African Journal of Agricultural Research Vol. 7(10), pp. 1524-1533, 12 March, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.1595
ISSN 1991-637X ©2012 Academic Journals

Full Length Research Paper

Application of the multivariate analysis method for some traits in maize

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Accepted 21 December, 2011

This experiment was carried out on the basis of complete randomized block design with three replications and 15 foreign hybrids new hybrids of corn in addition 3 commercial hybrid (as control) under normal sowing date and delayed sowing date condition in the Khorasan Razavi Agricultural Research Centre, Iran in the year 2008. This study showed that among all hybrids, EXP1 (18.61 ton/ha) and SIMON (17.91 ton/ha) had the highest yields in early planting (5thJune) and EXP1 (14.01 ton/ha) and BOLSON (13.06 ton/ha) produced the highest yields in late planting (20thJune). According to principal component analysis, four principal components (PC) had Eigen values >1 which accounted for 67% of the total variance in the data on early planting date and 73% of the total variance in the data on delayed planting date. The results obtained from the factor analysis identified 12 factors out of which only four were extracted which together explained 67.8% of the variance among the entries on the first planting date, and five factor in total 73.33% of the changes were justified on the second planting date. Based on cluster analysis, the 18 corn hybrids were separated into four and five major groups with each having two or more subgroups on early and delayed sowing dates respectively. Based on the present results, it was recommended to make crosses among genotypes in Clus1, Clus2 and Clus4, while Clus5 was made on both planting dates in breeding programs.

Key words: Maize, planting date, factor analysis, principal component analysis, cluster analysis.

INTRODUCTION

One of the greatest challenges to maize breeders is the selection of a hybrid with high mean yield and the widest possible adaptation across various environments such that the maize hybrids can be produced on a large scale (Khaldun et al., 2010). Early planting of corn is important to utilize the growing season and maximize yield. Late planted corn is taller than optimum plantings and often used for silage. Full-season hybrids planted at optimum dates to utilize the fall growing season have a greater yield potential than early-season hybrids. Many producers have adopted the early corn concept, which utilizes an early maturing hybrid (90 to 110 day maturity) planted 10 days to two weeks earlier than planting dates as suggested to farmers for optimum kernel yield (Hickman and Shroyer, 1994; Berzsenyi and Lap, 2001). Planting date was reported to affect the growth and yield of maize significantly. To date, the challenge for maize growers is finding the narrow window between planting too early and planting too late (Nielson et al., 2002). Multivariate data analysis facilitated a graphic display of the underlying latent factors and interface between

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Table 1. Variance analysis results on corn hybrids tested under early planting date conditions.

Variable	Early planting (5th June)				
	Replication	hybrid	Error	CV (%)	Mean
Plant height (cm)	21.86 ns	952.4 **	104.35	5.11	199.73
Ear height (cm)	848.9 ns	512.5 ns	350.42	17.7	105.8
Stem diameter (mm)	12.09 **	4.04 **	1.23	5.24	21.18
Leaves number	2.76 *	1.61 **	0.54	6.2	11.9
300 Kernel weight (g)	699.02 **	122.43 ns	81.04	8.45	106.42
Row number/ear	1.73 ns	3.51 *	1.47	7.8	15.56
Kernel number/row	59.9 ns	23.4 *	9.92	7.64	41.21
Physiological maturity	3.9 ns	55.39 **	7.69	2.13	130.01
Ear length (cm)	2.35 ns	5.32 **	1.58	6.52	19.28
Cob percentage	4.21 ns	8.7 **	1.85	8.37	16.27
Kernel depth (mm)	1.18 ns	1.35 *	0.64	6.99	11.5
Total yield (ton/ha)	44.62 **	11.21 **	2.42	11.18	13.92

