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Multivariate Analysis of Maize Inbred Lines under Normal and Stressed Watering Regimes

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ABSTRACT

Fifty S_3 lines along to ten S_{10} of ARC maize inbreds were evaluated under normal and stressed watering regimes to explore their potentiality by using cluster and principal components analyses. Cluster analysis grouped the inbred lines under each of both conditions into three groups as lower (LP), medium (MP) and higher (HP) performed groups. The grouping of the investigated inbreds using their performance under normal regimes is conducted on flowering dates and grain yield attributes. However, the screening process of inbreds grown under stressed watering regime by cluster analysis greatly considered the level of tolerance/susceptibility in addition to flowering and grain yield. The extent of variation proved that there opportunities to upgrade the ASI, proline content, drought susceptibility and tolerance of higher performed inbreds. The most of tested lines are common between LP, MP and HP groups under both regimes which pointed out that effective selection could be expected either practiced under normal or stressed environments. Principal components analysis proved that drought stress tolerance index playing a great role with yield and yield components under either normal or stress conditions which considers it as the main factor contributing the higher value from total variations. The interrelationships among the traits within clustered groups are variable with common significantly positive correlation between grain yield and drought tolerance. Cluster analysis seems to be effective for classifying the maize inbred lines during the early generation of development. However, the *per se* distinct lines need to be reliable as components maize hybrid via testing GCA.

***Keywords**:* Maize inbred, Cluster analysis, Principal components analysis, Drought stress.

INTRODUCTION

Drought stress is globally one of the major abiotic threatens the agricultural production and food security (Li *et al*., 2011 and Song *et al*., 2019). Population increment and expected climate change effects necessity huge efforts of breeding promising crops varieties that perform better under these conditions and able to achieve sustainability. Water stress conditions affected negatively and differently the performance and productivity as well as ASI of maize inbred lines (Magorokosho *et al.,* 2003; Istipliler *et al.*, 2016; Gazal *et al*., 2017; Rafique *et al.*, 2019 and Darwish *et al*., 2020).

The major technique for developing maize inbred lines is the selection among selfed families based on phenotypic and agronomical characters (Hallauer *et al.*, 1988 & 2010; Hallauer and Carena 2009; Rahman *et al.*, 2012; Ullah *et al.*, 2015 and Darwish *et al.*, 2020). Selection responses depended on many factors including the interrelationship between characters (Pahadi *et al*., 2017).

The evaluation and classification of developing inbred lines for somewhat several number of agronomical and tolerance traits are of great benefit and precise utilization in breeding program (Bin Mustafa *et al.* 2015; Darwish *et al*., 2015; Hefny *et al*. 2017; Rafique *et al.*, 2018 and Sandeep *et al.*, 2017). Multivariate statistical analyses such as cluster analysis and principal components analysis could achieve these purposes (Tanavar *et al*., 2014; Ali *et al.* 2015 & 2016 and Mounika *et al.* 2018). Hierarchical cluster analysis classifies studied genotypes into different groups depended on the degree of similarity (Tanavar *et al.*, 2014; Bin Mustafa *et al.*, 2015 ; Darwish *et al.*, 2015; Shrestha 2016; Hefny *et al.*, 2017; Suryanarayana *et al.*, 2017; and Rafique *et al.*,2018). Principal components analysis represent the value of greatest contribute of traits on variation among the studied genetic variation (Suryanarayana *et al.*, 2017 and Sandeep *et al.*, 2017).

Darwish *et al.* (2020) developed and evaluated sixty maize inbred lines from different parental sources for yield performance and drought tolerance. These lines varied significantly and differently between normal and stressed watering regimes. Remarkable expected gain for selection was recorded under stress conditions. They concluded that these inbred lines exhibited desirable performance and reliable drought tolerance accompanied with sufficient variation which offers further responses to upgrading.

The present investigation aimed to explore the potentiality of the developed inbred lines by using the cluster and principal components analyses for flowering, grain yield, physiological traits and drought tolerance indices.

