Journal of Agroecology and Natural Resource Management
Print ISSN: 2394-0786, Online ISSN: 2394-0794, Volume 1, Number 2; November-January, 2014 pp. 34-39

http://www.krishisanskriti.org/janrm.html

Genetic Variability and Character Association of Grain Yield Components in Some Inbred Lines of Maize (Zea mays L.)

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Abstract: *The present investigation was conducted to evaluate the various parameters of genetic variability, and nature of associations among traits affecting grain yield in thirty three inbred lines of maize (Zea mays L.) at Calcutta University's experimental farm, Baruipur, South 24 Parganas, West Bengal, India during rabi 2013-2014. Analysis of variance revealed presence of substantial variability among the genotypes for all the 11 traits studied. The equivalence between Genotypic coefficient of variation (GCV) and Phenotypic coefficient of variation (PCV) was close for all traits indicating that these characters were less influenced by environment. High GCV, heritability and relatively high genetic advance was observed for the traits viz., number of grains per cob, grain yield per plant, number of grains per row, plant height and ear height indicating that selection for these characters would prove quite effective since these characters seemed to be governed by additive gene action. It is inferred from correlation that all the traits studied were positively associated with grain yield per plant and exhibited significant positive genotypic and phenotypic correlation with the traits plant height, ear height and number of grains per cob whereas the other traits were not significantly associated with grain yield. Path analysis revealed that all the traits, with the exception of days to 50% silking, had positive direct effect on grain yield. Days to 50% tasseling, number of grains per cob, ear height and cob diameter due to its highly positive direct effect on grain yield and also indirect effect on all other traits could provide a good selection criteria for high yielding maize lines.Hence, these traits may be used as a reliable selection index for yield improvement in maize inbred lines.*

Keywords: *Genetic variability, Correlation analysis, Path coefficient analysis, Inbreds, Maize.*

1. INTRODUCTION

Maize *(Zea mays L.)* commonly known as Corn is the third most important and versatile cereal crop worldwide after rice and wheat and plays an important role in the world economy. It is one of the most widely distributed crops of the world owing to its expansive adaptability under diverse agro-climatic conditions and is also a valuable ingredient in industrial products that affect a large proportion of the world population. Maize inbred lines are important as they represent a fundamental resource for studies in genetics and breeding and are used extensively in hybrid corn production [5, 21]. The primary objective in most maize breeding programmes is increased production per unit area which can be achieved by increasing the inherent yielding ability of the crop, thus any trait that contributes to the stable production of high yielding maize lines will be of interest to plant breeders. Grain yield is the most important and complex trait i.e. interdependent on various other yield attributing traits. Knowledge of genetic variation and relationships between accessions is a prerequisite for any improvement in traits of economic importance as it helps to understand the magnitude of genetic variability which provides the basis for effective selection. Knowledge of heritability coupled with genetic advance is most useful in predicting the scope for genetic improvement through selection as heritability alone provide the basis for selection on phenotypic performance that doesn't indicate the amount of genetic improvement resulting from the selection of individual genotypes. For improvement in grain yield, it is essential to study the nature of association between yield and its components. Correlation coefficients measure the association between and among two or more traits, whereas path coefficient analysis measures the influence of one trait upon another by means of partitioning both direct and indirect effects. Thus, correlation and path coefficient analyses can assist to determine the appropriate traits to be used in indirect selection for the improvement of the complex character such as yield. An understanding of the nature and magnitude of variability for grain yield and its components among the inbred lines of maize and to ascertain the association among and between each components and yield is necessary for selecting an appropriate breeding procedure for evolving high-yielding varieties.

