Indian Res. J. Genet. & Biotech. 9(1) : 41-54 (2017)

GENETIC VARIABILITY AND CORRELATION STUDIES FOR MORPHOLOGICAL TRAITS IN MAIZE (ZEA MAYS L.) GENOTYPES

N. SARMA BARUA*, V. P. CHAUDHARY and G. N. HAZARIKA

Assam Agricultural University, Jorhat 785 013, Assam (India)

*** E-mail: *nsbarua63@yahoo.co.in***

(Received : October, 2016 : Revised : January, 2017; Accepted : January, 2017)

Abstract:

Genetic variability and correlation studies were undertaken in maize (*Zea mays* L.) genotypes for grain yield and yield contributing traits. High heritability exertion along with high genetic advance were recorded for plant height (95.00, 44.07), ear height (95.00, 30.42) and grain yield (90.00, 4484.69), indicating that these traits were controlled by additive genes and suggesting hybridization to be effective. Grain yield showed highly significant positive genotypic correlation with plant height (0.767) and ear height (0.823). Path analysis revealed that days to 50% silk (1.918) had shown the highest positive direct effect on grain yield followed by days to 50% pollen shed (1.779), days to 75% dry husk (0.840), plant height (0.753) and number of kernels per row (0.600) indicating these characters, can be strategically used to improve grain yield of maize. Thus, selection can be exercised on these traits in improving maize population for high grain yield.

Key words: Maize, Heritability, Correlation, Path analysis, Grain yiel

Corresponding author's e-mail : ***nsbarua63@yahoo.co.in***
Published by Indian Society of Genetics, Biotechnology Research and Development,
5, E Biotech Bhawan, Nikhil Estate, Mugalia Road, Shastripuram, Sikandra, Agra 282007 Online

Introduction-

The nature and magnitude of genetic variability present in a population of any crop is pivotal for the crop improvement program. The genotypic and phenotypic variances, heritability and the genetic advance of agronomic traits are some of the key parameters which determine the efficiency of a breeding programme. Genetic base of the material under study and the effects of environment are also very important while studying genetic correlation among various quantitative traits in crops.Maize morphologically exhibits a greater diversity of phenotypes than perhaps any other grain crop (Kuleshov, 1933). Very few studies have been conducted in North-Eastern India for genetic parameters studies on maize.

Grain yield is a highly complex trait and effect of environment on it is very much profound. Direct selection for grain yield is, thus, difficult and breeders have to rely upon some other traits which are relatively simpler and correlated to yield at genetic level. The correlation of characters reveals the type, nature and magnitude of association among the traits. Indirect selection for correlated traits helps in yield enhancement in population. Study of direct and indirect effects of component traits upon yield provides the basis for selection and hence, the problem of yield increase can be more effectively tackled on the basis of performance of yield components if they are closely related traits. Path coefficient analysis measures the direct and indirect effect for a variable upon another and helps in taking decision while choosing traits for selection and permits the partitioning of the correlation coefficient into direct and indirect effects. There is very little informationavailable using different company hybrids evaluated at North-Eastern regions of India along with local-check to be tested for thevariance components of different effects, which isimportant for the breeders to designing the breeding programs.

Hence, the present study was conducted with the objective to assess maize (*Zea mays* L.) genotypes for genetic variability and to determine the interrelationships among the traits under consideration.

Materials and methods

Experimental site and design

Seventeen maize genotypes including sixteen hybrids and a land race constituted the material of the experiment conducted at Instructional-Cum-Research (ICR) Farm of Assam Agricultural University, Jorhat (Assam) in *kharif* 2013. The experimental design used was randomized block design (RBD) for three

Corresponding author's e-mail : nsbarua63@yahoo.co.in
Published by Indian Society of Genetics, Biotechnology Research and Development,
5, E Biotech Bhawan, Nikhil Estate, Mugalia Road, Shastripuram, Sikandra, Agra 282007 Online

replications. Hand dibbling of seeds was done on 14th February, 2013 with two seeds per hill and later thinned out to maintain a single plant per hill 10-12 days after germination. Each individual plot for an entry consisted of 2 rows of 4 m length each with a spacing of 65 ×20 cm. Recommended cultural practices were undertaken as per package of practices (Anonymous 2009). Data collection was done on plant and plot basis as follows: plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of kernels per row and 100 kernel weight (g) were recorded on plant basis while days to 50 % pollen shed, days to 50 % silk, days to 75 % dry-husk and grain yield (kgha^{-1}) were recorded on plot basis. Data for traits taken on plant basis were recorded on five randomly selected plants and average was worked out for further analysis. The crop was harvested on 16th June, 2013.