**: Significant at P ≤ 0.01 level *: Significant at P≤0.05 level ns: not significant.

individual samples and variables (Nielsen and Munck 2003). Principal component analysis (PCA) has been widely used in plant sciences for the reduction of variables and grouping of genotypes. Kamara et al. (2003) used PCA to identify traits of maize (*Zea mays* L.) that accounted for most of the variance in the data. Granati et al. (2003) used PCA to investigate the relationship among Lathyrus accessions. Žáková and Benková (2006) identified traits that were the main sources of variation of genetic diversity among 106 Slovakian barley accessions. Cartea et al. (2002) and Salihu et al. (2006) used PCA and cluster analysis to group kale populations and winter wheat genotypes, respectively. Factor analysis (FA) and principal component analysis identified some similar characters as the most important for classifying the variation among corn hybrids. While PCA does not rely on any statistical model and assumptions, factors analysis does. It is also imperative to note that factor analysis suffers from other drawbacks, such as absence of 'error' structure and the dependence upon scale used to measure the variables (Bartual et al., 1985). The categorization of the diversity among the genotypes into groups with similar characteristics can be used to design a collection strategy (Ariyo, 1993). The purpose of this study was to determine the importance of traits associated with grain and other basic characteristics using PCA, FA and cluster analysis. The main objectives of the study were to (1) characterize and classify diverse corn hybrids based on their overall similarity in agronomic data on two planting dates and (2) identify the genotypes that best combined agronomic characters for future use in corn breeding.

MATERIALS AND METHODS

The present investigation was carried at the Khorasan Razavi Agricultural Research and Natural Resources Institute Mashhad, I.R. Iran in the year 2008. The soil texture at the experimental area was silt loam (pH 7.2 and EC 1.2 mmho/cm). Two independent experiments were laid out in a randomized complete block design (RCBD) with three replications and 18 new corn varieties including 15 foreign early and mid mature single cross hybrids and 3 Iranian commercial hybrids (KSC704, KSC647and DC370) were evaluated at two sowing dates (5th and 20thJune). The name of hybrids were 1- ZP434, 2- ZP341, 3- ZP684, 4- ZP677, 5- SIMON, 6- BOLSON, 7- EXP1, 8- EXP2, 9- BC582, 10- BC666, 11- OSSK602, 12- OSSK596, 13- OSSK552, 14- OSSK659, 15- OSSK617, 16- KDC370, 17- KSC647, 18- KSC704. The hybrids were grown in two row plots with 3.15 m length and 0.75 cm spacing between rows. Two seeds per hill were planted, which were thinned to one plant per hill at 4 to 5 leaf stage. The plant density was adjusted as 75000 plants/ha (Shoa Hoseini et al., 2007). Fertilizer was adjusted according to the soil analysis. At sowing 250 kg/ha Ammonium Phosphate ($NH_4H_2PO_4$), 200 kg/ha K_2SO_4, 250 kg/ha Urea (CH_4N_2O) was applied to each experiment and this was followed by 200 kg/ha N as urea at the 6 leaf stage. Data were recorded on 10 randomly selected plants from each plot for yield components and grain yield ($kgha^{-1}$) was calculated from the entire plot. Physiological maturity was confirmed in a study by Ma and Dwyer (2001) that related the progression of the kernel "milk line" with the decrease in moisture content during grain filling. Data were statistically analyzed using ANOVA appropriate for RCBD with SAS (ver. 9.1) and SPSS (ver. 16) software's. Means were compared using Duncan's multiple range tests at a 0.05 level of probability when the F values were significant (Steel and Torrie, 1984).

RESULTS

Analysis of variance showed significant differences among hybrids for all of the traits in both sowing date (P ≤ 0.01) (Tables 1 and 2), which demonstrated existence of high diversity among hybrids studied in this research. Our results concur with observations made by Berzsenyi and Dang (2008) and Ashofteh et al. (2011a) who reported that the sowing date had a significant effect on the yield of maize grain at a 5% level of probability. This study

Table 2. Variance analysis results on corn hybrids tested under delay planting date conditions.

Variable	Late planting (20th June)				
	Replication	Hybrid	Error	CV (%)	Mean
Plant height (cm)	961.9 **	679.2 **	96.01	4.9	199.61
Ear height (cm)	282.67 **	211.96 **	48.33	7.37	94.28
Stem diameter (mm)	1.25 ns	5.03 ns	3.27	8.56	21.11
Leaves number	4.1 ns	8.66 ns	6.56	21.01	12.18
300 Kernel weight (g)	15.36 ns	242.6 *	122.7	12.25	90.4
Row number/ear	0.19 ns	5.72 **	0.48	4. 5	15.53
Kernel number/row	18.12 ns	30.1 **	10.17	8.44	37.79
Physiological maturity	2.72 ns	35.45 **	2.76	1.19	138.66
Ear length (cm)	11.18 *	6.008 ns	3.29	10.05	18.05
Cob percentage	0.03 ns	9.32 ns	5.54	11.77	20
Kernel depth (mm)	1.07 ns	2.38 **	0.61	7.15	10.99
Total yield (ton/ha)	7.18 ns	7.08 *	3.37	16.63	11.05

