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Study on Genetic Variation, Trait Association and PCA of Different Quantitative Traits in Local Maize Germplasm

Hiramani Barman[1], Nagendra Sarma Barua[2], Debojit Sarma[2], Akhil Ranjan Baruah[3], Nabajyoti Bhuyan[4], Khonang longkho[5], Niranjan Kumar Chaurasia[6]

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ABSTRACT

Background: Maize has wider adaptability and high yielding ability among the cereals. North-East India is a hotspot of the biodiversity of maize. Lots of local germplasms are distributed throughout various eco-geographic situations of hills and the plains of the entire region. Characterization of local germplasm of maize helps to identify genotypes with different features and also depicts a picture on genetic variability in the genetic resources studied.

Methods: The present investigation comprised of a set of thirty five local germplasm along with five check hybrids in the crop was raised in augmented randomized block design duing *rabi* 2019 at Assam Agricultural University, Jorhat. Observation was recorded for twenty three quantitative characters. Analysis of variance and estimation of genetic parameter were done by using R software.

Result: The present study revealed that the genotypes differed significantly among themselves for all the characters except ear leaf width and leaf width. Moderate to high estimates of GCV and PCV were recorded for all the traits except days to 75% dry husk, days to maturity and moisture content. Moderate to high estimates of heritability and genetic advance percent of mean were observed for all the traits. Grain yield per plant exhibited positive and highly significant correlation with traits namely ear length, ear diameter, kernel rows per ear, kernels per row, kernel length, kernel width and 100 kernel weights. PCA generated four principal components with an eigen value of more than 1.0 accounting for 67.74% of the overall variation present in maize germplasm.

Key words: Genetic variation, Heritability, Local germplasm, Maize, PCA.

INTRODUCTION

Maize (*Zea mays*. L) is an important cereal crop belonging to grass family, Poaceae. Maize has wider adaptability and high yielding ability among the cereals. It is known as the queen of cereal crops. North-East India is a hotspot of the biodiversity of maize. Lots of local germplasms are distributed throughout various eco-geographic situations of hills and the plains of the entire region. Being a cross pollinated crop, exhibits a wide range of genetic variability.

Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are the measures of genetic variation and phenotypic variation, respectively for a trait and each of these two genetic parameters is comparable between two different traits even with different units. Heritability and genetic advance are also two important genetic parameters aiding breeders in selecting plants with desirable traits from a population. Heritability estimates along with an estimate of genetic advance (as per cent of mean) are normally more helpful in predicting the genetic gain under selection than heritability estimates alone. Characterization of local germplasm of maize helps to identify genotypes with different features and also depicts the extent of variation available in the germplasm. Study on genetic variability and diversity in local maize germplasms of NE India are relatively few although a few researchers worked on various aspects of such local germplasm.

Principal component analysis (PCA) is a useful tool available for summarizing and describing the inherent genetic variation in germplasm. This technique helps the breeders to identify traits that help distinguish the selected germplasm based on dissimilarities in one or more traits and classify the germplasm into separate groups. PCA helps to identify the important traits with high variability. PCA analysis is used to remove the redundancy in the

[1]Assam Seed and Organic Certification Agency, Guwahati-781 007, Assam, India.
[2]Department of Plant Breeding and Genetics, Assam Agricultural University, Jorhat-785 013. Assam, India.
[3]Department of Agricultural Biotechnology, Assam Agricultural University, Jorhat-785 013, Assam, India.
[4]Zonal Research Station, Assam Agricultural University, Gossaigaon-783 360, Assam, India.
[5]Arunachal University of Studies, Namsai-792 103, Arunachal Pradesh, India.
[6]Department of Genetics and Plant Breeding, School of Agricultural Sciences, Nagaland University, Medziphema-797 106, Nagaland, India.

Corresponding Author: Hiramani Barman, Assam Seed and Organic Certification Agency, Guwahati-781 007, Assam, India. Email: hiramonibarman93@gmail.com

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observed variables that are correlated with one another. PCA aims to identify a strong pattern in data by highlighting similarity and differences and directions along which the variation in the data is maximal. In PCA, Eigenvalues measure each component's importance and contribution to the total variance, whereas each coefficient of proper vectors indicates the degree of contribution of every original variable with which each principal component is associated.