Statistical analysis

The mean data were subjected to analysis of variance (Panse and Sukhatme1967). The estimation of genetic and phenotypic variances and heritability in broad sense were computed (Burton and Devane1953). The expected genetic advance (GA) and expected genetic advance as % of mean (GAM %) was computed (Johnson *et al.*1955). The data were used for correlation studies to find out the association among yield and its components (Johnson *et al.* 1955) and path coefficient analysis to sort out the traits that are directly or indirectly contributing towards yield (Dewey and Lu 1959).

Results and discussion

Analysis of variance showed that mean squares for genotypes was significant to highly significant for traits such as days to 50 % pollen shed, days to 50 % silk, days to 75 % dry-husk, plant height, ear height, ear length, ear diameter, 100 kernel weight and grain yield (Table 1). This indicates that the entries were sufficiently different from each other for the traits under study.

Estimates of variance components

Phenotypic (PCV) coefficient of variability values ranged from 4.34 % for days to 50 % silk to 23.67 % for grain yield, whereas the genotypic (GCV) coefficient of variability ranged from 2.89 % for ear diameter to 22.39 % for grain yield. Similar results have also been reported by Ghimire and Timsina (2015). The traits such as grain yield, plant height and ear height exhibited high GCV and PCV (Table 2) not only show that the selection can be effective for these traits but also indicated the existence of substantial variability, ensuring ample scope for their improvement through selection. These results were consistent with observations of earlier workers (Bello *et al.* 2012 and Nzuve*et al.* 2014). The higher differences observed between phenotypic variance and genotypic variance for ear length, ear diameter number of kernels per row and 100 kernel weight (Table 2) which reflect the influence of environment on the expression of traits. This was in accordance with the previous findings of

Kumar *et al*. 2013. However, this gap was narrow for days to 50% pollen shed, days to 50% silk, days to 75% dry husk, plant height, ear height and grain yield suggesting low environmental influence in expression of these traits and greater effectiveness of selection and improvement to be expected for these characters in future breeding programme. The results obtained in Table 2 depicted that phenotypic variances (σ^2p) and PCVs were higher than genetic variances (σ^2g) and GCVs for all the traits, suggesting the influence of environment in the expression of these traits. Similar results have also been reported by Nelson and Somers (1992) and Bello *et al.* (2012)

Estimation of heritability in broad sense and genetic advance

Estimates of heritability in broad sense (h^2) ranged from 52.46% for ear diameter to 97.60% for ear height (Table 2). Heritability estimate were high for days to 50% pollen shed (Grzesiak 2001), days to 50% silk (Grzesiak 2001), days to 75% dry husk, plant height, ear height and grain yield (Nelson and Somers 1992, Kalla*et al*. 2001 and Rafique*et al*. 2004). This suggested that heritability is due to the additive genetic effects and selection could be effective in early segregating generations for these traits and the possibility of improving maize grain yield through direct selection (mass selection) for grain yield related traits.

A perusal of genetic advance at 5% selection intensity revealed that it was high for grain yield (43.63%) and (22.83%). It was minimum for number of ear diameter (3.09%), days to 50% silk (8.04%), 100 kernel weight (8.45%), days to 50% pollen shed (8.64%) and days to 75% dry husk (9.34%). High heritability estimates along with the high genetic advance was recorded for plant height, ear height and grain yield indicating that the heritability is due to additive gene effects only which is fixable in subsequent generations. This also provides the evidence that larger proportion of phenotypic variance has been attributed to genotypic variance, and reliable selection could be made for these traits on the basis of phenotypic expression hence pedigree method of breeding will be a rewarding one to improve the traits under investigation. These results find support from the earlier studies by Kumar *et al*. 2014. The present study also reveals high heritability with low estimates of genetic advance as %of mean recorded for days to 50% pollen shed, days to 50% silk and days to 75 % dry husk which may be attributed to non-additive gene action governing these traits, and these characters could be improved through the use of hybridization and hybrid vigour. High heritability accompanied with low genetic advance as % of mean in days to 50 % pollen shed and days to 50 % silk had earlier been reported by Bello *et al*. (2012). Ear diameter exhibited low heritability along with low genetic advance as % of mean indicating non-additive genetic effects governing this trait.