2. MATERIALS AND METHODS

This study included thirty three maize inbred lines among which Sixteen of the inbred lines were obtained from the International Maize and Wheat Improvement Center (CIMMYT), India and 17 from the Directorate of Maize Research (DMR), New Delhi. A seed increase for each inbred line occurred at the Experimental Farm of University of Calcutta at Baruipur, South 24 Parganas, West Bengal during rabi season from last week of November, 2013 to 1st week of April, 2014. Thirty three different genotypes of maize were taken for this experiment. The experiment was laid out in Randomized Block Design (RBD) with three replications. The inbred lines were sown in the experimental plot with rows of 2m length and 60cm row to row and 20 cm plant to plant spacing. Normal inter culture operations were practiced throughout the growing period. Harvesting of maize inbreds were carried out manually and individually at 120 days after planting. Data was recorded on five randomly selected plants from each replication for eleven yield traits like:- Days to tasseling (50%), Days to silking (50%), Plant height (cm), Ear height (cm), Cob length (cm), Cob diameter (cm), No. of grain rows per cob, No. of grains per row, No. of grains per cob, 1000 grain weight (gm) and Grain yield per plant (gm) was calculated. Following data collections, the data obtained on various agromorphological characters were subjected to various analyses by applying standard statistical techniques. Analysis of variance (ANOVA), Coefficient of variability, broad sense heritability, genetic advance, correlation study and path coefficient analysis were worked out following Johnson *et al.* [10], Pearson's correlation analysis, Dewey and Lu [6].

2.1. Maintenance of Inbred lines

The Ear shoot and Tassel bag method was used for the maintenance of Inbred lines. The ear shoot on the plants to be self pollinated were covered with a semi transparent shoot bag before the emergence of the silks and the tassel shedding pollen was covered with tassel bag one day prior to pollination. On the day of pollination, the covered tassel was tapped to dislodge the pollens and then the tassel bag containing pollen was carefully removed from the tassel, the pollens in the bag were slowly shaken out of the bag to drop or dusted onto the silk of the same plant.The pollinated ear was then covered with the tassel or a new bag & stapled to the plant.

3. RESULTS AND DISCUSSION

In crop breeding variability plays an important role. Analysis of variance of grain yield per plant and related traits revealed the presence of substantial variability among the inbred lines for all the eleven traits studied as the mean sum of squares due to inbred lines showed significant differences for all the traits and are shown in **Table 1**.

3.1. Parameters of Genetic variability

Genotypic and Phenotypic coefficient of variability, heritability, genetic advance and genetic advance as percent of mean estimates are presented in **Table 2**. The estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) revealed that GCV was less than its corresponding estimates of PCV for grain yield and its related traits. Higher values of PCV than GCV is an indication of the significant role of environment in the expression of all the traits studied. GCV was estimated to be high for number of grains per cob followed by grain yield per plant, number of grains per row, 1000 grain weight, ear height and plant height. Estimates of PCV also showed a similar trend for all the above mentioned traits. Singh *et al.*[20], Abirami *et al.* [1] and Rafiq *et al.* [16] reported similar results i.e. high estimates of GCV and PCV for grain yield/plant and ear height. The high values of GCV for number of grains per cob, grain yield per plant, 1000 grain weight, number of grains per row, ear height and plant height suggested that these traits might be further improved through selection.

The heritability estimates were found to be high for plant height (94.0%), number of grains per row, number of grains per cob, grain yield per plant and cob length, 1000 grain weight, days to 50%tasseling, days to 50% silking and moderate for number of grain rows per cob (53.0%), whereas for cob diameter (39.0%) low heritability estimate was recorded. Traits with high heritability estimates showed that variation in these traits is predominantly governed by heritable factors, whereas both genetics and environment played equivalent roles in the expression of traits with moderately high heritability values and low heritability values indicated that the expression of the traits was mostly influenced by environment rather than genetic. Traits with high heritability estimates in broad sense can be utilized for genetic improvement as they are least influenced by environmental effects and thus having a potential for large genetic determination [13,23]. The results are in agreement with the findings of Vashistha *et al.* [23] in maize for grain yield per plant, plant height, ear height, 100 grain weight, days to 50%tasseling and days to 50% silking.

The expected genetic advance of traits was highest for number of grains per cob followed by 1000 grain weight, while the remaining characters exhibited moderate to very low genetic advance. To draw comparison among various traits which have different units of measurement, the genetic advance values for each trait are expressed as percent of the genotype mean [13]. The highest genetic advance as percent of mean was recorded for number of grains per cob followed by grain yield per plant, number of grains per row, plant height and ear height.Evaluation of genetic advance helps in interpreting the type of gene action involved in the expression of various polygenic traits. High values and low values of genetic advance are indicative of additive gene action and of non-additive gene action respectively [19].