**: Significant at P≤0.01 level *: Significant at P ≤ 0.05 level ns: not significant

showed that among all hybrids, EXP 1 (18.61 ton/ha) and SIMON (17.91 ton/ha) had the highest yields in early planting (5th June) and EXP 1 (14.01 ton/ha) and BOLSON (13.06 ton/ha) produced the highest yield in late planting (20th June) (data not shown). Results of this experiment also indicated that yield component such as ear height, 300 kernel weight, kernel number per row, row number per ear and kernel depth were adversely affected in delayed planting condition (Tables 1 and 2). Other researches showed that yield and other traits were highest in the optimum and early sowing date treatments, significantly declining when sowing was delayed by 10 or 20 days (Berzsenyi and Lap, 2005; Namakka et al., 2008; Ashofteh et al., 2011c).

Combined statistical analysis of the data revealed that planting date had significant differences for 300 kernel weight, kernel number per row, kernel depth, physiologic maturity, cob percentage of ear and total yield traits (Table 3). Results of this experiment also indicated that kernel depth was affected by Planting date* Hybrids interaction.

Result of correlation coefficients between the studied variables and total yield in delay planting conditions showed that plant height, ear height, row number per ear, kernel depth and physiological maturity were positive and significantly correlated with total yield (data not shown). This finding was in agreement with the results of Ashofteh et al. (2011b). In early planting condition, the highest correlations were for leaves number and total yield (0.57**) and then kernel depth, stem diameter, kernel number per row and physiological maturity with total yield, respectively (data not shown). The correlation between kernel number per row and ear length in early and delay planting condition was 0.78** and 0.82** respectively; the highest of all variables studied. This finding was in agreement with the results of Shoa Hoseini et al. (2007). The results are at par with the finding of Ashofteh et al. (2011a). Result of this research showed that, ear length, kernel number per row and kernel depth could be used as an important trait for prediction of total yield under delay planting. This finding was in agreement with the results of Jafari et al. (2009) and Golbashy et al. (2010).

Principal component scores were used for clustering maize samples into subgroups because a few principal components contained all of the information in the original variables. According to principal component analysis on first planting date, four principal components (PC) had Eigen values >1 and accounted for 67.8% of the total variance in the data (Table 4). While on second planting date (delay planting date), analysis of the principal component showed that five principal component analysis (PC) had Eigen values >1 and accounted for 73.33% of the total variance in the data (Table 5).

The proportions of the total variance attributable to the first three PC were 22, 18 and 14% respectively. The importance of traits to the different PC can be seen from the corresponding Eigen vectors which are presented in Table 6 on first planting date. The results showed that on first sowing date, plant height and ear height had the highest loadings in PC1 indicating their significant importance for this component. On the other hand, other traits were less important in PC1. Ear length (cm) and kernel number per row were the main traits of PC2. For PC3 traits such as total leaves number and cob percentage/ear were the most important, whereas, stem diameter (mm) was mainly contributing to PC4.

Correlation analysis was performed between the original data and the PC scores to determine the contribution of each trait to the total variance (data not shown). PC1 showed a significant correlation with most traits except row number per ear, 300 kernel weight (gr), cob percentage/ear and ear length (cm). The second principal component PC2 was significantly and positively

Table 3. Results of combined ANOVA for investigated traits of corn hybrids on 2008.

Sov.	Df.	Plant height (cm)	Ear height (cm)	Stem diameter (mm)	Leaves no.	300 Kernel weight (g)	Row no./ear	Kernel no./row	Physiological maturity	Ear length (cm)	Cob (%)	kernel depth (mm)	Total yield (ton/ha)
Planting date	1	0.415 ns	3588.02ns	0.12 ns	2.38 ns	6931.3*	0.013ns	316.2*	2019.3**	40.8 ns	374.7**	6.54 ns	223.3*
Rep (planting date)	4	491.88**	565.8 *	6.67 *	7.34 ns	357.19**	0.96ns	24.05 ns	3.31 ns	6.7 *	2.1 ns	1.12 ns	25.9**
Hybrids	17	1541.3**	557.9**	7.41**	7.35 *	288.3 **	8.04**	47.5**	86.7**	9.9**	15.1**	2.58**	15.9**
Planting date*hybrids	17	90.2 ns	166.5ns	1.66 ns	2.93 ns	76.6 ns	1.19 ns	5.9 ns	4.04 ns	1.34 ns	2.93ns	1.16 *	2.37 ns
Error 2	68	100.18	199.3	2.25	3.5	101.8	0.98	10.04	5.22	2.44	3.7	0.63	2.9
C.V.%		5.01	14.11	7.09	15.65	10.25	6.37	8.02	1.7	8.36	10.6	7.07	13.64

**: Significant at P≤0.01 level *: Significant at P≤0.05 level ns: not significant.

Table 4. Principal component analysis of first planting date: Eigen values and percent variation accounted by the first four principal components.