MATERIALS AND METHODS

Two field trials were carried out at the Agricultural Experiments and Research Farm of the Faculty of Agriculture, Minia University, El-Minia, Egypt during 2019

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summer season to evaluate fifty S_3 lines under two watering regimes trials. First was irrigated in 10 days intervals (as normal watering regime) and the second was conducted by irrigation each 20 days (as stressed one). The S_3 developed inbred lines were studied along to 10 S_{10} of ARC inbreds as mentioned in the first part of these studies (Darwish *et al.* 2020). The irrigation treatments as normal (N) and stressed (S) were adopted after 2nd irrigation (including Mohyaa irrigation) summed eight and five irrigation, respectively.

The five parental white maize populations of the developed inbred lines are I.280×TWC.310, I.278×G.2 and I.273×TWC.310, Cairo 1 Imp. and Giza 2.

Each field Experiment was conducted as RCBD design with three replicate. Each line was represented in each replicate by one ridge with three meters long and 70 cm wide (2.1m^2) in one side of the ridge in hills distanced 25 cm. Seedlings were thinned to one plant / hill three weeks after sowing.

The dates of flowering were recorded as the numbers of days to tasseling (TD) and silking (SD) of 50% plants per plot. The difference between these dates was considered as anthesis-silking interval (ASI). 100 Kernel weight (KI) and grain moisture content (GMC) were recorded. Harvested grain yield per plant (GYP) adjusted to15.5% grain moisture.

Proline content was determined according to Bates *et al.* (1973) by using leaf sample (0.5 g) at flowering stage and homogenized in 10 ml of 3 % aqueous sulfosalicyclic acid (extracted solution), and filtered through Whatman's No. 2 filter paper. In a test tube, two ml of filtrate was mixed with 2 ml of acid-ninhydrin and 2 ml of glacial acetic acid. The mixture was placed at 100ºC in a water bath for 1 h, then placed 15 minutes in the snow path to stop the reaction. The reaction cooled to room temperature, then 4 ml toluene had add and mixed for 15-20 minutes, the proline was collected with toluene layer. The absorbance was measured at 520 nm UV spectrometer. Suitable proline standards curve have been included for calculation its concentration in the sample. The proline concentration was calculated from a standard curve and determined as follows, based on fresh weight:

µmoles proline/ g of fresh weight material = [(µg proline/ml × ml toluene) / 115.5 µg/µmole]/[(g sample)/5].

Stress susceptibility index (SSI) and Stress tolerance index (STI) were calculated according to Fernandez (1992) as the following formulae:

$$\textbf{SSI} = [\mathbf{1}-\left(\frac{YiS}{YiN}\right)]/[\mathbf{1}-\left(\frac{\mathbf{YS}}{\mathbf{YN}}\right)]$$

$$\textbf{STI} = \frac{(YiN)(YiS)}{(YN)^{\wedge}2}$$

Where:

Y_{iN} = the yield of genotype I under normal regime of a given rep.

Y_{iS} = the grain yield of genotype I under stressed regime of a given rep.

Y_N = the mean of grain yield a given replicate under normal regime.

Y_S = the mean of grain yield a given replicate under stress regime.

Hierarchical cluster analysis was performed using SD, ASI, KI, GYP, GMC, Proline, SSI and STI of normal and stress watering regimes in descending order. The cluster analysis aims to group observations according to cluster groups, so that each group contains as homogeneous observations as possible in relation to the clustering variables used. Cluster analysis is used to classify a group of individuals or experimental units into subgroups defined specifically and without intersection .Such analysis and dendrogram were carried out using SPSS Software version 23 based on Euclidean method (Sokal and Michener, 1958).

Principal components analysis considered a tool to check multivariate data, thus, it use a mathematical method that is based on converting a set of explanatory variables that are related to each other into a new set of unrelated variables (orthogonal) that namely the principal components. Each of these new variables is a linear mathematical combination of all the original explanatory variables. Data was collected for the dimensional reduction of the Principal Components Analysis (PCA) and to know the significance of different traits in describing multivariate polymorphism (Sneath and Sokal, 1973). Principal component analysis and correlation processed using SPSS Software version 23.

RESULTS AND DISCUSSION

Cluster Analysis

The dendrograms and mean performance of formed maize inbreds groups according to cluster analysis based on SD, ASI, KI, GYP, GMC, Proline content (mg gr^{-1}) of leaf fresh weight, SSI and STI under either normal or stressed watering regimes are presented in Table (1) and Figs. 1 .