According to Vashistha *et al*. [23], heritability alone does not provide any indication of the amount of genetic improvement that would result from selection of individual genotypes. Thus, to arrive at more reliable conclusion high heritability should be accompanied by high genetic advance [10]. Thus Knowledge of heritability and genetic advance of the character indicate the scope for the improvement through selection.In the present investigation high heritability with moderately high estimates of genetic advance as percent of mean were recorded for no. of grains per cob, grain yield per plant, no. of grains per row, plant height, ear height and 1000 grain weight where careful selection may lead towards improvement for these traits and high heritability with low genetic advance for days to 50% tasseling, days to 50% silking and cob length. Traits exhibiting high heritability coupled with high or moderate or low genetic advance suggest that the traits are governed by additive gene action, equal contribution of additive and non-additive gene action and non additive gene action respectively as reported by different researchers [13,18, 21].

In this study the traits number of grains per cob, grain yield per plant, number of grains per row, plant height and ear height showed high GCV, heritability and moderately high genetic advance suggesting additive genetic effects. According to Sahao *et al*. [17], high GCV coupled with high heritability and genetic advance provides more desirable information than a single parameter alone.

3.2 CHARACTER ASSOCIATION

Correlation studies: Studies on correlation coefficients of different plant traits are useful criterion to identify desirable traits that contribute to improve the dependent variable (grain yield). The genotypic and phenotypic correlations among the traits studied pointed out the existence of several statistically significant relationships and are presented in **Table 3 and 4**Grain yield showed significant and positive genotypic correlation with plant height, ear height, number of grains per cob, cob diameter and number of grains per row while the remaining traits exhibited positive but non-significant genotypic correlation, whereas at phenotypic level all the traits evaluated, with the exception of plant height, ear height and number of grains per cob exhibiting significant and positive correlation coefficients with grain yield per plant, showedpositive but weak phenotypic correlations with grain yield. These results are in accordance with Rafiq *et al.*[16] and Wali *et al*. [24] for plant height, ear diameter and grains per row. The yield related traits displaying positive and significant association with grain yield per plant suggested that grain yield can be improved through simultaneous selection for these traits [14].The genotypic correlation is greater than phenotypic correlation for all the assessed traits except for 1000 grain weight. These findings are in close conformity of Alake *et al*., [3] who suggested that the low phenotypic correlation may result from the modifying effect of environment on the association trait at genetic level. Selection is generally based on phenotypic expression of traits. Hence, selection for the traits exhibiting positive significant genotypic and positive phenotypic correlation would be of major use in indirect and direct selection for grain yield respectively[3].

Path analysis: Correlation is not sufficient to explain the true association as it does not indicate the cause and effect relationship, hence the correlated traits have to be further analysed for their direct effects of specific yield components on yield and also indirect effects via other yield components on grain yield. The results of path coefficient analysis and the direct and indirect effects of each coefficient are given in **Table 5.**Grain yield per plant as dependent variable was evaluated against other measured traits as independent variables. Path analysis revealed that most of the traits had positive direct effect on grain yield. The highest direct effect on grain yield was exhibited by days to 50% tasseling followed by number of grains per cob and days to 50% silking had the largest positive indirect effect on grain yield followed by plant height through days to 50% tasseling. Moreover, days to 50% silking had the largest negative direct effect on grain yield though it had positive but non-significant correlation withgrain yield, while days to 50% tasseling had the highest negative indirect effect via days to 50% silking. Wali *et al*. [24] also reported similar observations in maize. Most of the traits displayed positive indirect effect on grain yield through days to 50% tasseling, ear height, cob diameter and number of grains per cob. Thus these traits could be used as the selection criteria in grain yield improvement of maize as suggested by ILKER [9]. High positive direct effect has been reported by various researchers for days to 50% silking [23]; for ear height [2, 11]; for cob diameter [7,15], for number of grains per row [8,12,24,4]. The residual effect of 0.4569 indicates that there are some more traits contributing to the grain yield that need to be studied.

