0.023	0.101 0.043
No. of kernels/row											0.947** 0.646**	0.088 0.213	0.638** 0.476**	0.727** 0.617**
Cob weight (g)												0.067 0.096	0.747** 0.675**	0.927** 0.817**
Shelling (%)													0.353* 0.309*	0.362** 0.358*
100-kernel weight (g)														0.822** 0.754**

*, ** indicate correlation estimates significant at 5 and 1 % respectively

Electronic Journal of Plant Breeding, 7(3): 505-513 (September 2016)
ISSN 0975-928X

Table 5. Direct and indirect effects of component traits on grain yield in quality protein maize inbreds

Effect of characters	Effect *via*													Correlation with grain yield per plant (g)
	Days to 50 % tasseling	Days to 50 % silking	Days to 75 % dry husk	Plant height (cm)	Ear height (cm)	No. of leaves/ plant	Cob length (cm)	Cob girth (cm)	No. of kernel rows/cob	No.of kernels/ row	Cob weight (g)	Shelling (%)	100-kernel weight (g)	
Days to 50 % tasseling	**-0.121**	0.093	-0.068	0.009	0.044	0.095	0.023	0.010	0.001	0.001	0.086	-0.018	0.025	0.179
Days to 50 % silking	-0.118	**0.096**	-0.074	0.009	0.044	0.099	0.023	0.014	0.001	0.001	0.110	-0.012	0.028	0.221
Days to 75 % dry husk	-0.056	0.049	**-0.145**	0.010	0.061	0.092	0.031	0.038	0.001	0.001	0.312	-0.009	0.049	0.432
Plant height (cm)	-0.049	0.040	-0.069	**0.021**	0.096	0.087	0.036	0.024	0.001	0.001	0.357	0.024	0.081	0.646
Ear height (cm)	-0.050	0.040	-0.083	0.019	**0.107**	0.099	0.033	0.026	-0.001	0.001	0.358	-0.001	0.073	0.620
No. of leaves/plant	-0.080	0.066	-0.093	0.013	0.074	**0.143**	0.023	0.020	0.001	0.001	0.246	0.004	0.034	0.448
Cob length (cm)	-0.029	0.022	-0.046	0.008	0.037	0.003	**0.097**	0.033	0.001	0.001	0.086	-0.003	0.066	0.491
Cob girth (cm)	-0.041	0.016	-0.065	0.006	0.033	0.034	0.038	**0.085**	0.003	0.001	0.384	0.019	0.094	0.633
No. of kernel rows/cob	-0.027	0.025	-0.017	-0.002	-0.011	0.004	0.002	0.044	**0.006**	0.001	0.056	0.016	0.004	0043
No. of kernels/row	-0.016	0.012	-0.033	0.008	0.041	0.042	0.046	0.018	-0.002	**-0.001**	0.372	0.050	0.078	0.617
Cob weight (g)	-0.018	0.018	-0.079	0.013	0.066	0.061	0.048	0.056	0.001	-0.001	**0.575**	0.023	0.110	0.875
Shelling (%)	0.009	-0.005	0.006	0.002	-0.001	0.002	-0.001	0.007	0.001	0.001	0.055	**0.236**	0.650	0.358
100-kernel weight (g)	-0.019	0.017	-0.043	0.010	0.047	0.029	0.039	0.049	0.001	0.001	0.388	0.073	**0.163**	0.754

R^2= 89.529, Residual effect = 0.324