Estimation of Correlation:

In the present study, genotypic correlations in general were higher than the phenotypic correlation, revealing strong inherent relationship among the characters studied and also reveal that association may be largely due to genetic reason (strong coupling linkage) (Sharma 1988). This result is in harmony with those obtained by Duvick (2001). Days to 50 % pollen shed had a significant positive correlation at both genotypic and phenotypic levels with all the traits under study except for ear diameter and grain yield. Plant height also had a significant positive at both genotypic and phenotypic levels correlation with all the other traits under study except for ear diameter and 100 kernel weight. Similar observations were reported by Bhole and Patil (1984).

The perusal of phenotypic and genotypic correlation (Table 3) analysis revealed that, grain yield showed highly significant positive correlation with plant height (Zarei*et al*. 2012) and ear height (Wali*et al*. 2006) at both levels. These results indicated that the aforementioned traits (plant height and ear height) were highly correlated with grain yield and were considered important for indirect selection. In the present investigation, positive correlation coefficient betweenany two characters suggested that they can be improved simultaneously and improvement in one will automatically cause correlated response in the other. However, such simultaneous improvement is not possible for those traits that are negatively correlated. Therefore, correlated traits can be improved by indirect selection.

Sometimes, correlation coefficients give misleading picture because the correlation between two variables may be due to a third factor. It is therefore necessary to analyze the cause and effect relationship between dependent and independent variables to entangle the nature of relationship between the variables. Path coefficient analysis (Dewey and Lu 1959) furnished a method partitioning the correlation coefficient into direct and indirect effects and the information on path wise contribution of component traits on the yield may be obtained.

Path Analysis:

In the present study, direct and indirect effects of nine characters on grain yield were estimated and are presented in Table 4. Study revealed that, days to 50 % silk (1.918) had shown the highest positive direct effect to grain yield followed by days to 50 % pollen shed (1.779), days to 75 % dry husk (0.840), plant height (0.753) and number of kernels per row (0.600). In the present study, positive correlations of days to 50 % silk, days to 50 % pollen shed, days to 75 % dry husk, plant height and number of kernels per row with grain yield were due to their substantially large positive direct effects on grain yield. The results were supported by the earlier findings of Lingaiah*et al.* (2014) for days to 50 % silk, plant height, ear length and ear diameter, Arunkumar (2013) for plant height and Pavan*et al.* (2011) for days to 50 % silk and plant height and Ahmad and Saleem (2003) for days to 75 % dry husk and 100 kernel weight. The characters *viz.,* ear diameter and ear height (0.011) had positive low direct effects on grain yield. None of the traits under study showed any negative direct effect on grain yield. The characters with positive estimates of correlation could be used more confidently as the selection criteria for the improvement of grain yield in maize.

Among the studied traits days to 50 % pollen shed *via* ear height (0.095), ear diameter (0.470), number of kernels per row (0.701) and 100 kernel weight and days to 50 % silk via 75 % dry husk (0.786), plant height (0.534), ear length (0.094) and 100 kernel weight (0.255) and days to 75 % dry husk via plant height (0.367), ear length (0.094) and 100 kernel weight (0.165) revealed positive indirect effect on grain yield. Similarly, days to 50 % pollen shed, days to 50 % silk, days to 75 % dry husk, plant height, ear length and 100 kernel weight were exhibited positive indirect association with each other towards maize grain yield. Ear diameter and number of kernels per row showed negative indirect association with all other traits towards grain yield except for days to 50 % pollen shed. Study revealed that direct selection for these traits would be effective.

The correlation coefficient and the direct effects were almost equal for the traits such as ear length and 100 kernel weight with the grain yield. This explained the true relationship and a direct selection through this trait will be effective. The residual effects permit precise explanation about the pattern of interaction of other possible components of yield. The residual effect recorded was 0.5734; it indicates the studied characters contribute 42.66% of variations in yield of maize.

Our study indicated that the mean squares (ANOVA), due to genotypes were significant for most studied traits indicating the existence of high level of variability and the possibility of selection in the population for grain yield and agronomic traits of interest. The component characters manly ear height and plant height depicted significant and positive correlation with grain yield. Path coefficient analysis revealed that days to 50 % silk, days to 50 % pollen shed, days to 75 % dry husk and plant height had shown the highest positive direct effect to grain yield. These component traits also exhibited positive inter-association with most of the other traits and positive indirect effects on grain yield irrespective of management practices. Hence, further experiments are needed to capitalise its focus on these components which may be further given importance in selection programme to improve the grain yield in maize breeding program. These traits can also play a crucial role and become a valuable strategic plan in the improvement of inbred lines as well as for the development of superior hybrids in maize.