Factor	Eigen value	Variance percentage	Cumulative variance percentage
1	2.73	22	22
2	2.26	18	41
3	1.7	14	55
4	1.4	11	67

Table 5. Principal component analysis on second planting date: Eigen values and percent variation accounted by the first five principal components.

Factor	Eigen value	Variance percentage	Cumulative variance percentage
1	2. 80	23	23
2	2.28	19	42
3	1.56	13	55
4	1.09	9	64
5	1.05	8	73

associated with row number per ear, physiological maturity, cob percentage/ear and ear length (cm) and negatively with 300 kernel weight (gr). PC3 had a significantly and positive correlation with traits such as row number/ear, total leaves number and cob percentage/ear. In the fourth PC, the most important traits which showed positive and significant correlation with the scores were kernel number/row, ear length (cm) and stem diameter (mm). On second planting date, the proportions of the total variance attributable to the first three PC were 23, 19 and 13% respectively. The importance of traits to the different PC can be seen from the corresponding Eigen vectors which are presented in Table 7.

Results obtained from the study showed that on delay sowing date, ear length (cm) and kernel number per row had the highest loadings in PC1

Table 6. Eigen vectors (loadings) of the first four principal components on first planting date.

Trait	Eigen vector			
	PCA 1	PCA 2	PCA 3	PCA 4
Plant height (cm)	0.5041	0.1638	- 0.0283	0.0766
Ear height (cm)	0.5151	0.0419	0.0639	0.2149
Stem diameter r(mm)	0.1606	- 0.1665	0.0303	0.6117
Total leaves number	0.3053	0.0033	0.4986	0.2221
physiological maturity	0.3141	0.2585	- 0.0011	- 0.4644
300 kernel weight (g)	0.0764	- 0.2729	- 0.0068	- 0.0463
Row number/ear	- 0.1292	0.2679	0.3566	- 0.2537
Kernel number/row	- 0.1165	0.4977	- 0.3237	0.2615
Ear length (cm)	- 0.1071	0.5159	- 0.2555	0.2903
Cob percentage/ear	- 0.0879	0.4310	0.4209	0.0147
Kernel depth (mm)	0.3682	0.1669	- 0.0486	- 0.2434
Total yield (ton/ha)	0.2681	- 0.0537	- 0.5182	- 0.1728

Table 7. Eigen vectors (loadings) of the first five principal components on delay planting date.

Trait	Eigen Vector				
	PCA 1	PCA 2	PCA 3	PCA 4	PCA 5
Plant height (cm)	0.0178	0.5258	0.2004	0.1641	- 0.1179
Ear height (cm)	0.1052	0.4829	- 0.1599	0.0116	0.1955
Stem diameter (mm)	0.2627	0.1383	- 0.3771	0.2956	0.4268
Total leaves number	- 0.1048	0.5722	0.1474	0.1000	- 0.0732
physiological maturity	- 0.0316	- 0.0842	0.6151	- 0.2095	0.3055
300 kernel weight (g)	0.1288	0.0982	- 0.3387	- 0.5798	0.4469
Row number/ear	- 0.1299	- 0.0757	0.3655	0.3311	0.6585
Kernel number/row	0.4923	- 0.2141	0.0804	0.2309	- 0.0022
Ear length (cm)	0.4931	- 0.0306	- 0.0262	0.2529	- 0.0183
Cob percentage/Ear	- 0.3966	0.1335	- 0.1051	0.0333	0.0929
Kernel depth (mm)	0.3267	0.1223	0.2294	- 0.5146	0.0044
Total yield (ton/ha)	0.3526	0.2037	0.2694	- 0.0489	- 0.1562

indicating their significant importance for this component. On PC2 plant height (cm) and ear height (cm) were important at this principal component. Physiological maturity is the main traits of PC3. For PC4 traits such as row number per ear and stem diameter (mm) were the most important, but row number per ear and 300 kernel weight (g) were mainly contributing to PC5. Correlation analysis on PC1 showed a significant correlation with row number per ear, kernel depth, cob percentage/ear, ear length, stem diameter and total yield. PC2 had a significantly and positively correlation with traits such as plant height, ear height, total leaves number and total yield. The third principal component (PC3) was significantly and positively associated with row number per ear, kernel depth, physiological maturity and total yield. PC4 had a significantly positive correlation with row number per ear, and stem diameter. Finally fifth principal component was significantly with traits such as row number per ear, 300 kernel weight, physiological maturity and stem diameter.

