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PERFORMANCE OF GUAR GENOTYPES UNDER IRRIGATED AND DROUGHT STRESS CONDITIONS AS EVALUATED THROUGH PCA AND CLUSTER ANALYSIS

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ABSTRACT

The experiment comprised of 7 guar genotypes (*Cyamopsis tetragonoloba* (L.) Taubert sown in two sets under drought and irrigated conditions. Six characters i.e. Plant Height, Cluster/Plant, Pods/Cluster, Pods/Plant, Pod length, Grains/Pod were studied and analyzed the data by PCA analysis out of which the first three characters accounted for 65.44%, 25.56% and 6.87% of total variation, respectively under irrigated conditions. While in drought condition, the first three characters accounted for 53.18%, 35.83% and 8.27% of total variation, respectively. In cluster analysis, three cluster are made, cluster 1 (3 genotypes) showed near about 80-85% of similarity distance between characters, while cluster 2 (3 genotypes) showed 60-65% of similarity distance between characters and cluster 3 (1 genotype) showed 15% similarity distance with other clusters. While in drought conditions, cluster 1 (4 genotypes) showed near about 70-80% of similarity distance between characters, while cluster 2 (2 genotypes) showed 65% of similarity distance between characters and cluster 3 showed 59% similarity distance with other clusters.

Keywords: Drought, PCA, Cluster Analysis

INTRODUCTION

Cluster bean (*Cyamopsis tetragonoloba* (L.) Taubert is generally well-known as guar in Pakistan. It is a entirely self-fertile and very much self-pollinated crop with an upright growth and have deep root system. It has its place to the family Leguminosae (Fabaceae) and has high yield, with maximum nutritional value and drought resistant. Guar is commonly known from its endosperm which contain polysaccharide gum known as galactomannan, which used in shale energy production field (fracking in petroleum industries) and also in textile, paper, pharmaceutical, cosmetic and other industries. Guar has been cultivated in Pakistan and India from centuries which mainly used as vegetables (green pods), mature grains used as pulses and lush green plants used as fodder and for soil manuring due to its nitrogen fixation ability. The guar plant is highly drought tolerant, and has ability to use all soil water efficiently. Therefore, it can be easily grow in the rainfed and semi-arid regions. The most producers of guar seed are India, Pakistan and United States. Due to leguminous crop, guar plant has ability to fix nitrogen in the soil and enhance the nitrogen with help of soil bacteria.

Drought is abiotic stress which is a predictable and repeated feature of agriculture in all over the world. It was estimated that near about 1/3 of the world's land suffers from water shortage (Khan *et al*., 2004).

As concerned with biometrical procedures, the principal component analysis (PCA) has main edge because each variety could be assigned to only one group and it also showed the maximum variability to the largest contributor from the total variability (Sharma, 1998). Genotypic variability of agronomic characters has been calculated by the using of principal component analysis (Sarvanan *et al*., 2006; Esmail *et al*., 2008; Li *et al*., 2008).

The main purpose of this experiment was to estimate the genetic variability between guar varieties mainly for drought resistance and selected the best performed genotypes by using PCA and cluster analysis so that best genotypes can be further used in the guar breeding material.

MATERIAL AND METHODS

The experiment was conducted at Agricultural Research Station Bahawalpur at longitude and latitude of 71.6833°E and 29.3957°N, respectively, during the year 2014-2015. The experiment consisted of 7 guar genotypes including two approved varieties as check namely, BR90, BR-99, S-5274, S-5299, S-5394, S-5509 and S-5548. The sowing was done in Randomized Complete Block Design (RCBD) with four rows/genotype and three replications. Plant to Plant distance and Row x Row distance was kept as 15cm and 45cm, respectively. Guar genotypes were sown in two sets under drought and irrigated conditions. In drought conditions, irrigation was applied before sowing to retain moisture for germination of seeds while under irrigated conditions, 3 irrigations were applied at different growth stages of crop. All necessary cultural practices were made according to the crop requirements. Data were

recorded from 5 randomly selected plants from each genotype/plot. Data for following morphological characters i.e. Plant Height, Clusters/Plant, Pods/Cluster, Pods/Plant, Pod length and Grains/Pod were recorded.

The data were subjected to basic statistics, cluster analysis and principal component analysis (PCA) using statistical software "Statistical Tool for Agricultural Research (STAR) version 2.0.1". The principal components were plotted against each other to find out the patterns of variability among genotypes.