4. CONCLUSION

This study concluded that the variations observed for the eleven traits may be attributed to diverse genetic background of the inbred lines studied. According to Alake *et al*. [3] in a population of maize genotypes, there is an opportunity to select desirable genotypes with increased yield components traits which may be able to perform well and give increased yield. High estimates of GCV and PCV were recorded for number of grains per cob, grain yield per plant, number of grains per row, 1000 grain weight, and ear height proposing adequate variability and indicating that these traits might be further improved through selection. Traits with high heritability and moderately high genetic advance such as number of grains per cob, grain yield per plant, number of grains per row, plant height and ear height indicates indicate the importance of additive gene action where cautious selection may lead towards improvement for these traits. Conclusively, the information generated from the above study on character association suggested that the traits number of grains per cob, number of grains per row, ear height, cob diameter and plant height of maize inbred lines could be considered as target traits to improve maize grain yield as they showed positive significant genotypic correlation with grain yield and this strong genetic correlation resulted in high positive direct effect on grain yield. The traits days to 50% tasseling, number of grains per cob, ear height and cob diameter due to its highly positive direct effect on grain yield and also indirect effect via all other traits could provide a good selection criteria for high yielding maize lines. Hence, selection for these traits will increase the grain yield of maize.

Table 1: Mean sum of square of eleven different characters of thirty three inbred lines of maize

S.O.V	Days to tasseling (50%)	Days to silking (50%)	Plant height (cm)	Ear height (cm)	Cob Length (cm)	Cob Diameter (cm)	No. of grain rows/cob	No. of grains/row	No. of grains/cob	1000 grain weight (gm)	Grain Yield/plant (gm)
MS(R)	43.13	82.22	18.67	281.73	2.06	6.12	0.18	4.98	997.53	619.66	40.98
MS(V)	3087.51**	3066.17**	90308.61**	27188.02**	388.78**	59.99**	77.19**	2014.14**	410531.45**	250291.96**	15615.05**
MS(E)	434.04	502.95	4053.42	3061.23	31.63	40.60	35.35	118.80	30485.68	32358.34	1292.25

- SOV= Source of Variation.
- MS(R) = Replication Mean Sum Of Square,
- MS(V)=Variety Mean Sum Of Square,
- MS(E) = Error Mean Sum Of Square.
- ** Denotes 1% level Of Significance,* Denotes 5% Level Of Significance.
- GCV=Genotypic Coefficient Of Variation, PCV=Phenotypic Coefficient Of Variation, H%=Heritability%, GA=Genetic Advance, GA% of Mean=Genetic Advance Percentage of Mean.

Table 2: Estimates of GCV, PCV, H%, GA, GA% of mean for eleven different characters in thirty three inbred lines of maize

PARAMETER	Days to tasseling (50%)	Days to silking (50%)	Plant height (cm)	Ear height (cm)	Cob Length (cm)	Cob Diameter (cm)	No. of grain rows/cob	No. of grains/row	No. of grains/cob	1000 grain weight (gm)	Grain Yield/plant (gm)
GCV	5.96	5.67	19.87	21.27	16.40	5.35	6.03	22.15	25.43	21.36	24.75
PCV	6.60	6.38	20.54	23.09	17.41	8.52	8.30	23.13	26.86	23.47	26.30
H%	82.00	79.00	94.00	85.00	89.00	39.00	53.00	92.00	90.00	83.00	89.00
GA	9.18	8.80	58.44	28.57	3.60	0.52	0.86	8.52	118.48	84.26	22.77
GA% of mean	3.34	3.07	12.76	12.39	9.99	1.45	2.19	13.94	15.65	12.15	15.05

Table 3: Genotypic correlation coefficient among grain yield and its components in thirty three inbred lines of maize

Traits	Days to tasseling (50%)	Days to silking (50%)	Plant height (cm)	Ear height (cm)	Cob Length (cm)	Cob Diameter (cm)	No. of grain rows/cob	No. of grains/row	No. of grains/cob	1000 Grain weight (gm)	Grain Yield/plant
Days to tasseling(50%)	1.00	0.99**	0.45**	0.48**	0.23	0.40*	-0.15	0.09	-0.03	0.22	0.25
Days to silking (50%)		1.00	0.42*	0.47**	0.25	0.37*	-0.13	0.08	-0.07	0.15	0.21
Plant height (cm)			1.00	0.89**	0.23	0.37*	-0.19	0.26	0.26	0.22	0.49**
Ear height (cm)				1.00	0.41*	0.40*	-0.17	0.32	0.26	0.41*	0.49**
Cob Length (cm)					1.00	0.63**	0.08	0.65**	0.47**	0.27	0.18
Cob Diameter(cm)						1.00	-0.18	0.47**	0.31	0.32	0.38*
No. of grain rows/cob							1.00	0.22	0.38*	-0.41	0.06