MATERIALS AND METHODS

The materials of the present investigation comprised of forty germplasm *viz*., thirty five local maize germplasm and five check hybrids (Table 1). The experiment was conducted in the ICR Farm, Assam Agricultural University, Jorhat, during the *rabi* season 2019. The germplasm were evaluated in augmented randomized block design with four blocks. All recommended packages of practices were followed to raise a successful crop of maize. Ten representative plants were sampled from each germplasm in each block for recording of quantitative data. Border rows and border plants were excluded in sampling of plants. Days to 50% pollen shed, days to 50% silk, days to 75% dry husk and days to maturity were recorded on plot basis. The adjusted mean of germplasm for twenty three morphological trait data was subjected to the analysis of variance and covariance and the Pearson's correlation coefficients (r) among the various traits were computed using the following formula (Singh and Chaudhary, 1985). Path coefficient analysis suggested by Wright (1921) and Dewey and Lu (1959). PCA was done by using FactoMineR software package.

RESULTS AND DISCUSSION

Estimation of genetic parameter

The estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) of yield and yield attributing characters are presented in (Table 2). In the present investigation, high genotypic coefficient of variation and phenotypic coefficient of variation was observed for ear height and lowest was observed for DM. Heritability estimate differed for different traitsranged from (99.15%) - (44.37%). Expected genetic advance as per cent of mean was highest for ear height followed by kernel length. Traits with high heritability and high genetic advance as percent of mean was observed in days to 50% pollen shed, days to 50% silk, plant height, ear height ,tassel length, branches per tassel, leaves per plant, kernels per row, ear leaf length, leaf area, kernel length and grain yield. It indicates that these traits are governed largely by genes with additive gene action. Simple selection such as mass selection may improve such traits. However, testing genotypes across locations and years will give us a clear picture. Decision on choice of appropriate breeding methods will be possible if germplasms are tested across environments.

Correlation coefficient

Correlation study helps to determine the dependence of the traits on some relatively independent traits which are less affected by environments. The relationship of a trait with yield and other component characters could also be useful while selecting plants from a genetically diverse population and in choice of parents for a hybridization programme. Since the grain yield depends upon many yield contributing characters, it becomes

Table 1: List of germplasm included in the present study.

Name of germplasm	Source
Local germplasm	
ARR1	Pasighat, Arunachal Pradesh
NLB1	Wokha, Nagaland
ARY1	Arunachal Pradesh
ASKAW1	Karbi Anglong, Assam
ARW1	Sepa, Arunachal Pradesh
MNB1	East Imphal, Manipur
NLY1	Wokha, Nagaland
ARY2	Aloo, Arunachal Pradesh
ASKAW2	West Karbi Anglong, Assam
ASKAR	Karbi Anglong, Assam
ARW2	Aloo, Arunachal Pradesh
ARY3	Sepa, Arunachal Pradesh
ASKAY	Karbi Anglong, Assam
NLP	Wokha, Nagaland
ARY4	Tawang, Arunachal Pradesh
ARW3	Sepa, Arunachal Pradesh
NLB2	Wokha, Nagaland
MNB2	Manipur
ASGPY	Goalpara, Assam
MZW1	Mizoram
ARR2	Arunachal Pradesh
ASTTB1	Titabar, Assam
NLYW	Kohima, Nagaland
MZW2	Mizoram
ASSV1	Sivsagar Akhoiphutia, Assam
ASTSY	Tinsukia, Assam
ML	Shillong, Meghalaya
ARY5	Tawang, Arunachal Pradesh
MNY	Manipur
ARY6	Arunachal Pradesh
NLY2	Wokha, Nagaland
TRP	Tripura
ASTTB2	Titabar, Assam
ASDJ	Jonai, Dhemaji
ASSV2	Sivsagar Charaideo, Assam
Check	
5106	M/S Hytech Seed India Pvt. Ltd.
5202	M/S Hytech Seed India Pvt. Ltd.
5402	M/S Hytech Seed India Pvt. Ltd.
Sriram9682	M/S DCM Shriram Consolidated Ltd.
VMH53	VPKAS (ICAR), Almora, UK

essential to study the association of each such character to the yield. Character with high heritability, relatively simple inheritance and with desirable association to yield is considered for selecting plants and such a selection effects correlated response in the progeny. Further, path coefficient analysis helps to estimate the cause and effect of various yield components and finally gives a clear picture on high direct and indirect effects of the independent traits on the dependent variable such as yield.

The mean values of twenty-three quantitative traits in forty entries comprising of thirty five germplasms and five check hybrid varieties of maize were analyzed for elucidating the simple correlation coefficient between them (Table 3).