RESULT AND DISCUSSION

PCA Analysis (Irrigated Conditions)

Six components were extracted from the six studied traits by PCA analysis. The first two components revealed more than one Eigen value while rest of the four components showed less than one Eigen values. The first, second and third principal components accounted for 65.44%, 25.56% and 6.87% of total variation, respectively. The cumulative percent of variance accounted for 97.86% of total variation in the first three components (Table 1).

The characters like Plant Height (cm), Pods/Cluster, Pods/Plant, Pod length (cm) and Grains/Pod (g) exhibited significant positive values in PC-I while Clusters/Plant exhibited negative values. The 2nd principal component was associated to diversity between guar genotypes for all traits and exhibited positive loadings except Plant Height which showed negative loading. The PC-3 was associated to variation between genotypes due to positive values of characters like Plant Height, Clusters/Plant, Pods/Plant and Pods/Cluster while negative loadings were exhibited by Pod Length and Grains/Pod. The PC-4 was elucidated by diversity among the genotypes which showed three characters with negative loadings and three characters with positive loading (Table 1). From the Fig. 1 it is cleared that variables and genotypes are super imposed on the plot as vectors. The distance of each variable with respect to PC-1 and PC-2 showed the contribution of these variables in the variation of genotypes used. The biplot showed that Plant Height, Pod length, Pods/Cluster, Grains/Pod showed maximum contribution to variability in guar varieties.

Table1. Principle component analysis of different traits in guar genotypes under irrigated conditions.

Variable	PC1	PC2	PC3	PC4	PC5	PC6
Plant height	0.418	-0.381	0.459	0.144	0.387	0.547
Cluster/plant	-0.425	0.381	0.196	0.672	0.425	-0.053
Pods/Cluster	0.473	0.190	0.393	-0.144	0.261	-0.705
Pods/Plant	0.128	0.760	0.318	-0.241	-0.268	0.418
Pod length	0.490	0.018	-0.105	0.670	-0.544	-0.064
Grains/Pod	0.407	0.309	-0.696	-0.008	0.483	0.149
Eigen value	3.9263	1.5334	0.4120	0.1043	0.0230	0.0010
Percent of variance	65.44	25.56	6.87	1.74	0.38	0.02
Cumulative% of Variance	65.44	91.00	97.86	99.60	99.98	100.00

Table 2. Principle Component Analysis of different traits in guar genotypes under drought conditions.

Variable	PC1	PC2	PC3	PC4	PC5	PC6
Plant height	0.111	-0.551	0.778	0.228	-0.162	-0.028
Cluster/plant	0.462	0.369	0.212	0.009	-0.041	0.777
Pods/Cluster	-0.252	-0.584	-0.203	-0.561	-0.037	0.488
Pods/Plant	0.536	0.078	0.107	-0.682	-0.277	-0.391
Pod length	0.491	-0.310	-0.138	0.042	0.799	-0.066
Grains/Pod	0.427	-0.342	-0.527	0.407	-0.506	0.021
Eigen value	3.1908	2.1501	0.4967	0.1322	0.0240	0.0062
Percent of variance	53.18	35.83	8.27	2.20	0.40	0.10
Cumulative% of Variance	53.18	89.01	97.29	99.49	99.89	100

Table 3. Cluster analysis of various traits and membership of guar genotypes under irrigated conditions.

Variable	Cluster 1	Cluster 2	Cluster 3
Pl. height	99.700	150.133	106.8
Cluster/plant	24.433	14.000	23.3
Pods/Cluster	4.800	9.000	9.6
Pods/Plant	114.300	120.133	223.9
Pod length	5.067	5.700	5.5
Grains/Pod	8.333	8.900	9.1

Table 4. Cluster analysis of various traits and membership of guar genotypes under drought conditions.

