Trait Association and Principal Component Analysis in Maize (*Zea mays* L.) Inbred Lines

Pradhan P., Thapa B., Ghosh A., Subba V., Kundagrami S.

ABSTRACT

Thirty-three maize (*Zea mays* L.) inbred lines were evaluated for trait association and Principal Component Analysis. The genetic and phenotypic correlations of twelve traits were studied to know the yield-contributing traits having true associations with grain yield per plant and also to determine their contribution towards the total variability in these inbred lines. Single cob weight, cob length, number of grains per row and number of grains per cob were found to have a highly significant and positive association with grain yield per plant at both the genotypic and phenotypic levels, indicating selection for these traits would be effective in improving grain yield per plant.

The first three Principal Components accounted for 81.95% of the variation in the measured traits. The critical traits that were the major contributors to total variation are grain yield per plant, number of grains per cob, Days to 50% tasselling, Days to 50% silking and Number of grain rows/cob. The material studied is diversified in nature and can be employed in the breeding program to create better genotypes and as parents in hybrids.

INTRODUCTION

Maize (*Zea mays* L.) belonging to the family Poaceae is the third leading cereal crop in the world. It provides food and nutritional security in some of the world's poorest regions especially in Africa, Asia and Latin America, making it one of the most important economic and staple food crops. According to Shiferaw *et al.* (2011), maize, together with rice and wheat, is a crucial source of at least 30% of the dietary calories consumed by more than 4.5 billion people in around 94 developing nations. Because it has the largest genetic production potential of any other cereal, maize is regarded as the queen of cereals worldwide. It is one of the crops with the broadest range of adaptability. Maize, which is the only food cereal crop that can be grown in different seasons, requires a moderate climate for growth. It grows well in loamy soils but a surplus of poor rains adversely affects yields as well as quality. It is grown across more than 160 million

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ha in 166 different nations, where there is a greater variety of soil, climate, biodiversity and management techniques. It has also the potential to be bred (by benefitting from its hybrid vigor) and the ability to develop new varieties with superior traits. Maize crop plays an important role in the world economy and is a valuable ingredient in manufactured items that affect a large proportion of the world population, Alvi *et al*. (2003).

Correlation analysis can assist to determine certain traits to be used in the improvement of complex chakra characteristics such as yield, Joshi (2005). The correlation coefficient is one of the important biometrical tools for formulating a selection index as it reveals the strength of the relationship among the group of characters. Genotypic and phenotypic correlation coefficients tell us the association between and among two or more characters. A significant association suggests that such characters could be improved simultaneously. Correlation studied between yield and yield components and between yield components themselves is a prerequisite to planning a meaningful breeding program, Ahmad and Saleem (2003). Principal Component Analysis (PCA) is better utilized for studying the diversity among the genotypes in various crops. The number of variables is reduced through Principal Component (PC) analysis to linear functions known as canonical vectors, which account for the majority of the variation created by the traits under investigation. Based on estimations of genetic diversity, genotypes will be evaluated, characterized and classified to help find varied parental lines that may be employed in hybrid breeding to create prospective hybrids or varieties. Considering the aforementioned circumstances, the current investigation was carried out by including inbred lines from different sources.

MATERIALS AND METHODS

The experiment was conducted during 1st week of December 2017 at the Experimental Farm of the University of Calcutta at Baruipur, South 24 Parganas. The material for the present study comprised 33 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. In the evaluation trial, each inbred was grown within the plot of single rows of 3m long with three replications and row-to-row spacing of 60 cm and plant-to-plant spacing of 20 cm respectively. Recommended package of agronomic practices and plant protection measures were adopted. Before flowering, each row of inbred lines was covered separately with muslin cloth nets to prevent outcrossing. Harvesting was carried out from the last week of April 2018. Data were recorded on five randomly selected plants excluding border plants from each replication for twelve traits like Days to tasseling (50%), Days to silking (50%), Plant height (cm), Ear height (cm), Cob length (cm), Cob diameter (cm), Number of grain rows/cob, Number of grains/row, Number of grains/cob, 100-grain weight (g), Single cob weight, Grain yield/plant. The data collected for all quantitative traits were subjected to analysis of correlation and principal component analysis for which all the traits were used for calculation except single cob weight. The analysis was carried out using the software Statistical Package for the Social Sciences (SPSS) 16.0 package Levesque (2007).