Table 1. Performance of clustering the maize inbred lines based on SD, ASI, KI, GYP, GMC, Proline, SSI and STI grown during 2019 summer season under normal (N) and stressed (S) watering trials.

Traits	**Normal**					
	Group A (31)		**Group B (19)**		**Group C (10)**	
	Mean	**CV%**	**Mean**	**CV%**	**Mean**	**CV%**
SD	66.6	2.3	66.4	2.8	67.0	2.5
ASI	2.1	30.5	2.2	30.0	2.5	6.5
KI	36.5	4.8	32.3	6.2	45.8	7.9
GYP	164.8	5.5	128.0	9.2	216.0	9.7
GMC	24.5	7.1	23.6	4.9	26.8	5.0
Proline	2.36	31.1	2.41	33.3	2.63	30.4
SSI	1.426	60.7	0.983	38.1	2.201	73.3
STI	1.362	13.4	0.861	20.4	2.247	28.4
	Stress					
Traits	Group A (30)		Group B (25)		Group C (5)	
	Mean	CV%	Mean	CV%	Mean	CV%
SD	69.3	2.4	68.9	2.2	70.1	2.4
ASI	2.8	30.7	2.7	37.5	3.1	44.8
KI	33.0	7.6	28.9	6.2	39.3	8.2
GYP	150.5	5.5	116.9	10.2	203.8	7.5
GMC	22.4	5.7	22.4	6.3	22.7	5.0
Proline	3.06	21.4	3.24	26.4	3.13	31.1
SSI	1.354	55.6	1.527	84.0	1.217	52.0
STI	1.481	14.7	0.918	20.9	2.736	15.8

At 5% level of probability cluster analysis grouped the studied fifty S_3 developed inbreds plus the ten S_{10} of ARC inbred lines under both investigated conditions into three groups. These three classes may be designated as lower (LP), medium (MP) and higher (HP) performed group referred to grain yield traits. It's worthy to mention that under normal condition the two HP clusters are considered one group comprises ten inbreds. The mean performances of each group are corresponding to the coefficient of variability (CV % = (Standard deviation/mean) ×100) as a common measure of variation of member's inbreds performances of studied traits.