References:

Ahmad, A. and Saleem, M. 2003. Path coefficient analysis in *Zea mays* L. *Int. J. Agri. Biol.* **5(3)**: 245-248.

Anonymous. 2009. Package of practices for rabi crops of Assam. Published jointly by Assam Agricultural University, Jorhat and Department of Agriculture, Assam. pp - 33-37.

Arunkumar, B. 2013. Genetic Variability, Character Association and Path Analysis Studies in Sorghum (*Sorghum bicolor* L. Moench). *The Bioscan*. **8(4)**: 1485-1488.

Bello, O.B., Ige, S.A., Azeez, M.A., Afolabi, M.S., Abdulmaliq, S.Y. and Mahamood, J. 2012. Heritability and Genetic Advance for Grain Yield and its Component Characters in Maize (*Zea Mays* L.). *International Journal of Plant Research*. **2(5)**: 138-145.

Bhole, G.R. and Patil, R.C. 1984. Genotypic and phenotypic correlations in maize. *Journal of Maharashtra Agricultural Universities*. **9**: 250-251.

Burton, G.W and Devane, E.H. 1953. Genetic variability and heritability in soybean. *Agron. J*.**45**: 478-481.

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

Duvick, D.N. 2001. Biotechnology in the 1930s, The Development of Hybrid Maize. *National Review of Genetics*. **2**: 69-74.

Ghimire, B. and Timsina, D. 2015. Analysis of Yield Chitwan, Nepal. *World Journal of Agricultural Research*, **3(5)**: 153-162.

Grzesiak, S. 2001. Genotypic variation between maize (*Zea mays* L.) single-cross hybrids in response to drought stress. *Act a PhysiologiaePlantarum*, **23(4)**: 443-456.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybean. *Agron. J*.**47**: 314-318.

Kalla, V., Kumar, R. and Basandrai, A. K. 2001. Combining ability analysis and gene action estimates of yield and yield attributing characters in maize (*Zea mays* L.). *Crop Res*. **22(1)**: 102-106.

Kuleshov, N.N. 1933. World's diversity of phenotypes of maize. *J. Agron*., **25**: 688-700.

Kumar, B., Singh, M.C., and Jaiswal, K.K. 2013. Genetic Variability, Association and Diversity Studies in Bread Wheat (*Triticumaestivum* L.). *The Bioscan*. **8(1)**: 143-147.

Kumar, P.G., Reddy, V.N., Kumar, S.S. and Rao, V.P. 2014. Genetic Variability, Heritability and Genetic Advance Studies in Newly Developed Maize Genotypes (*Zea mays* L.). *Int. J. Pure App. Biosci.***2(1)**: 272-275.

Lingaiah, N., Kumar, P.G. and Venkanna, V. 2014. Character association and path analysis for yield contributing and physiological parameters for grain yield in Maize (*Zea mays* L.). *Int. J. Pure App.*

Nzuve, F., Githiri, S., Mukunya, D.M. and Gethi, J. 2014. Genetic Variability and Correlation Studies of Grain Yield and Related Agronomic Traits in Maize. *J. Agric. Sci*. **6**: 166-176.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical Methods for Agricultural Workers, 2nd Ed. ICAR publication, New Delhi, India. pp. 381.

Pavan, R., Lohithaswa, H.C., Wali, M.C., Prakash, G. and Shekar, B.G. 2011. Correlation and path coefficient analysis of grain yield and yield contributing traits in single cross hybrids of maize (*Zea mays* L.). *Electron. J. Plant Breed.***2(2)**: 253-257.

Rafique, M., Hussain, A., Mahmood, T., Alvi, A.W. and Alvi, B. 2004. Heritability and interrelationships among grain yield and yield components in maize (*Zea mays* L). *Int. J. Agri. Biol.*,**6(6)**: 1113-1114.

Sharma, J.R. 1988. Statistical and biometrical techniques in plant breeding. New age international (Pvt) Ltd., New Delhi. Reprint: 2008. pp. 35.

Wali, M.C., Salimath, P.M., Prashanth, M. and Harlapur, S.I. 2006. Studies on character association as influenced by yield, starch and oil in maize (*Zea mays* L.). *Karnataka J. Agric. Sci.***19(4):** 932-935.

Zarei, B., Kahrizi, D., Aboughadaresh, A.P. and Sadeghi, F. 2012. Correlation and path coefficient analysis for determining interrelationships among grain yield and related characters in corn hybrids. *International Journal of Agriculture and Crop Sci.***4(20):** 1519-152

.