FA (Factor analysis) was applied after PCA because it was generally recommended that PCA be performed as a first step before other multivariate analysis to check for abnormalities present in data set (Johnson, 1998). The following model may help to understand parameters used in FA (Everitt and Dunn, 2001; Johnson, 1998). Principal factor analysis gave similar results to those from PCA, in which the two principal components were determined. Because the two largest eigen values were determined by principal factor analysis, these two factors were initially used for maximum likelihood factor analysis. (Lee et al., 2005).

The results obtained from the factor analysis of the characters on early sowing date are presented in Table 8. The analysis identified 12 factors out of which only four were extracted which together explained 67.8% of the

Table 8. Results of factor analysis (factor pattern) on first planting date.

Trait	Factor 1	Factor 2	Factor 3	Factor 4
Plant height (cm)	0.8336	0.2466	-0.0369	0.0917
Ear height (cm)	0.8518	0.0631	0.0834	0.2572
Stem diameter (mm)	0.2657	-0.2508	0.0395	0.7319
Total leaves number	0.5049	0.0049	0.6505	0.2658
physiological maturity	0.5194	0.3893	-0.0015	-0.5557
300 kernel weight (g)	0.1264	-0.4109	-0.0090	-0.0554
Row number/ear	-0.2136	0.4035	0.4653	-0.3036
Kernel number/row	-0.1927	0.7495	-0.4224	0.3129
Ear length (cm)	-0.1771	0.7768	-0.3333	0.3474
Cob percentage/ear	-0.1454	0.6490	0.5492	0.0176
Kernel depth (mm)	0.6088	0.2513	-0.0634	-0.2913
Total yield (ton/ha)	0.4433	-0.0809	-0.6761	-0.2068

Table 9. Results of factor analysis (factor pattern) on second planting date.

Trait	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Plant height (cm)	0.0299	0.7951	0.2506	0.1716	- 0.1211
Ear height (cm)	0.1761	0.7302	- 0.20	0.0121	0.2008
Stem diameter (mm)	0.4396	0.2092	-0.4716	0.3092	0.4384
Total leaves number	-0.1755	0.8653	0.1843	0.1046	-0.0752
physiological maturity	-0.0529	- 0.1274	0.7692	- 0.2191	0.3138
300 kernel weight (g)	0.2157	0.1485	- 0.4236	- 0.6063	0.4590
Row number/ear	-0.2174	- 0.1145	0.4571	0.3463	0.6764
Kernel number/row	0.8240	- 0.3238	0.1006	0.2415	-0.0022
Ear length (cm)	0.8253	-0.0464	- 0.0327	0.2645	- 0.0188
Cob percentage/ear	- 0.6639	0.2020	- 0.1315	0.0349	0.0954
Kernel depth (mm)	0.5468	0.1850	0.2869	- 0.5382	0.0045
Total yield (ton/ha)	0.5902	0.3081	0.3369	-0.0511	- 0.1605

variance among the entries. The first factor with Eigen value of 2.73 accounted for only 22.79% of the variance and is primarily related to plant height, ear height and kernel depth. The second factor that accounted for 18.89% of the total variance is mainly loaded by ear length and kernel number per row.

The third factor that accounted for 14.19% of the total variance is mainly described by total leaves number and cob percentage/ear.

The fourth factor was loaded by stem diameter and ear length and it accounted for just 11.93% of the total variance.

In spite of the delay sowing date, factor analysis revealed that only five were extracted which together explained 73.33% of the variance among the entries. First factor with eigen value of 2.80 that accounted for 23.34% of the total variance was mainly loaded by ear length, kernel number per row and total yield (Table 9).

The second factor accounted for 19.05% of the variance and was primarily related to total leaves number, plant height and ear height. The third factor was loaded by physiological maturity and row number per ear and it accounted for just 55.43% of the total variance. The fourth factor that accounted for 9.11% of the total variance is mainly described by row number per ear. Fifth factor was connected to row number per ear and 300 kernel weight with 8.79% of the total variance. Zeinali et al. (2005) operating characteristics such as phonology and seed number in their research reported that a similar result was obtained.