Variable	Cluster 1	Cluster 2	Cluster 3
Plant height	97.625	81.95	92.3
Clusters/plant	19.675	11.25	38.2
Pods/Cluster	7.300	7.40	4.5
Pods/Plant	108.250	73.30	158.7
Pod length	5.050	4.60	5.3
Grains/Pod	8.225	7.40	8.2

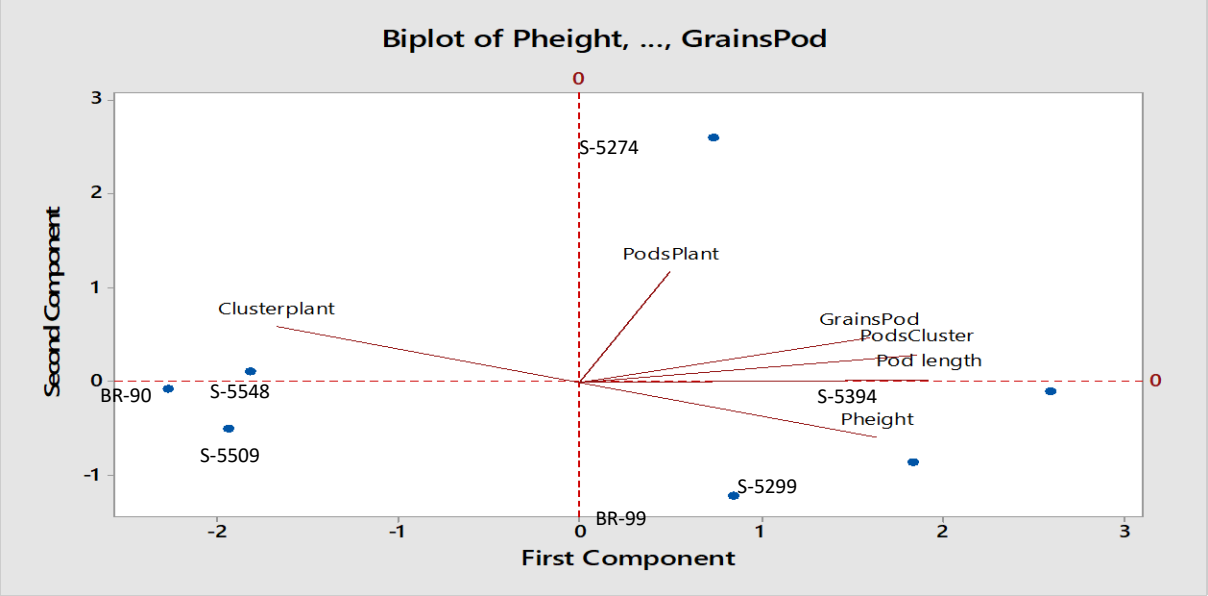

Fig.1. Biplot between PC-1 and PC-2 showing contribution of various traits in variability of germplasms under irrigated conditions.

Drought Condition

In drought conditions, same characters were studied and the data were analyzed by PCA analysis. The first two components revealed more than 2 Eigen value while rest of the four components showed lower Eigen values than one. The first, second, third and fourth principal component accounted for 53.18%, 35.83%, 8.27% and 2.20% of total variation, respectively. The cumulative percent of variance accounted for 99.49% of total variation in the first four components (Table 2).

The all characters exhibited significant positive values in PC-I except Pods/Cluster which exhibited negative values (Table 2). The 2nd Principal Component was associated with variability between guar varieties for such traits like Clusters/Plant, Pods/Plant with their positive loadings and other four traits showed negative loadings factors. The 3rd Principal Component was showed by diversity between guar genotypes along with three characters showed positive values while other three traits showed negative values. The 4th PC showed long diversity between the guar varieties for Pods/Cluster, Pods/Plant with negative loadings while other characters exhibited positive factor. While in PC-5 explained their variability among the genotypes with all characters showing negative loading except Pod length and when PC-6 discussed three characters showing positive loading and other three showed negative loading

(Table 2). From Figure.2 it was cleared that characters and varieties are super imposed on the plot as vectors. The distance of every character regarding with PC-1 and PC-2 exhibited that variation among the genotypes are present due to contribution of these variables. The biplot exhibited that Cluster/Plant, Pod length, Grains/Pod and Pods/Cluster contributed maximum diversity in guar genotypes.

