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MULTIVARIATE ANALYSIS IN YELLOW INBRED LINES OF MAIZE *(Zea mays* L.)

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Abstract

Twenty five yellow inbred lines of normal maize were evaluated for eleven parameters to study the genetic divergence using Mahalonabis's D^2 and Rao 's canonical variate analysis. The twenty five inbreds fell into five distinct clusters. The intra-cluster distance in all the five clusters was more or less low, indicating the genotypes within the same clusters were closely related. The highest inter-cluster distance was observed between cluster I and VI and the lowest between the cluster II and III. The cluster IV and V each contained the highest number of genotypes. Cluster V showed the highest mean values for kernel yield and all the yield contributing traits except 1000-kernel weight and cluster II had the lowest mean values for plant and ear height and maturity characters. Days to silking, ear length, number of kernels/row, 1000-kernel weight and kernel yield showed maximum contribution towards total divergence among different characters. Based on medium to high inter-cluster distances, per se performances and desirable traits, fourteen yellow inbred lines viz. BIL 77, BIL 97, CML 287, CML 470, CML 480, CML 486, CZ 2370-22-2, CZ 2370-24-3, CZ 2370-28-2, CZ 23 70-31-3, IPB 911-2, IPB 911-22, IPB 911-36 and IPB 911-50 were selected for future hybridization program. Crossing between these genotypes have the chance to obtain higher heterosis with high performing crosses.

Keywords: Maize (*Zea mays* L.), Inbred lines, genetic divergence.

Introduction

Maize *(Zea mays* L.) is becoming an important cereal crop in the rice based cropping system of Bangladesh. Hybrid maize has higher yield potentiality than those of synthetics and composites. Prospective parent (inbred line) selection is a pre-requisite work for hybrid development. Several studies on maize have shown that inbred lines from diverse stocks tend to be more productive than crosses of inbred lines from the same variety (Vasal, 1998). Saxena *et al.* (1998) also reported that manifestation of heterosis usually depends on the genetic divergence of the two parental lines. The quantification of genetic diversity through biometrical procedure made it possible to choose genetically diverse parents

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Genetic diversity is one of the useful tools to select appropriate genotypes/lines for hybridization. The genetic diversity between the genotypes is important as the genetically diverged parents are able to produce high heterotic effects (Falconer, 1960; Arunachalam, 1981; Ghaderi *et al.*, 1984 and Mian and Bahl, 1989). Knowledge of germplasm diversity and of relationship among elite breeding materials has a significant impact on the improvement of crop plant (Hallauer *et al.*, 1988). Maize breeders are consistently emphasizing on the importance of diversity among parental genotypes as a significant factor contributing to heterotic hybrids (Ahloowalia and Dhawan, 1963). Characterization of genetic diversity of maize germplasm is of great importance in hybrid maize breeding (Xia *et al.*, 2005). D^2 analysis is a useful tool for quantifying the degree of divergence between biological population at genotypic level and in assessing relative contribution of different components to the total divergence both at intra and inter-cluster level (Murty and Arunachalam, 1966; Ram and Panwar, 1970 and Sachan and Sharma, 1971). Therefore, the present investigation was undertaken with a view to estimate the nature and magnitude of genetic diversity of maize genotypes.

Materials and Method

Twenty five local and exotic yellow inbred lines of normal maize were grown in the field of Bangladesh Agricultural Research Institute, Joydebpur in a alpha lattice design with three replications during rabi 2009-10 .The seeds of each entry were sown on 4 December 2010 in one row of 5 m long with spacing 25 x 20 cm between rows and hills, respectively. One plant was kept per hill after proper thinning. Fertilizers were applied @ 120,80,80,20, 5 and 1 kg/ha of N, P2OS, K_20, S, Zn and B, respectively. The other intercultural operations were done timely and properly to raise the crop uniformly. Observation was recorded on whole plot basis for days to pollen shedding and silking. Ten randomly selected plants were used for recording observations on kernel yield/plant (g), plant height (cm), ear height (cm), number of kernel rows/ear, number of kernels/row, ear length (cm), ear diameter (cm), 1000-kernel weight (g), husk cover (1-5 scale) and disease reaction (l-5 scale). Genetic diversity was estimated using Mahalanabis generalized distance (D^2) extended by Rao (1952). Tocher’s method was followed to determine the group constellation. Canonical variate analysis was also performed as per Rao (1964) to confirm the results of cluster D^2 analysis. The data were analyzed using GENSTAT 5.0 software program.