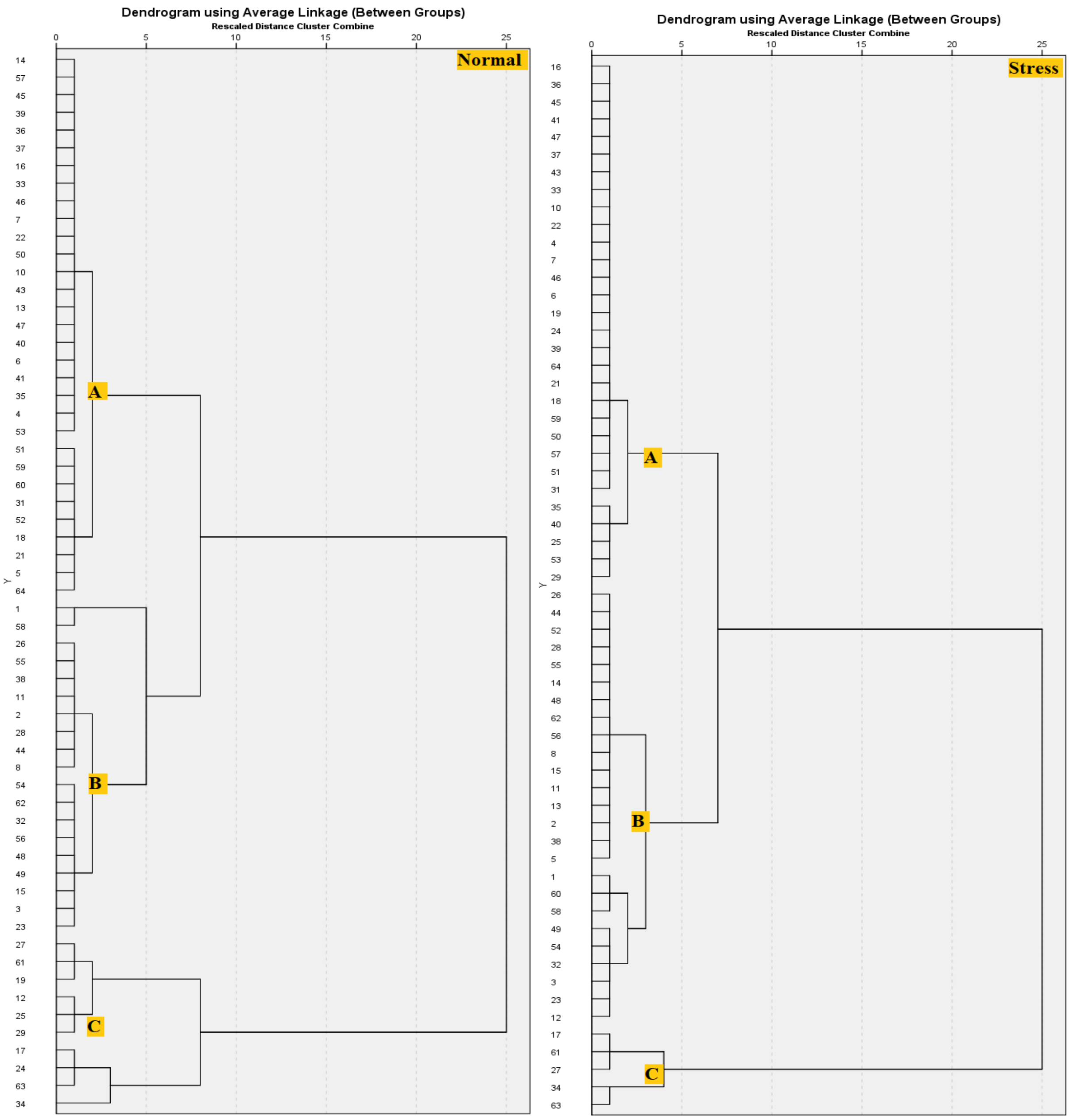

Fig.1. Dendrogram of average linkage clustering of the maize inbred lines grown under normal and stress conditions during 2019summer season, for SD, ASI, KI, GYP, GMC, Proline, SSI and STI.

Accordingly, under normal watering regimes, the group (B) as lower performed (LP) includes 19 lines, produced the lowest grain yield (128.0 g) with lighter seed wt. and most dried kernels (23.6%) coupled with least stress susceptible (SSI) and tolerance (STI) indices, whereas this group is intermediate for ASI and proline content in the fresh leaves. The HP group (C) comprises ten inbreds and produced the higher GYP corresponding with later silking date (at day 67.0), longer ASI (2.5 days), higher 100 kernel-wt. (45.8 g), higher grain moisture content (GMC=26.8) and proline leaf content (2.63 mgg^{-1}) with higher tolerance index (2.247) than SSI (2.201). On the other hands, the medium performed (MP) group performed intermediately for all tabulated traits. Concerning CV% as a measure of dispersion the performances membered inbreds of the group around the corresponding mean, it's the lowest percentages for SD, KI, GYP and GMC in all clustered groups. However, moderate CV% (≈ 30%) for ASI in LP and MP, leaf proline content in the three formed groups, SSI in LP and STI in LP and HP. The rest cases, i.e. SSI in MP and HP showed highest CV% (more than 60%), which may be an indication of wider variation of inbreds attributes of and overlapping them to the performance of other groups. On the other hands, the lower CV% proved that clustered lines greatly not overlapped to other group for the given traits. Based on this point of view, it may be concluded that the grouping of the investigated maize inbreds using their performance under normal watering regimes is conducted on flowering dates and grain yield attributes.

Under stressed watering regime, the cluster analysis formed the investigated lines into three groups also, groups A, B and C that included 30, 25 and 5 inbreds, respectively. Group A, B and C exhibited medium (MP), lower (LP) and higher (HP) performance, respectively. The plants of higher performed group (HP) silked later (at day 70.1) with longer

ASI (3.1) and heavier kernels (KI=39.3) as well as higher GYP (203.8 g) than other two groups (LP & MP).

The stress tolerance index (STI) is much higher than counterpart calculated SSI in HP under drought conditions and vice versa for LP. However, such two indexes, i.e. SSI and STI are similar for MP under stressed regime likewise for all formed groups under normal conditions. Therefore, the screening process of inbreds grown under stressed watering regime by cluster analysis take into consideration the level of tolerance/susceptibility in addition to flowering and grain yield.

