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Genetic Divergence in Newly Developed Inbred Lines of Maize

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Abstract

One hundred twenty inbred lines of maize (*Zea mays* L.) derived from seven different open-pollinated varieties were classified into ten clusters based on principal component analysis for 20 quantitative traits. The cluster I and III were clearly separated from rest of the clusters based on the first principal component axis. These two clusters were characterized by having high mean values for ear height, tassel length, ear length, seed weight, seed volume, kernel weight and grain yield. Maximum inter-cluster distance was found between cluster III and VI. The inbreds included in these diverse clusters can be used as promising parents in hybridization program for obtaining high heterotic response and thus better segretgants in maize.

Key words : Genetic divergence, Inbreds, Principal component analysis, Maize.

Identification of useful germplasm is one of the most important factors in a breeding program. Choice of source population is perhaps more important than defining breeding methodology (1). Multi-attribute selection based on aggregate index value (2–4) requires known or estimated phenotypic and genotypic covariance between attributes included in the index. In preliminary evaluations of accessions, lack of family structure required for estimation of genetic covariances, makes the traditional selection index impractical for characterization and selection of accessions. An alternative is multivariate analysis particularly principal component analysis (PCA), where the individuals are classified or ordered based on simultaneous consideration of numerous descriptive attributes.

Methods

One hundred twenty inbred lines of maize derived from seven different open-pollinated varieties were studied for 20 quantitative traits. The experiment was conducted in augmented design (5,6) at Crop Research Center, Pantnagar. Each plot consisted of two rows of 5 meter length and spaced 75cm apart maintaining plant to plant distance of 25 cm. The recommended cultural practices were followed to raise a good crop. The data were recorded on five competitive plants selected randomly from each plot at maturity. The adjusted mean values were subjected to principal component analysis following Hotellin (7). The genetic divergence among 120 inbred lines was studied using the method of non-hierarchical Euclidean cluster analysis (8, 9).

Results and Discussion

After analysis of all the 20 quantitative traits in augmented design, the adjusted mean values of the all the 120 inbred lines were used for principal component analysis (PCA) and clustering of the inbreds. The first principal component possessed largest eigen value of 8.93 and accounted for 44.7% of total variation present in the original data followed by second and third principal components (Table 1). The cumulative percentage of variations of the first two principal components together constituted more than half (58.7%) whereas the first 11 components together explained 95.3% variation of the original data

Table 1. Eigen vectors and associated variation for different principal components in maize inbreds.

Eigen vectors	1	2	3	4	5	6	7	8	9	10	11
Eigen values (λ)	8.93	2.81	2.05	1.17	1.01	0.35	0.66	0.50	0.41	0.39	0.29
Variation (%)	44.66	14.06	10.28	5.84	5.02	4.24	3.28	2.47	2.07	1.95	1.47
Cumulative (%)	44.66	58.72	69.00	74.84	79.86	84.1	87.38	89.85	91.92	93.87	95.34

Table 2. Clustering pattern of maize inbreds. Figures in parentheses indicate the number of inbred lines.

Cluster no.	No. of inbreds	Source population
I	9	Pop 31 (7), Tarun (2)
II	12	Pop 31 (2), D 831 (1), Suwan-1 (6), Tarun (2) Pool 16 Seq BAC-1 (1)
III	22	Tarun (4), Pop 31, D 741 (6), Suwan 1 (4), D 831 (2)
IX	21	Suwan 1 (4), D 831 (6), Pop 31 (4), D 741(5), Pop 45 C6 (1), Tarun (1)
V	20	Tarun (6), Suwan 1 (2), Pop 31 (4), Pop 45 C6 (2), D 831 (1), D 741 (5)
VI	1	Pool 16 Seq BAC 1 (1)
VII	11	Tarun (4), Suwan 1 (2), D 741 (3), D 831 (1) Pool 16 Seq BAC 1 (1)
VIII	12	Pop 45 C6 (1), Tarun (3), Pool 16 Srq BAC 1 (1), Suwan 1 (2), Pop 31 (3), D 741 (2)
IX	9	Suwan 1 (2),Pop 31 (4), D 741 (2), D 831 (1)
X	3	Suwan 1 (1), D 741 (1), Pool 16 Seq BAC 1 (1)

and were taken for Euclidean cluster analysis. Tassel length, plant height and seed weight were the three important characters mainly contributed for genetic divergence.

The genetic divergence among 120 inbreds was assessed employing non-hierarchical cluster analysis based on the first 11 principal components. The inbreds were randomly grouped into 10 non-overlapping clusters (Table 2). The maximum number of genotypes (22) were included in cluster III, followed by cluster IV (21) and cluster V (20). Cluster VI possessed only one inbred (Pool 16, sequence BAC 1 (1). These 10 clusters consisted of inbreds of different source populations. Inbreds of different origin clustered together and inbreds of same source population grouped in different clusters. Random inclusion of inbreds in 10 different clusters indicated the presence of wide diversity in the experimental material for majority of the characters irrespective of their source populations. The pattern of clustering also indicated that there was no association between source population and genetic divergence as inbreds developed from diverse populations clustered together and vice-versa. This kind of genetic association might be due to differential adaptation and selection criteria fol-

Table 3. Cluster means for 20 characters in 120 maize inbreds. 1. DT =Days to tasseling, 2. DS= Day to silking, 3. PH = Plant height (cm), 4. EH = Ear height (cm), 5. TL = Tassel length (cm), 6. Ear=Length (cm), 7. ED= Ear diameter (cm), 8. SD=Shank diameter (cm), 9. NK/E = No. of kernels/ear, 10. NKR/E=No. of kernel rows/ear, 11. KL = Kernel length (cm) , 12. KL = Kernel width (cm), 13. KT= Kernel thickness (cm), 14. SW = Seed weight (g), 15. SV= Seed volume (ml), 16. KW/E = Kernal weight/ ear (g), 17. ShW/E = Shank weight/ear (g),18. EW = Ear weight (g), 19. SP = Shelling percentage, 20. GY = Grain yield (kg/plot).