Traits	Days to tasseling (50%)	Days to silking (50%)	Plant height (cm)	Ear height (cm)	Cob Length (cm)	Cob Diameter (cm)	No. of grain rows/cob	No. of grains/row	No. of grains/cob	1000 Grain weight (gm)	Grain Yield/plant
No. of grains/row								1.00	0.89**	-0.15	0.35*
No. of grains/cob									1.00	-0.19	0.44**
1000 grain weight (gm)										1.00	0.22
Grain Yield/plant											1.00

Table 4: Phenotypic correlation coefficient among grain yield and its components in thirty three inbred lines of maize

Traits	Days to tasseling (50%)	Days to silking (50%)	Plant height (cm)	Ear height (cm)	Cob Length (cm)	Cob Diameter (cm)	No. of grain rows/cob	No. of grains/row	No. of grains/cob	1000 Grain weight (gm)	Grain Yield/plant
Days to tasseling (50%)	1.00	0.96**	0.37*	0.37*	0.20	0.19	-0.08	0.07	-0.01	0.18	0.23
Days to silking(50%)		1.00	0.34*	0.35*	0.22	0.16	-0.06	0.04	-0.04	0.14	0.19
Plant height (cm)			1.00	0.81**	0.22	0.23	-0.16	0.23	0.25	0.18	0.44**
Ear height (cm)				1.00	0.38*	0.28	-0.04	0.31	0.25	0.28	0.41*
Cob Length (cm)					1.00	0.39*	-0.03	0.59**	0.43*	0.22	0.16
Cob Diameter (cm)						1.00	0.11	0.31	0.20	0.23	0.26
No. of grain rows/cob							1.00	0.18	0.33	-0.28	0.02
No. of grains/row								1.00	0.82**	-0.13	0.31
No. of grains/cob									1.00	-0.12	0.41*
1000 grain weight (gm)										1.00	0.25
Grain Yield/plant											1.00

** and * Denotes 1% and 5% Level Of Significance respectively.

Table 5: Direct and indirect effects of different traits on grain yield

Traits	Days to tasseling (50%)	Days to silking (50%)	Plant height (cm)	Ear height (cm)	Cob Length (cm)	Cob Diameter (cm)	No. of grain rows/cob	No. of grains/row	No. of grains/cob	1000 Grain weight (gm)
Days to tasseling (50%)	4.58	-4.52	0.12	0.23	0.02	0.02	-0.04	0.05	0.01	-0.07
Days to silking(50%)	4.56	-4.54	0.12	0.23	0.02	0.02	-0.04	0.04	0.04	-0.05
Plant height (cm)	3.18	-1.89	0.28	0.43	0.02	0.02	-0.05	0.14	-0.13	-0.07
Ear height (cm)	2.21	-2.13	-0.08	0.48	0.04	0.12	-0.04	-0.06	0.16	0.07
Cob Length (cm)	1.05	-1.14	-0.02	0.19	0.09	0.19	-0.02	-0.13	0.29	0.05
Cob Diameter(cm)	1.82	-1.66	-0.03	0.19	0.06	0.31	-0.05	-0.09	0.19	0.06
No. of grain rows/cob	-0.69	0.58	0.02	-0.08	0.03	-0.06	0.25	-0.04	0.24	-0.07
No. of grains/row	0.66	-0.53	0.07	0.12	-0.24	0.14	0.01	0.53	-0.43	0.05
No. of grains/cob	-0.19	0.51	0.08	0.09	-0.17	0.10	0.01	0.48	0.62	0.06
1000 grain weight (gm)	1.53	-1.07	0.06	0.15	-0.10	0.10	-0.01	0.03	0.09	0.17

*Residual effect is 0.4569

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