The four variables in the principal components analysis were also used for cluster analysis of the hybrids with UPGMA linkage as in Hart et al. (2007). Based on cluster analysis on trait mean on first sowing date, the 18 corn hybrids were separated into four major groups with each having two or more subgroups. Figure 1 illustrates the four clusters formed by hierarchical clustering. Table 10 summarizes the number of hybrids in each cluster. The first cluster is a small group consisting of only one hybrid OSSK 596 (12 at picture). Second cluster consisted of EXP2 and SIMON hybrids respectively. The third cluster (Clus 3) comprises of the OSSK 644 hybrid. Hybrids of

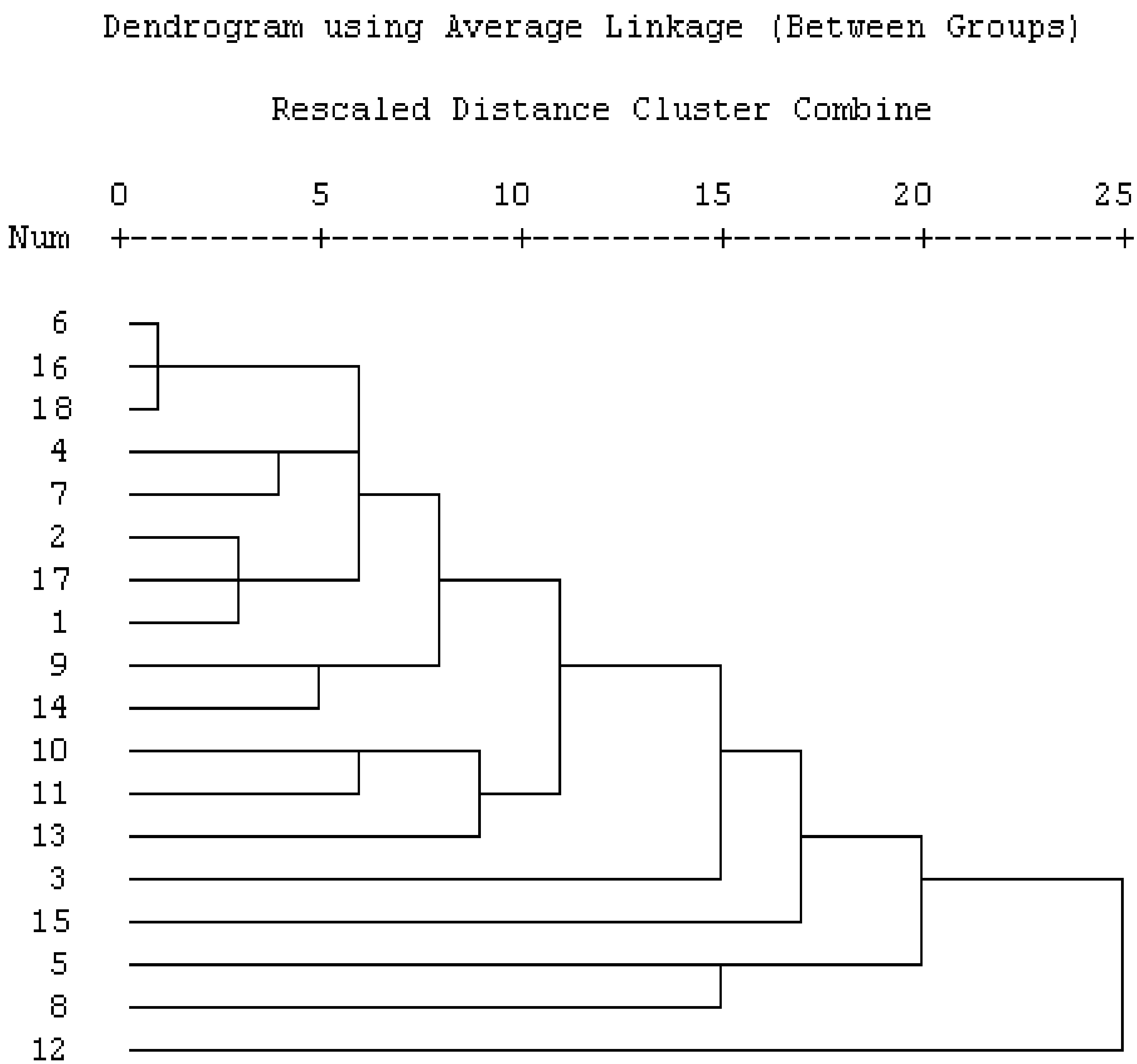

Figure 1. Dendrogram of the cluster analysis based on the genotypic scores of the first four principal components. Arrangement of hybrids: 1- ZP434, 2- ZP341, 3- ZP684, 4- ZP677, 5- SIMON, 6- BOLSON, 7- EXP1, 8- EXP2, 9- BC582, 10- BC666, 11- OSSK602, 12- OSSK596, 13- OSSK552, 14- OSSK659, 15- OSSK617, 16- KDC370, 17- KSC647, 18- KSC704.