Grain yield per plant had positive and highly significant correlation with traits namely ear length, ear diameter, kernel rows per ear, kernels per row, kernel length, kernel width and 100 kernel weight. Days to 50% pollen-shed and days to 50% silk showed highly significant and negative correlation with the grain yield (Table 3). Similar finding was reported by Pavan *et al.* (2011). They opined that grain yield had positive significant genetic correlation with ear length, ear circumference, number of kernel rows/ear, number of kernels/row and 100-grain weight. El-Shouny *et al.* (2005) also reported positive and significant with ear diameter, ear length, number of kernels per row, 100-kernel weight, number of rows per ear with grain yield per plant. The cause of correlation can be genetic or environmental. Genetic cause may be attributed to pleiotropism or linkage or both.

Path analysis

Grain yield is an ultimate product of interaction among its component traits under the various influences of environment. Path analysis provides an effective means of partitioning direct and indirect causes of association. It measures the relative importance of each component traits towards grain yield. Results of path analysis were presented on Table 4.

Days to 50% silk, ear length, ear diameter, plant height, branches per tassel, kernels per row, 100 kernel weight, kernel length and kernel width had showed positive direct effect on grain yield. Highest positive direct effect was recorded for days to 50% silk. Hence, these traits can be considered as the important for selection in a maize breeding program for grain yield improvement. This finding was in agreement with the report of Mogesse, (2021) that on ear length, 1000-kernel weight and number of kernel rows per ear contributed directly to grain yield. Yahaya, (2021) also reported plant height followed by 1000 grain weight gave positive direct effects on grain yield. Lal *et al*. (2022) also found that kernels per row gave positive direct effect on grain yield.

Trait days to 50% silk had recorded high or very high positive direct effect on grain yield along with high heritability. If we select plants with lateness with respect to days to 50% silk there will be corresponding increase in grain yield, too. Trait days to 50% pollen shed had exhibited high negative direct effect on grain yield along with high heritability. Therefore, selection of plants with fewer days to 50% pollen shed may yield high yielding plants. This finding was in agreement with the report of Sumalini, (2015). Shukla, (2017) also found that days to male flower initiation showed negative direct effect on grain yield.

Principal component analysis

The characters which showed significant to highly significant correlation with grain yield per plant were studied for principal component analysis. In the present study, PCA created four principal components with an Eigenvalue of more than 1.0, accounting for 67.74% of the overall variation present in the maize germplasm (Table 5). The first principal component showed the highest variability, 28.87%, with Eigenvalue of 6.64, while the fourth component was the lowest contributor. In PC1, the highest value was observed for days to 50% silk (10.82) which was followed by days to 50% pollen shed (10.15), ear diameter (8.84) and ear length (8.30). The second component, *i.e*. PC2, contributed 18.34% to the total variability with Eigenvalue of 4.22. The third component (PC3) contributed 11.98% to the total variability with an Eigenvalue of 2.76. The character grain yield showed the highest contribution to the variance so far as the PC3 was concerned. Similarly, the fourth component contributed 8.55% to the total variability with an Eigenvalue of 1.97. The characters, namely, kernels per row (12.48), number of rows per ear (8.38), 100 kernel weights (11.25) and kernel length (8.84), showed the highest value of PC4 only. PCA identified few prominent traits that play an important role in classifying the variation existing in the

Table 2: Estimates of genetic parameters for different quantitative traits.

Traits	GCV (%)	PCV (%)	h^2 (%)	Gs (% mean)
D50%PS	11.88	12.15	95.59	23.96
D50%S	11.49	11.78	95.11	23.12
D75%DH	5.87	6.25	88.31	11.38
DM	5.51	5.8	90.38	10.81
PH	21.29	21.38	99.15	43.73
EH	33.33	34.4	93.87	66.62
TL	19.26	22.56	72.89	33.92
B/T	27.43	30.39	81.48	51.09
L/P	19.35	21.68	79.62	35.62
EL	13.79	18.57	55.19	21.14
KR/E	10.24	11.69	76.71	18.49
K/R	17.37	20.82	69.6	29.9
ELL	12.89	15.81	66.5	21.69
LL	10.12	12.31	67.53	17.15
LA	15.18	18.63	66.41	25.52
100KW	15.76	23.66	44.37	21.66
KL	27.47	29.48	86.85	52.81
M C	8.69	9.52	83.38	16.38
GY	13.75	16.5	69.5	23.65

Table 3: Simple correlation coefficients among various traits on grain yield.