Results and Discussion

The mean performances of 25 yellow inbred lines are presented in Table 1. Significant differences were observed among the lines for all the characters studied and therefore diversity analysis was carried out. The highest variability was observed in ear height followed by number of kernels/row, kernel yield/plant and ear length. Hence there is scope for selecting high yield potential lines based on the above characters.

Multivariate analysis based on Mahalanabis's D^2 statistics revealed that genotypes could be grouped into five different clusters (Table 2). This suggested the presence of high degree of divergence in the material. Cluster III and V comprised maximum number of genotypes (7) followed by cluster II and cluster IV comprising 6 and 4 genotypes, respectively. The lowest single genotype was included in cluster I.

The intra- and inter cluster values among the five clusters are presented in Table 3. The inter-cluster distances were larger than the intra-cluster values. The inter-cluster distance was maximum between cluster I and V (16.93), indicating wide genetic diversity between these two clusters followed by the distance between cluster I and II (12.53), cluster IV and V (12.43), cluster I and III (10.78). The minimum inter-cluster distance was observed between cluster III and IV (6.76), followed by cluster II and V (6.01), cluster II and III (4.39), indicating that the genotypes of these clusters were genetically close (Table 3). The intra-cluster distance ranged from 0.6142 to 0.9285. Comparatively, higher intra-cluster distances were observed in cluster III, cluster II and cluster V, yet they were not so far diversed from others.

The cluster mean values of all the 11 characters for each of the cluster are presented in Table 4. The data revealed that different clusters exhibited different mean values for almost all the characters. Cluster V was composed of seven genotypes and this cluster earned maximum mean values (Table 4) for plant height (128 cm), ear length (12.4 cm), ear height(53 cm), ear diameter (4.3 cm), number of kernels/row (27), number of kernels/ear (344) and kernel yield/plant (69.9g). The genotypes of cluster I produced the lowest values for maturity traits like days to pollen shedding (87 days) and silking (90 days) and shortest plants (93 cm) and ear height (34 cm), indicating the early and dwarf genotypes in this group. This cluster also had the highest mean values for 1000-kernel weight (260.5 g). The genotypes of cluster II produced the highest mean values for single parameter, the number of kernel rows/ear (14). The cluster III contained 7 and cluster IV had 4 genotypes each, but none of these two clusters produced the highest mean for any traits studied.

Table 1. Mean performances of 25 yellow inbred lines of maize evaluated at Joydebpur.

Inbred lines	Days to pollen shedding	Days to silking	Plant height (cm)	Ear height (cm)	*Husk cover (1-5 scale)	**Disease TLB (1-5 scale)
1. BIL77	90	96	108	46	1	1
2. BIL95	93	96	130	53	2	1
3. BIL97	91	94	143	55	1	1
4. BML 2	93	97	125	46	2	2
5. CML197	89	93	116	49	2	1
6. CML287	95	99	139	55	1	1
7. CML 431	91	93	100	42	2	1
8. CML 453	94	98	124	54	2	2
9. CML 465	96	99	123	44	3	2
10. CML 470	87	90	93	34	1	1
11. CML 480	92	95	94	36	1	1
12. CML 481	88	93	116	45	1	2
13. CML 486	89	93	118	40	1	1
14. CML 496	95	99	125	58	1	2
15.CZ 2370-15-2	94	96	124	52	3	1
16. CZ 2370-18-2	95	99	133	48	2	3
17. CZ 2370-22-2	92	96	124	49	1	1
18. CZ 2370-24-3	91	94	119	46	2	1
19. CZ 2370-28-2	94	99	118	44	1	1
20. CZ 2370-31-3	93	97	119	48	1	3
21. IPB 911-2	88	90	148	60	1	1
22. IPB 911-22	88	90	135	59	1	1
23. IPB 911-36	93	97	112	43	1	1
24. IPB 911-47	92	95	100	46	2	2
25. IPB 911-50	90	90	133	61	1	1
Minimum	88	91	93	34	-	-
Maximum	95	99	148	61		-
Mean	91	95	120	48		-
F- test	**	**	**	* *	-	-
CV (%)	0.60	0.54	3.13	7.87	-	-
LSD 5%	1.14	0.99	7.74	7.75	-	-