RESULTS AND DISCUSSION

The genetic and phenotypic correlations of the twelve traits under study and the contributions of genetic and environmental factors to their associations have been given in (Tables 1 - 2). In the current study higher genotypic correlation coefficients were observed than phenotypic values indicating a strong intrinsic association reduced at the phenotypic level due to significant environmental effects. Bhuisal *et al*. (2017) and Mahesh *et al*. (2013) also reported similar results.

For the majority of the traits, the phenotypic correlation coefficients were typically lower than the genotypic correlation coefficients. The low phenotypic correlation may be caused by the environment's altering influence on the genetic level of the associated traits Alake *et al*. (2008). When phenotypic correlation exceeds genotypic correlation, it means that the environment has a positive influence sort of interaction in addition to genes, Wali *et al*. (2012).

Grain yield per plant was found to have a highly

Table 1. Genotypic (Upper values) and Phenotypic (Lower values) correlation coefficient among grain yield and its components in thirty three inbred lines of maize. ** and * Denotes 1% and 5% Level of significance respectively.

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	100 Grain weight (g)	Single cob weight (g)	Grain yield/plant (g)
Days to tasseling (50%)	1.00	0.89**	-0.22	-0.53	-0.68	-0.72	-0.30	-0.81	-0.73	-0.42	-0.76	-0.67
		0.79**	-0.22	-0.33	-0.24	-0.33	-0.21	-0.44	-0.43	-0.32	-0.48	-0.47
Days to silking (50%)		1.00	-0.11	-0.42	-0.43	-0.70	-0.44	-0.69	-0.65	-0.27	-0.64	-0.52
			-0.10	-0.19	-0.23	-0.33	-0.30	-0.44	-0.42	-0.23	-0.41	-0.38
Plant height (cm)			1.00	0.82**	0.52**	0.22*	-0.11	0.36**	0.34**	0.39**	0.45**	0.66**
				0.70**	0.31**	0.34**	0.13	0.26**	0.31**	0.22*	0.37**	0.43**
Ear height (cm)				1.00	0.62**	0.47**	0.09	0.53**	0.53**	0.43**	0.71**	0.86**
					0.37**	0.41**	0.23*	0.38**	0.41**	0.26**	0.50**	0.54**
Cob length (cm)					1.00	0.47**	0.04	0.86*	0.76**	0.34**	0.83**	0.88**
						0.43**	0.22*	0.75***	0.67**	0.21**	0.66**	0.65**
Cob diameter(cm)						1.00	0.63**	0.75**	0.86**	0.23*	0.87**	0.73**
							0.61**	0.60**	0.64**	0.12	0.65**	0.54**
No. of grain rows/cob							1.00	0.29**	0.66**	-0.44	0.29**	0.22*
								0.35**	0.63**	-0.31	0.31**	0.27**
No. of grains/row								1.00	0.91**	0.29**	0.95**	0.87**
									0.91**	0.21*	0.88**	0.80**
No. of grains/cob									1.00	0.06	0.87**	0.81**
										0.04	0.82**	0.79**
100 grain weight (g)										1.00	0.49**	0.50**
											0.36**	0.39**
Single cob weight (g)											1.00	0.94**
												0.85**
Grain yield/plant (g)												1.00

significant and positive association with traits including single cob weight, cob length, number of grains per row and number of grains per cob both the genotypic and phenotypic levels. Most of the traits yielded positive and significant genotypic and phenotypic correlation with grain yield per plant except days to tasseling (50%) and days to silking (50%) which attributed negative and significant correlation with a comparable report by Bhuisal et al. (2017). Days to tasseling (50%) and Days to silking (50%) showed positive and significant correlation with each other corroborating with the findings of Taiwo et al. (2020). A significant positive correlation was observed be-

tween days to 50% tasselling and days to 50% silking, as well as between ear height with plant height (Troyer and Larkin 1985, Selvaraj and Nagarajan 2011, Dar et al. 2016). Similar results are supported by Ojoet et al. (2006). Rafiq et al. (2010) for plant height, number of grains per row and number of grain rows per ear, Alake et al. (2008) for kernel rows per ear, kernels per row, Wali et al. (2012) for number of kernels per row, plant height and ear circumference and Bello et al. (2012) for kernel number per cob, kernel number per row and cob diameter. Hence, selection for the traits of single cob weight, number of grains/row, number of grains/cob, cob length, cob diameter, ear height, plant height, 100 grain weight and number of grains rows/cob will increase the grain yield per plant of maize. The majority of yield-related traits were positively and significantly correlated with grain yield per plant, suggesting that grain output may be increased by simultaneously selecting for these traits.