	D50%PS	D50%S	D75%DH	DM	PH	EH	TL	B/T	L/P	EL	ED	KR/E	K/R	ELL	ELW	LL	LW	LA	100KW	KL	KW	MC
D50%PS	1																					
D50%S	0.99**	1																				
D75%DH	0.78**	0.76**	1																			
DM	0.77**	0.76**	0.97**	1																		
PH	-0.21	-0.20	-0.22	-0.22	1																	
EH	0.31	0.31*	0.25	0.26	0.57**	1																
TL	-0.36**	-0.34**	-0.23	-0.21	0.53**	0.06	1															
B/T	0.19	0.21	0.25	0.25	0.18	0.23	0.01	1														
L/P	0.02	-0.01	0.18	0.19	0.26	0.10	0.19	0.16	1													
EL	-0.44**	-0.46**	-0.27	-0.26	0.22	-0.26	0.14	-0.27	0.27	1												
ED	-0.53**	-0.57**	-0.29	-0.28	0.18	-0.25	0.13	-0.38*	0.12	0.68**	1											
KR/E	-0.52**	-0.54**	-0.24	-0.28	-0.00	-0.37	0.01	-0.35*	0.08	0.63**	0.75**	1										
K/R	-0.32**	-0.36*	-0.09	-0.08	0.13	-0.25	0.01	-0.29	0.18	0.81**	0.75**	0.75**	1									
ELL	-0.13	-0.13	-0.12	-0.12	0.46**	0.16	0.54**	-0.01	0.38*	0.27	0.09	-0.05	0.01	1								
ELW	0.23	0.23	0.19	0.32*	0.11	0.19	0.22	-0.00	0.24	-0.04	-0.15	-0.31	-0.07	0.40**	1							
LL	-0.14	-0.14	-0.19	-0.20	0.51**	0.25	0.48**	-0.13	0.19	0.29	0.20	-0.02	0.08	0.81**	0.26	1						
LW	0.13	0.11	0.12	0.17	0.09	0.19	0.10	-0.07	0.21	0.12	-0.10	-0.24	-0.13	0.39*	0.65**	0.26	1					
LA	0	-0.01	-0.03	-0.01	0.38*	0.27	0.37*	-0.15	0.25	0.26	0.08	-0.15	-0.01	0.76**	0.57**	0.81**	0.77**	1				
100KW	-0.55**	-0.58**	-0.36**	-0.34*	-0.20	-0.37*	0.13	-0.44**	0.24	0.40*	0.34*	0.37*	0.32*	0.14	0.06	-0.01	0.08	0.05	1			
KL	-0.39*	-0.42**	-0.27	-0.17	-0.03	-0.15	0.18	-0.33*	0.17	0.36*	0.34*	0.22	0.34*	0.15	0.41**	0.12	0.27	0.26	0.69**	1		
KW	-0.27	-0.29	-0.05	0.01	-0.08	-0.13	0.13	0.01	0.02	0.19	0.21	0.06	0.17	-0.09	0.09	-0.13	0.15	0.01	0.38*	0.33*	1	
MC	0.34*	0.37*	0.38*	0.32*	-0.16	-0.09	-0.29	0.15	0.07	-0.20	-0.25	-0.12	-0.18	-0.37*	-0.09	-0.40*	-0.01	-0.26	-0.37*	-0.27	-0.08	1
GY/P	-0.39**	-0.44**	-0.13	-0.10	-0.01	-0.27	0.14	-0.31	0.18	0.68**	0.62**	0.51**	0.67**	0.13	0.09	0.09	0.11	0.15	0.65**	0.57**	0.52**	-0.26

*, **Significant at 5% and 1% level, respectively.

D50%PS= Days to 50% pollen shed; EH= Ear height; ED = Ear diameter; 100KW= 100 Kernel weight; D50%S = Days to 50% silking; TL= Tassel length; KR/E = Kernel rows per ear: KL = Kernel length; D75%DH= Days to 75% dry husk; B/T= Branches per tassel: K/R = Kernels per rows: KW = Kernel width: DM = Days to maturity: L/P= Leaves per plant: ELL= Ear leaf length: PH= Plant height: EL = Ear length: ELW = Ear leaf width: GY/P=Grain yield per plant: LL= Leaf length; LW =Leaf width; LA = Leaf area.

Table 4: Direct (bold) and indirect effects of various component traits on grain yield.