*1= excellent, 5= unaccepted; ** 1= resistant, 5= susceptible; TLB: Turcicum leaf blight.

Table 1. Cont'd.

Inbred lines	Ear length (cm)	Ear dia meter (cm)	No. of kernel rows/ear	No. of kernels/ row	No. of kernels/ ear	1000- kernel wt. (g)	Kernel yield/ plant (g)
1. BIL77	11.9	3.7	12	30	361	246	70.0
2. BIL95	12.1	4.0	12	25	296	233	61.0
3. BIL97	11.5	4.1	12	24	275	256	72.5
4. BML 2	11.8	3.7 -	12	22	247	276	66.0
5. CML 197	9.7	3.9	12	17	200	232	44.0
6. CML 287	12.8	4.2	12	30	359	255	73.5
7. CML 431	10.8	3.9	12	22	266	226	58.0
8. CML 453	9.8	3.7	12	21	250	242	51.5
9. CML 465	10.1	4.1	12	21	250	247	57.5
10. CML 470	10.3	4.0	12	19	224	260	51.0
11. CML 480	10.5	4.2	14	22	294	228	63.0
12. CML 481	9.7	3.8	14	20	268	222	58.5
13. CML 486	11.2	4.1	14	22	280	251	69.5
14. CML 496	10.8	4.0	10	22	220	212	51.0
15. CZ 2370-15-2	12.2	4.2	14	18	259	210	60.5
16. CZ 2370-18-2	10.1	3.6	10	22	198	232	48.0
17. CZ 2370-22-2	12.7	4.1	12	22	259	258	67.5
18. CZ 2370-24-3	12.9	4.1	14	23	312	258	66.0
19. CZ 2370-28-2	12.7	4.2	10	19	202	241	64.0
20. CZ 2370-31-3	10.4	3.8	12	22	255	231	62.5
21. IPB 911-2	12.4	4.1	12	28	327	254	73.0
22. IPB 911-22	12.2	4.2	14	27	361	238	72.5
23. IPB 911-36	11.7	4.1	12	23	259	242	71.5
24. IPB 911-47	10.8	3.5	12	27	329	229	66.5
25. IPB 911-50	12.3	4.2	14	26	359	253	68.0
Minimum	9.7	3.5	10	16	169	210.0	44.0
Maximum	12.9	4.2	14	30	361	276.5	72.5
Mean	11.3	3.9	12	23	274	242	62.4
F- test	**	**	**	**	**	**	**
CV (%)	4.31	3.75	3.70	6.72	3.96	1.66	6.24
LSD 5%	1.00	0.30	0.61	3.13	22.21	8.19	7.96

Contribution of the characters towards divergence is presented in Table 5. Vector I obtained from PCA expressed that ear length, ear diameter and number of kernel rows/ear were the major characters that contribute to genetic divergence, which was the reflection of first axis of differentiation. On the contrary, the negative absolute values for vector I and positive values for vector II for the characters days to pollen shedding, plant height and number of kernels/ear indicated the responsibility of secondary differentiation. From the result it appeared that the values of both vectors (vector I and vector II) for days to silking, ear length, number of kernels/row, 1000-kernel weight and kernel yield/plant were positive. Such results indicated that these five traits contributed maximum towards diversity of genotypes. So, the greater divergence in the present materials due to these five characters will offer a good scope for improvement of yield through selection of parents.