Table 1. Analysis of variance for different characters in maize.

Source of variation	**df**	**Mean squares**							
		Days to 50 % pollen shed	Days to 50 % silk	Days to 75 % dry husk	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Number of kernels /row
Replication	2	19.47**	0.13	4.74	65.30	7.27	0.71	0.00	122.64**
Genotypes	16	9.91**	9.69**	43.11*	1481.31**	698.41**	8.61**	0.10**	46.59**
Error	32	0.22	0.34	1.62	28.28	11.41	1.59	0.05	15.12
CD (5 %)		0.78	0.98	2.12	8.85	5.62	2.10	0.37	6.47
CV		1.13	1.37	1.64	2.76	3.73	8.12	4.69	1.95

* and ** denote significance at 0.05 and 0.01 % level of probability.

Table 2. Estimates of genetic variance and related parameters for different characters in maize.

Genetic parameters	Days to 50 % pollen shed	Days to 50 % silk	Days to 75 % dry husk	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Number of kernels/ row
$\sigma^2 g$	3.23	3.12	13.83	484.39	228.99	2.34	0.02	10.49
GCV	4.34	4.12	4.79	11.41	16.72	9.84	2.88	9.13
$\sigma^2 p$	3.45	3.46	15.45	512.66	240.41	3.94	0.07	25.61
PCV	4.48	4.34	5.07	11.73	17.14	12.76	5.52	14.26
h^2	94.00	90.00	90.00	95.00	95.00	60.00	27.00	41.00
GAM	3.58	3.45	7.24	44.07	30.42	2.43	0.14	4.27
General Mean	41.47	42.90	77.56	192.97	90.48	15.55	4.79	35.49

Table 3. Phenotypic (below diagonal), genotypic (above diagonal) correlation of quantitative traits in maize.

Traits	Days to 50 % pollen shed	Days to 50 % silk	Days to 75 % dry husk	Plant height	Ear height	Ear length	Ear diameter	Nun kern
Days to 50 % pollen shed	1	0.999**	0.594**	0.496*	0.656**	0.553*	0.380	0.6
Days to 50 % silk	0.990**	1	0.619**	0.444*	0.575*	0.563*	0.489*	0.6
Days to 75 % dry husk	0.587*	0.606**	1	0.464*	0.441*	0.884**	0.766**	0.8
Plant height	0.489*	0.434*	0.451*	1	0.774**	0.587*	0.006	0.6
Ear height	0.648**	0.559*	0.419	0.759**	1	0.377	-0.183	0.
Ear length	0.486*	0.487*	0.779**	0.510*	0.343	1	0.902**	0.8
Ear diameter	0.280	0.341	0.547*	0.008	-0.144	0.591**	1	0.7
Number of kernels/row	0.538*	0.549*	0.731**	0.516*	0.253	0.665**	0.391	
100 kernel weight	0.537*	0.536*	0.534*	0.135	0.169	0.595**	0.286	0.:
Grain yield	0.321	0.219	0.290	0.740**	0.797**	0.231	-0.147	0.

* and** indicate significance of value at P = 0.05 and 0.01, respectively.

Table 4. Path co-efficient analysis of quantitative traits in maize.

Traits	Days to 50% pollen shed	Days to 50% silk	Days to 75% dry husk	Plant height	Ear height	Ear length	Ear diameter
Days to 50% pollen shed	**1.779**						
Days to 50% silk	-1.847	**1.918**					
Days to 75% dry husk	-0.727	0.786	**0.840**				
Plant height	-0.575	0.535	0.368	**0.753**			
Ear height	0.095	-0.085	-0.043	-0.073	**0.012**		
Ear length	-0.091	0.095	0.095	0.063	-0.005	**0.014**	
Ear diameter	0.471	-0.607	-0.581	-0.021	-0.010	-0.080	**0.566**
Number of kernels / row	0.701	-0.741	-0.632	-0.427	0.026	-0.079	0.449
100 kernel weight	-0.244	0.256	0.166	0.043	-0.006	0.024	-0.077
Genotypic correlation with grain yield	0.320	0.223	0.299	0.767**	0.823**	0.274	-0.159

*and** indicate significance of values at P = 0.05 and 0.01, respectively. Underlined bold figures indicate direct effect c

References:

Ahmad, A. and Saleem, M. 2003. Path coefficient analysis in Zea mays L. Int. J. Agri. Biol. 5(3): 245-248.