Traits	D50%PS	D50%S	PH	EH	TL	B/T	EL	ED	KR/E	K/R	100KW	KL	KW	r_{iy}
D50%PS	**-1.041**	1.237	-0.020	-0.013	0.004	0.026	-0.120	-0.150	0.024	-0.038	-0.291	-0.001	-0.066	-0.385*
D50%S	-1.036	**1.243**	-0.019	-0.013	0.004	0.029	-0.127	-0.162	0.025	-0.042	-0.308	-0.001	-0.073	-0.425**
PH	0.225	-0.251	**0.094**	-0.025	-0.006	0.028	0.064	0.053	0.000	0.016	-0.118	0.000	-0.020	-0.003
EH	-0.312	0.381	0.053	**-0.043**	-0.001	0.032	-0.071	-0.072	0.017	-0.030	-0.194	0.000	-0.032	-0.270
TL	0.376	-0.429	0.050	-0.003	**-0.011**	0.000	0.042	0.038	-0.001	0.002	0.071	0.001	0.034	0.146
B/T	-0.187	0.256	0.018	-0.010	0.000	**0.143**	-0.083	-0.105	0.016	-0.035	-0.239	-0.001	0.005	-0.296
EL	0.423	-0.536	0.020	0.010	-0.002	-0.040	**0.295**	0.195	-0.028	0.097	0.192	0.001	0.047	0.673**
ED	0.547	-0.704	0.017	0.011	-0.002	-0.052	0.201	**0.286**	-0.035	0.089	0.178	0.001	0.055	0.626**
KR/E	0.543	-0.672	-0.001	0.016	0.000	-0.049	0.182	0.215	**-0.046**	0.089	0.187	0.001	0.014	0.501**
K/R	0.336	-0.441	0.013	0.011	0.000	-0.043	0.240	0.216	-0.035	**0.119**	0.161	0.001	0.043	0.669**
100KW	0.558	-0.706	-0.020	0.016	-0.002	-0.063	0.104	0.094	-0.016	0.035	**0.543**	0.002	0.092	0.623**
KL	0.400	-0.515	-0.003	0.006	-0.002	-0.050	0.109	0.097	-0.010	0.042	0.376	**0.003**	0.081	0.567**
KW	0.275	-0.363	-0.007	0.006	-0.002	0.003	0.056	0.063	-0.003	0.020	0.201	0.001	**0.249**	0.519**

R= 0.21

r_{iy} = Correlation coefficient of grain yield and its i^{th} component trait.

Table 5: Principal component analysis of forty maize germplasm using ten quantitative traits.

Traits	PC1	PC2	PC3	PC4
Days to 50% pollen shed	10.15	0.86	5.12	1.02
Days to 50% silk	10.82	0.85	4.06	1.02
Ear length	8.30	0.08	3.26	6.76
Ear diameter	8.84	0.48	1.32	7.59
Kernel row per ear	6.76	3.59	1.15	8.38
Kernels per rows	6.50	0.68	6.43	12.48
100-Kernel weights	6.92	0.21	2.52	11.25
Kernel length	5.40	0.56	4.86	8.84
Kernel weight	1.53	0.09	3.84	5.35
Grain yield	7.65	0.03	9.60	0.01
Eigen value	6.64	4.22	2.76	1.97
Variance per cent	28.87	18.34	11.98	8.55
Cumulative variance per cent	28.87	47.21	59.19	67.74

germplasm. Therefore, emphasis should be given on the traits for selection of individuals from a heterogenous population during the crop improvement programme. Al-Naggar *et al.* (2020) performed PCA analysis among the nineteen maize genotypes and reported two main components contributing 57.91% of the total variability. In India, thirty maize accessions were studied by Suryanarayana *et al*. (2017) for PCA and cluster analysis. They found 85.31% of the total variance along with greater than one Eigenvalue.

CONCLUSION

The present investigation generated useful information on genetic variability, simple correlation analysis, path analysis and PCA of local maize germplasm of Northeast India. The present study indicated the presence of sufficient variation among the local germplasm. The top five entries which gave higher grain yield per plant among the local germplasm tested were ARR1, ASTSY, ASSV2, ASKAR and ASDJ. The strong genetic correlation of grain yield with the seven component traits mentioned above will help the breeder to select plants with higher values of these components in desirable directions to improve a population for higher grain yield. The importance of days to 50% silk and 100 kernel weight to improve population for high grain yield was indicated by their respective high and positive direct effects on grain yield.

Conflict of interest

We declare that there is no any conflict of interest in connection with the work submitted by us.

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