Table 2. Distribution of 25 yellow inbred lines of maize in five clusters.

Cluster	No. of genotypes	Genotypes in different clusters
I	1	CML 470
II	6	BIL 95, CML 431, CML 480, CML 481, CZ 2370-15-2 and CZ 2370- 31-3
III	7	BIL 97, BML 2, CML 453, CML 465, CML 486, CZ 2370-22-2 and IPB 911-36
IV	4	CML 197, CML 496, CZ 2370-18-2 and CZ 2370-28-2
V	7	IPB 911-2, IPB 911-22, IPB 911-47, IPB 911-50, CZ 2370-24-3, BIL 77 and CML 287

Table 3. Intra (bold) and inter-cluster distances of 25 yellow inbred lines of maize.

Clusters	I	11	III	IV	V
I	**0.7301**	12.53	10.78	6.90	16.93
II		**0.8842**	4.39	7.36	6.01
III			**0.9285**	6.76	7.69
IV				**0.6142**	12.43
V					**0.7908**

The crosses involving parents belonging to the divergent clusters are expected to manifest maximum heterosis and also variability in genetic architecture. Mian and Bahl (1989) reported that the parents separated by D value of medium magnitude generally showed higher heterosis. Sharma (1998) reported that choice of parents based on divergence can be made for hybridization purposes. Considering these themes and agronomic performances, crosses between genotypes of cluster I with those of cluster II, III and IV are expected to improve earliness and short statured crop. Crosses between genotypes of cluster IV and V are also expected to improve the yield of maize.

Table 4. Cluster means for 11 different characters of 25 yellow inbred lines of maize.

Characters	Cluster means				
	I	II	III	IV	V
Days to pollen shedding	87	92	93	93	90
Days to silking	90	94	96	97	93
Plant height.(cm)	93	114	121	123	126
Ear height (cm)	34	46	45	50	53
Ear length (cm)	10.3	11	11.3	10.8	12.4
Ear diameter (cm)	4	4	4.1	3.9	4.3
No. of kernel rows/ear	12	14	12	10	12
No. of kernels/row	16	21	22	20	27
No. of kernels/ear	169	273	260	205	344
1000-kemel wt (g)	260	225	253	229	247
Kernel yield/plant (g)	45	60.6	65.1	51.8	69.9

Table 5. Relative contribution of different characters to total divergence in yellow maize inbred lines.

Character	Vector I	Vector II
Days to pollen shedding	-0.5831	0.0719
Days to silking	0.5448	0.2766
Plant height.(cm)	-0.1115	0.1285
Ear height (cm)	0.2093	-0.3224
Ear length (cm)	0.2553	1.0873
Ear diameter (cm)	6.7031	-1.1434
No. of kernel rows/ear	1.5041	-0.9663
No. of kernels/row	1.3566	0.7776
No. of kernels/ear	-0.1794	0.0910
1000-kemel weight (g)	0.0289	0.1337
Kernel yield/plant (g)	0.0695	0.1912

Selection of parents

Based on medium to high inter-cluster distances, *per se* performances and desirable traits, the fourteen yellow inbred lines viz. CML 470 from cluster I; CML 480 and CZ 2370-31-3 from cluster II; BIL 97, CML 287, CML 486, CZ 2370-22-2 and IPB 911-36 from cluster III; CZ 2370-28-2 from cluster IV and

BIL 77, CZ 2370-24-3, IPB 911-2, IPB 911-22, IPB 911-50 from cluster V could be selected for future hybridization program.

Conclusion

The crosses between the above mentioned selected inbred lines of cluster I with those of cluster II, III and IV are expected to improve earliness and short statured crop. Crosses between genotypes of cluster IV and V are also expected to improve yield of maize. Days to pollen shedding, ear length, number of kernels/row, 1000-kernel weight and kernel yield contributed maximum towards divergence. Hence major emphasis should be given on them for selecting parents for hybridization in maize.

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