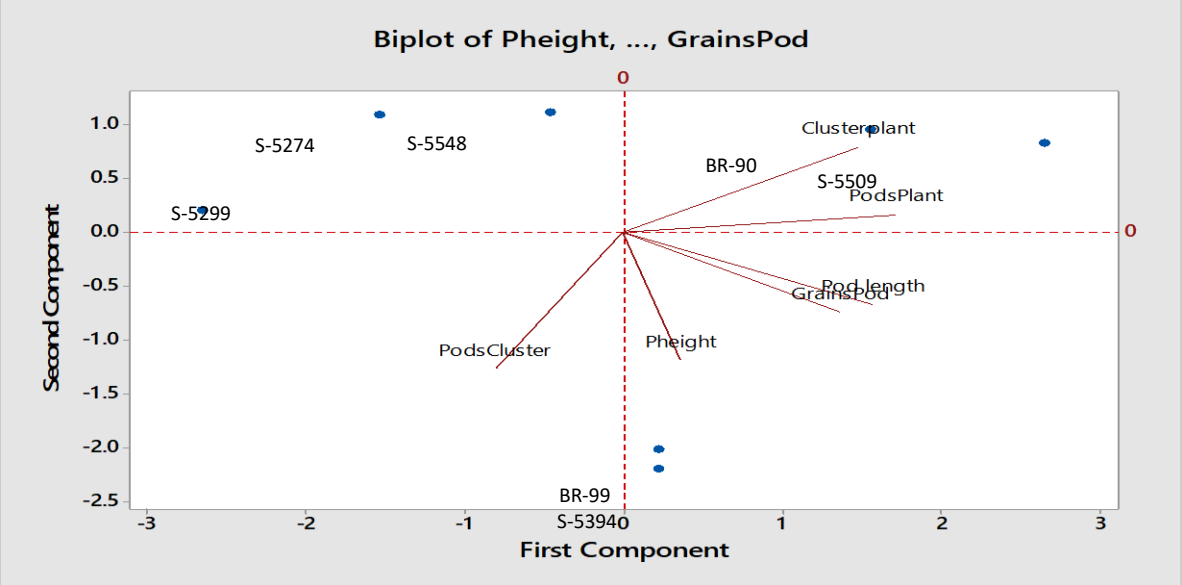

Fig. 2. Biplot between PC-1 and PC-2 showing contribution of various traits in variability of germplasms under drought conditions.

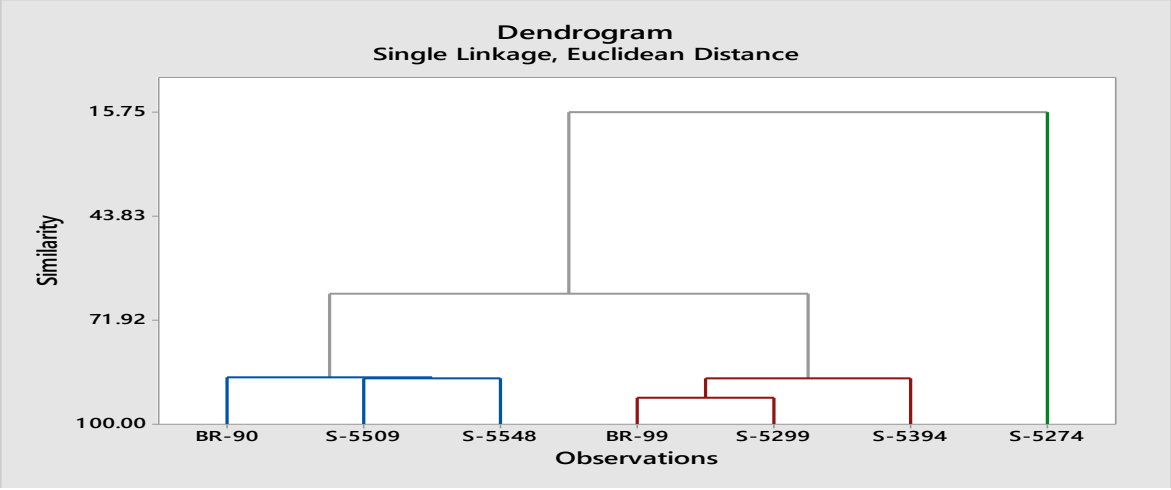

Fig. 3. Tree diagram of 7 guar genotypes based on different morphological traits under irrigated conditions.