Anonymous. 2009. Package of practices for rabi crops of Assam. Published jointly by Assam Agricultural University, Jorhat and Department of Agriculture, Assam. pp - 33-37.

Arunkumar, B. 2013. Genetic Variability, Character Association and Path Analysis Studies in Sorghum (Sorghum bicolor L. Moench). The Bioscan. 8(4): 1485-1488.

Bello, O.B., Ige, S.A., Azeez, M.A., Afolabi, M.S., Abdulmaliq, S.Y. and Mahamood, J. 2012. Heritability and Genetic Advance for Grain Yield and its Component Characters in Maize (Zea Mays L.). International Journal of Plant Research. 2(5): 138-145.

Bhole, G.R. and Patil, R.C. 1984. Genotypic and phenotypic correlations in maize. Journal of Maharashtra Agricultural Universities. 9: 250-251.

Burton, G.W and Devane, E.H. 1953. Genetic variability and heritability in soybean. Agron. J.45: 478-481.

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

Duvick, D.N. 2001. Biotechnology in the 1930s, The Development of Hybrid Maize. National Review of Genetics. 2: 69-74.

Ghimire, B. and Timsina, D. 2015. Analysis of Yield and Yield Attributing Traits of Maize Genotypes in Chitwan, Nepal. World Journal of Agricultural Research, 3(5): 153-162.

Grzesiak, S. 2001. Genotypic variation between maize (Zea mays L.) single-cross hybrids in response to drought stress. Act a PhysiologiaePlantarum, 23(4): 443-456.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybean. Agron. J.47: 314-318.

Kalla, V., Kumar, R. and Basandrai, A. K. 2001. Combining ability analysis and gene action estimates of yield and yield attributing characters in maize (Zea mays L.). Crop Res. 22(1): 102-106.

Kuleshov, N.N. 1933. World's diversity of phenotypes of maize. J. Agron., 25: 688-700.

Corresponding author's e-mail : ***nsbarua63@yahoo.co.in***
Published by Indian Society of Genetics, Biotechnology Research and Development,
5, E Biotech Bhawan, Nikhil Estate, Mugalia Road, Shastripuram, Sikandra, Agra 282007 Online

Kumar, B., Singh, M.C., and Jaiswal, K.K. 2013. Genetic Variability, Association and Diversity Studies in Bread Wheat (Triticumaestivum L.). The Bioscan. 8(1): 143-147.

Kumar, P.G., Reddy, V.N., Kumar, S.S. and Rao, V.P. 2014. Genetic Variability, Heritability and Genetic Advance Studies in Newly Developed Maize Genotypes (Zea mays L.). Int. J. Pure App. Biosci.2(1): 272-275.

Lingaiah, N., Kumar, P.G. and Venkanna, V. 2014. Character association and path analysis for yield contributing and physiological parameters for grain yield in Maize (Zea mays L.). Int. J. Pure App. Biosci.2(1): 118-121.

Nzuve, F., Githiri, S., Mukunya, D.M. and Gethi, J. 2014. Genetic Variability and Correlation Studies of Grain Yield and Related Agronomic Traits in Maize. J. Agric. Sci. 6: 166-176.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical Methods for Agricultural Workers, 2nd Ed. ICAR publication, New Delhi, India. pp. 381.

Pavan, R., Lohithaswa, H.C., Wali, M.C., Prakash, G. and Shekar, B.G. 2011. Correlation and path coefficient analysis of grain yield and yield contributing traits in single cross hybrids of maize (Zea mays L.). Electron. J. Plant Breed.2(2): 253-257.

Rafique, M., Hussain, A., Mahmood, T., Alvi, A.W. and Alvi, B. 2004. Heritability and interrelationships among grain yield and yield components in maize (Zea mays L). Int. J. Agri. Biol.,6(6): 1113-1114.

Sharma, J.R. 1988. Statistical and biometrical techniques in plant breeding. New age international (Pvt) Ltd., New Delhi. Reprint: 2008. pp. 35.

Wali, M.C., Salimath, P.M., Prashanth, M. and Harlapur, S.I. 2006. Studies on character association as influenced by yield, starch and oil in maize (Zea mays L.). Karnataka J. Agric. Sci.19(4): 932-935.

Zarei, B., Kahrizi, D., Aboughadaresh, A.P. and Sadeghi, F. 2012. Correlation and path coefficient analysis for determining interrelationships among grain yield and related characters in corn hybrids. International Journal of Agriculture and Crop Sci.4(20): 1519-1