	Cluster number									
Character	I	II	III	IV	V	VI	VII	VIII	IX	X
DT	40.86	50.08	46.68	48.45	45.87	55.17	49.74	47.92	51.05	53.61
DS	50.27	53.47	50.17	52.00	49.10	55.75	52.48	51.83	52.55	57.36
PH	191.51	153.78	194.66	159.26	172.18	170.54	182.62	141.14	172.66	119.99
EH	73.79	60.58	76.00	57.77	60.45	66.83	70.62	47.4	65.87	37.61
TL	31.90	30.78	35.37	31.59	31.58	30.08	31.87	28.25	30.73	20.03
EL	12.96	11.99	13.86	10.89	12.35	8.41	11.89	9.48	12.38	8.82
ED	3.55	3.14	3.74	3.29	3.42	3.26	3.74	2.91	3.54	3.19
SD	2.26	2.08	2.34	2.12	2.13	2.60	2.36	1.97	2.33	2.21
NK/E	232.43	155.83	232.42	178.30	236.26	65.71	244.27	140.04	221.71	79.26
NKR/E	10.84	10.45	12.89	13.28	12.28	14.52	15.03	12.11	11.36	11.42
KL	0.80	0.71	0.86	0.72	0.79	0.70	0.80	0.64	0.75	0.68
KW	0.81	0.75	0.76	0.96	0.74	0.64	0.70	0.65	0.78	0.77
KT	0.46	0.47	0.39	0.40	0.41	0.45	0.40	0.43	0.42	0.53
SW	20.23	15.68	17.37	11.90	15.68	10.11	13.72	11.11	17.16	16.37
SV	17.30	13.75	14.86	10.44	13.54	9.71	12.18	9.89	14.62	15.21
KL/E	52.70	28.86	69.53	31.51	47.03	8.33	44.94	22.75	44.48	17.11
ShW/E	12.14	8.28	13.60	9.03	9.35	10.58	11.28	5.11	12.55	6.92
EW	64.84	37.14	83.13	40.06	56.39	18.92	56.22	27.86	57.03	24.03
SP	81.11	76.95	83.61	77.95	83.61	54.91	80.39	80.44	77.55	70.27
GY	2.33	1.54	2.80	1.56	1.97	1.83	2.06	1.18	2.08	2.00

Table 4. Average inter-and intra-cluster distances in 120 maize inbreds. Values in parentheses are intra-cluster distances.

Cluster no.	I	II	III	IV	V	VI	VII	VIII	IX	X
I	(2.264)									
II	4.716	(3.03)								
III	3.476	6.844	(2.691)							
IV	5.814	3.208	6.439	(2.663)						
V	3.383	3.914	3.943	3.360	(2.870)					
VI	9.651	6.931	10.699	6.295	8.931	(0.000)				
VII	4.593	4.928	4.051	3.407	3.241	7.354	(2.953)			
VIII	7.834	4.047	8.997	3.015	5.360	7.192	6.180	(2.750)		
IX	2.702	3.329	4.205	3.979	3.088	7.532	3.185	6.270	(2.236)	
X	8.160	4.864	10.424	6.432	7.826	6.642	7.977	6.054	6.42	(3.031)

lowed.

The cluster means indicated that inbreds included in cluster I were having high mean values for plant height, ear height, tassel length, ear length, kernel length, kernel width, seed weight, seed volume, kernel weight/ear and grain yield (Table 3). The inbreds in cluster III had high mean values for plant height, ear height, tassel length, ear length, ear diameter, number of kernels/ear, kernel length, seed volume, kernel weight/ear, shank weight/ear,ear weight, shelling percentage and grain yield. These inbreds were early in days to taseseling and silking. The inbeds of cluster X had high mean values for days to tasseling and silking, kernel thickness and low mean values for plant height, ear height, tassel length, ear length, number of kernels/ear, kernel length, kernel weight/ear, ear shank weight/ear weight and shelling percentage.

The estimates of average intra-and inter-cluster distances (Table 4) indicated the maximum intra-cluster distance in cluster X (3.031) and maximum inter-cluster distance between cluster III and VI (10.699) followed by cluster II and X (4.864).

It can be concluded that the inbreds included in the diverse clusters (cluster III vs VI and X) hold good promise as parents for obtaining potential hybrids and thereby creating large variability. The principal component analysis has helped in identifying diverse parents for exploitation of maximum heterosis. Inbreds of each cluster can be maintained with less cost and management without loosing genetic diversity present in the tested inbred germplasm. Similar conclusions have also been drawn while studying genetic diversity in oat (10) and maize (11).

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