Table 10. The number of hybrids in each cluster on first sowing date.

Cluster number	Hybrids in each cluster
Clus1	OSSK 596
Clus2	EXP2, SIMON
Clus3	OSSK 644
Clus4	ZP684, OSSK 552, OSSK 602, BC666, OSSK 659, BC582, ZP434, KDC647, ZP341, EXP 1, ZP677, KDC704, KDC370, BOLSON

clus 4 are ZP684, OSSK 552, OSSK 602, BC666, OSSK 659, BC582, ZP434, KDC647, ZP341, EXP 1, ZP677, KDC704, KDC370 and BOLSON. The second planting date elucidated the cluster analysis. Figure 2 illustrates

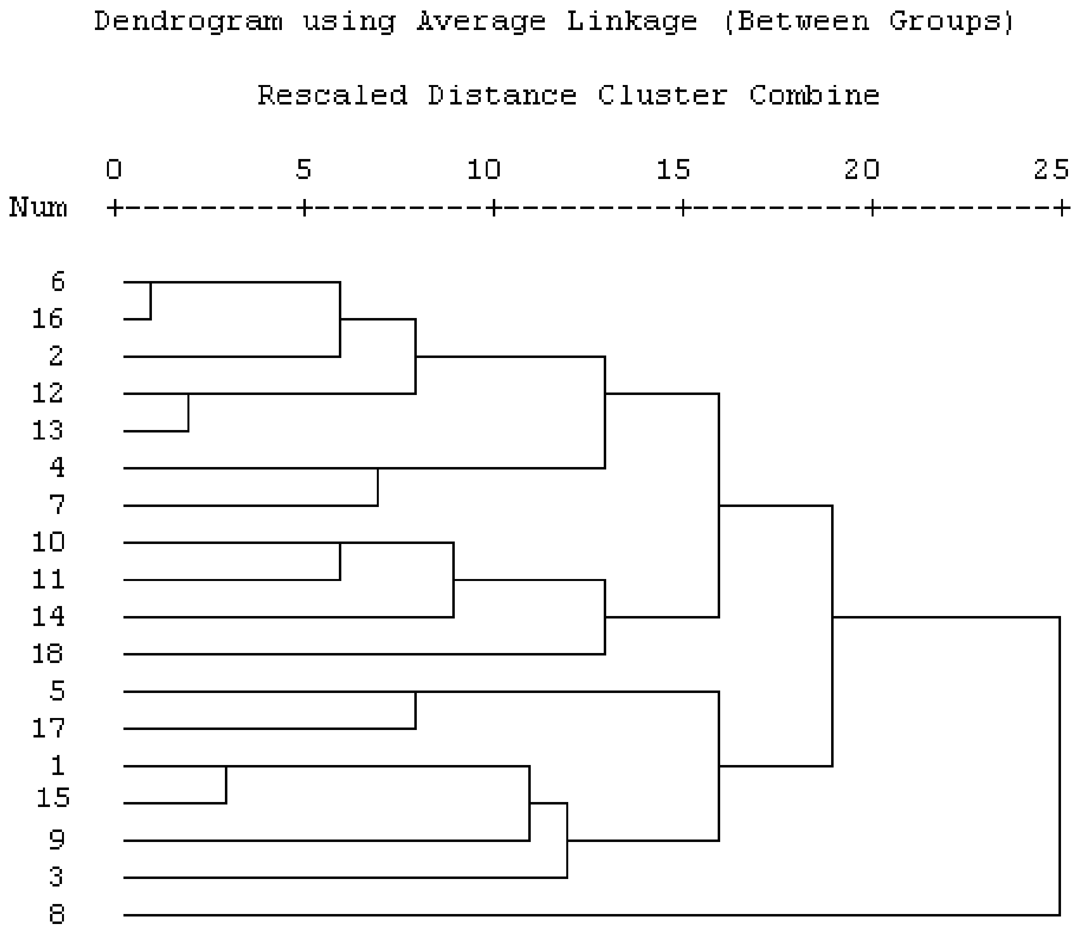

Figure 2. Dendrogram of the cluster analysis based on the genotypic scores of the first five principal components. Arrangement of hybrids: 1- ZP434, 2- ZP341, 3- ZP684, 4- ZP677, 5- SIMON, 6- BOLSON, 7- EXP1, 8- EXP2, 9- BC582, 10- BC666, 11- OSSK602, 12- OSSK596, 13- OSSK552, 14- OSSK659, 15- OSSK617, 16- KDC370, 17- KSC647, 18- KSC704.