Cluster Analysis

Irrigated Conditions

Agronomic characters can be used for the measurement of genetic variability and development of cultivar so that they provided an easy way for estimation of genetic variation (Fufa *et al*., 2005). Estimation of genetic variability from genotypes assortment in the grouping of germplasm for the possible utilization in specific breeding programme (Mohammadi and Prasanna, 2003). The cluster analysis divided the varieties into different clusters which showed highly similarity in the cluster and maximum difference among clusters (Jaynes *et al*., 2003). Cluster analysis of 7 genotypes of guar divided them into 3 clusters (Fig. 3). Group of every cluster is presented in Table 3. The 1st Cluster contained 3 varieties (BR-90, S-5569 and S-5548), while 2nd cluster consisted of 3 varieties (BR-99, S-5299 and S-5394) and 3rd cluster contained only 1 variety (S-5274). Cluster analysis arranged the genotypes and make grouping on the basis of similarity in the morphological traits in genotypes Zubair *et al*., (2007), Ahmad *et al*.,

(2008) and Ali *et al*., (2008) also described absence of relationship among morpho- agronomic characters and origin. Cluster-1 showed low Plant Height, Pods/cluster and Pods/Plant but maximum in clusters/plant while cluster-2 showed maximum Plant Height with minimum cluster/plant and finally 3rd cluster showed maximum Pods/Plant, Grains/Pod and Pods/Cluster (Table 3).

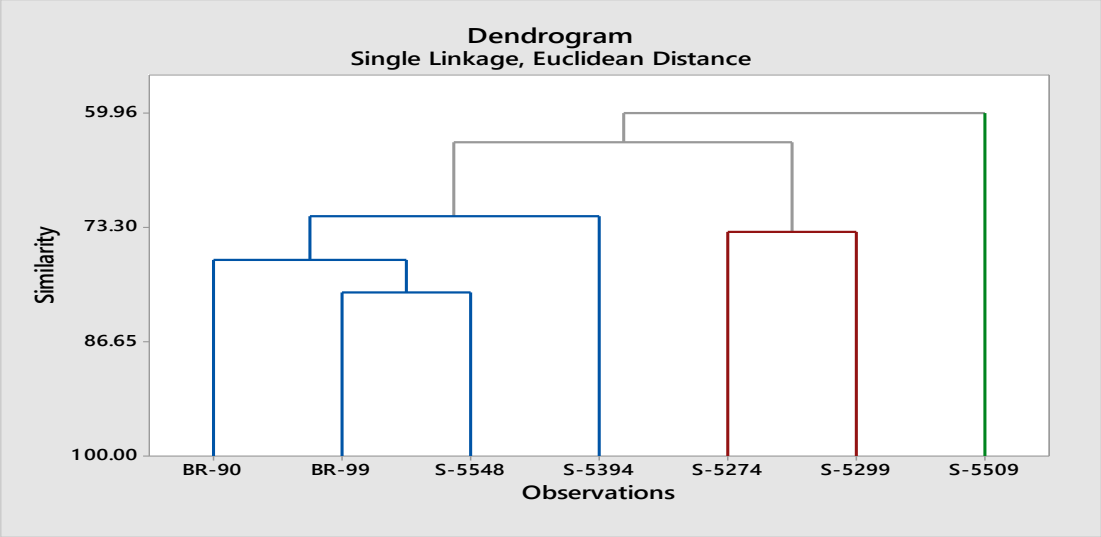

Fig. 4. Tree diagram of 7 guar genotypes based on different morphological traits under drought conditions.

In the tree dendrogram (Fig. 3) cluster-1 (3 genotypes) showed near about 80-85% of similarity distance between characters, while cluster-2 (3 genotypes) showed 60-65% of similarity distance between characters as comparison to cluster-1 genotypes while cluster-2 showed 85-90% similarity within genotypes. Cluster-3 showed 15% similarity with other clusters.

Drought Condition

Cluster analysis of 7 genotypes of guar was divided into 3 clusters (Fig.4). Members of each cluster are presented in Table 4. Cluster 1 consisted of 4 genotypes (BR-90, BR-99, S-5394, S-5548), cluster 2 consisted of 2 genotypes (S-5274, S-5299), cluster 3 contained 1 genotype (S-5509). The cluster 1 showed maximum effect of plant height, pods/plant and clusters/plant. In the cluster 1, the genotypes agglomerated with 70-80% of similarity amongst them while cluster 2 (2 genotypes) showed agglomeration of similarity of around 73%.
The two clusters linked at around 65% similarity level. In irrigated as well as drought conditions, plant height and pod per plant appeared to bear overriding effect in the genotype clustering.

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