Table 2. PCA of different agro-morphological characters with factor loadings in maize inbred lines.

Parameters	Components		
	1	2	3
Eigen values	5.406	2.071	1.539
% of variance	49.145	18.824	13.99
Cumulative %	49.145	67.969	81.959

Brown and Caligari (2008) reported that high and favorable correlations between traits like plant

height and ear height as well days to tasseling and silking suggested that each pair of traits might be regulated by genes that are closely related, the same or similar genes, or genes with pleiotropic effects on these traits. Hence, selection for these traits could be used to indirectly select grain yield.

Grain yield is an example of a quantitative attribute that expresses itself closely to multiple other traits. Typically, changes in the expression of many other traits follow changes in the expression of one trait. As a result, the associations found in the current study can be used to choose traits that directly and significantly affect grain yield, Aman *et al*. (2020).

Table 3 lists the eigen values, relative variance percentages and factor loading of the various characters under investigation. Canonical vectors, which make up most of the variables in canonical variate analysis, are linear functions that account for most of the variance caused by these characters.

The first three PCs accounted for 81.95% of the variation in the measured agronomic traits. The first PC, PC1, explained 49.14% of the variation, making the first three PCs important. Grain yield per plant and number of grains per cob was the most significant traits in PC1. In the second and third, PCs explained 18.82% and 13.99% of the variation, respectively where Days to 50% tasselling and Days to 50% silking in PC2 and Number of grain rows/cob and Days to 50% silking in PC3 which were the most critical traits.

Furthermore, Fig. 1 also displays the scree plot.

Table 3. Estimates of principal component analysis of maize inbreds and factor loadings of major three PCs by various characters.

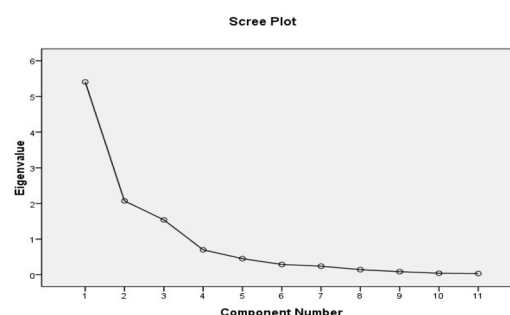| Characters	Eigenvectors		
	1	2	3
DT 50%	0.165	0.922	0.311
DS 50%	0.090	0.931	0.309
PH (cm)	0.772	0.228	-0.315
EH (cm)	0.834	0.213	-0.242
CL (cm)	0.828	-0.017	-0.177
CD (cm)	0.792	-0.072	0.170
GR/C	0.545	-0.210	0.699
G/R	0.890	-0.212	0.137
G/C	0.896	-0.236	0.240
100 GW (g)	0.246	0.311	-0.729
GY/P (g)	0.902	-0.09	-0.178

Fig. 1. Scree test for component analysis.

The eleven Principal Components utilized in this investigation are plotted in this exhibit. The plot begins with the first PC and falls steeply downward until gradually becoming roughly horizontal. The maximum number of components to extract is thought to be indicated by where the curve first starts to flatten out. As can be observed in Figs. 1-3 Principal Components were taken into account. As a result, these findings show the necessity of using several choice factors when determining the number of components to be kept. The principal factor analysis revealed that grain yield per plant, days to 50% tasselling and days to 50% silking as major contributors to the total divergence with similar results reported by Ahmed *et al*. (2010), Solanke *et al*. (2013), Sandeep *et al*. (2017) and Swapnil *et al*. (2021).

CONCLUSION

The information generated from the above study on character association suggested that the traits of single cob weight, number of grains/row, number of grains/cob and cob length of maize inbred lines could be considered as target traits to improve grain yield per plant as selections for one would result in simultaneous positive results to other as they are significantly and positively correlated. Since the majority of the inbred traits displayed a wide range of diversity, the knowledge gained will be useful in developing the selection approach that will be employed in the breeding program to increase yield.

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