Table 11. The number of hybrids in each cluster on second sowing date.

Cluster number	Hybrids in each cluster
Clus1	EXP 2
Clus2	ZP684, BC582, OSSK 644, ZP434
Clus3	KDC647, SIMON
Clus4	KDC704, OSSK 659, OSSK 602, BC666
Clus5	EXP 1, ZP677, OSSK 552, OSSK 596, ZP341, KDC370, BOLSON

the five clusters formed by the UPGMA method based on the average similarity coefficient between race groups hierarchical clustering.The hybrids were separated into five major clusters (Table 11).

The first cluster is a small group of only one hybrid EXP 2. Second cluster consist of ZP684, BC582, OSSK 644 and ZP434 hybrids respectively. The third cluster also is a small and has two hybrids KDC647 and SIMON. The hybrids such as KDC704, OSSK 659, OSSK 602 and BC666 belonged to the fourth cluster. Finally, the fifth cluster comprises of the EXP1, ZP677, OSSK 552, OSSK 596, ZP341, KDC370 and BOLSON hybrids.

DISCUSSION

In this experiment, it was observed that planting date (delay sowing) had significant effects on the yield of maize hybrids and its components. EXP 1 (18.61 ton/ha) and SIMON (17.91 ton/ha) hybrids were the best hybrids under early planting (5th June) condition and EXP 1 (14.01 ton/ha) and BOLSON (13.06 ton/ha) showed the best behaviour under late planting (20th June) condition.

There was a dry spell in the second and third week of July, 2008, which affected crop establishment for planting done on 20th June. The rains also ceased in September, 2008 thereby, inducing drought stress for the corn crops during the grain filling period particularly for corn planted in late June. This study showed that sowing date had a significant effect on plant height (Table 1). The planting date of 5th June, gave the shortest plants (Tables 1 and 2). Remison and Dele (1978) in Nigeria reported that lodging in maize was associated with ear and plant heights and length of basal internodes and that total yield mainly depends upon the kernel number per ear. Effective application of multivariate analysis on agronomic characters can result in meaningful groupingof hybrids. On the basis of genetic diversity in regards to important agronomic traits, the investigated new corn hybrids were grouped into four groups on first planting date and five groups on second planting date by PCA and cluster analysis. PCA combined with cluster analysis clearly separated the new corn hybrids.

Recently, PCA has been used by various authors for the reduction of multivariate data into a few artificial varieties which can be further used for classifying of materials. This approach is especially valuable for the screening of a large number of genetic resources by a large number of descriptor variables (Cartea et al., 2002; Granati et al., 2003; Kamara et al., 2003; Salihu et al., 2006). The correlation analysis between agronomic traits was found to be significant between almost all the traits. Based on the present results, making of crosses among genotypes in Clus1, Clus2, Clus4, and Clus5 on both planting dates in breeding programs was recommended. Classifying genotypes according to their agronomic traits with sophisticated multivariate techniques can reduce the cost of time and money in crop improvement.

However, stability analysis of different traits on the already established groups of the current study requires further investigations based on sufficient data that covered different years and experimental locations.

Conclusion

This study has shown that planting date had significant effects on the yield of maize hybrids and its components. This experiment has also shown delaying of planting date reduced yield and its components (ear height, 300 kernel weight, kernel number per row, row number per ear and kernel depth).By using PCA and FA, the complex and complicated data with many variables and observations could be reduced into a small number of new variables that allow us to interpret and characterize large number of samples easily and conveniently. The groups created by the cluster analysis are believed to have unique hybrids group properties that might be considered for predicting of results should the best hybrids be grown on this location.

ACKNOWLEDGEMENTS

The authors wish to thank Dr. Saied Khavari Khorasani, Dr. Khodadad Mostafavi and Eng. Mohsen Niyazian for reading of the manuscript and their valuable discussion.

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