Regarding CV%, all coefficients of variability are lower in magnitudes except for ASI (30-45%), leaf proline content mg g^{-1}fresh wt. (≈ 25%) and higher more than 52% for SSI in all groups in spite of lower CV% than 21 for STI in all groups of inbreds under stressed irrigation. Thus there is an opportunity to upgrade the ASI, proline content, drought susceptibility and tolerance of higher performed (HP) S_3 inbred lines.

The code (line #) and their parental origins (PO) of inbred lines membered to LP, MP and HP groups according to cluster analysis of obtained data under normal (N) and stressed (S) watering trials are presented in Table (2).

The higher performed groups under both investigated conditions possessed five common inbred lines; two of them are belonged to S_{10} of ARC inbreds (I.278 and I.280), one selected from the sib population of I.278×G.2, one developed from the sib population of I.273×TWC310 and the last one from G.2. The rest five lines of higher performed group under normal regime came from MP group (except line #12) of stressed condition. Concerning the lines belonged to MP or LP groups about 26 lines (84%) of the tested lines and 19 inbreds (76%) are common between the similar groups of both regimes. Thus reliable drought tolerance coupled with proper performance could be guaranteed from selection either under each of normal or stressed conditions.

Table 2. Code (line #) and their parental origins (PO) of inbred lines membered to HP, MP and LP groups according to cluster analysis of obtained data of normal (N) and stressed (S) watering trials.

PO	Line #	PO	Line #	PO	Line #	PO	Line #
Higher Group C (10) (N)				Higher Group C (5) (S)			
Giza2	17	I.278	61	Giza2	17		
I.278×Giza2	24	Giza2	19	I.278	61		
I.280	63	Giza2	12	I.278×Giza2	27		
I.273×TWC310	34	I.278×Giza2	25	I.273×TWC310	34		
I.278×Giza2	27	I.278×Giza2	29	I.280	63		
Medium Group A (31) (N)				Medium Group A (30) (S)			
Giza2	14	I.273×TWC310	40	Giza2	16	I.273×TWC310	39
I.274	57	I.280×TWC310	6	I.273×TWC310	36	I.281	64
C.1	45	I.273×TWC310	41	C.1	45	Giza2	21
I.273×TWC310	39	I.273×TWC310	35	I.273×TWC310	41	Giza2	18
I.273×TWC310	36	I.280×TWC310	4	C.1	47	I.276	59
I.273×TWC310	37	C.1	53	I.273×TWC310	37	C.1	50
Giza2	16	C.1	51	I.273×TWC310	43	I.274	57
I.278×Giza2	33	I.276	59	I.278×Giza2	33	C.1	51
C.1	46	I.277	60	I.280×TWC310	10	I.278×Giza2	31
I.280×TWC310	7	I.278×Giza2	31	Giza2	22	I.273×TWC310	35
Giza2	22	C.1	52	I.280×TWC310	4	I.273×TWC310	40
C.1	50	Giza2	18	I.280×TWC310	7	I.278×Giza2	25
I.280×TWC310	10	Giza2	21	C.1	46	C.1	53
I.273×TWC310	43	I.280×TWC310	5	I.280×TWC310	6	I.278×Giza2	29
Giza2	13	I.281	64	Giza2	19		
C.1	47			I.278×Giza2	24		
Lower Group B (19) (N)				Lower Group B (25) (S)			
I.280×TWC310	1	I.273	56	I.278×Giza2	26	I.280×TWC310	2
I.275	58	C.1	48	I.273×TWC310	44	I.273×TWC310	38
I.278×Giza2	26	C.1	49	C.1	52	I.280×TWC310	5
I.272	55	Giza2	15	I.278×Giza2	28	I.280×TWC310	1
I.273×TWC310	38	I.280×TWC310	3	I.272	55	I.277	60
I.280×TWC310	11	I.278×Giza2	23	Giza2	14	I.275	58
I.280×TWC310	2			C.1	48	C.1	49
I.278×Giza2	28			I.279	62	C.1	54
I.273×TWC310	44			I.273	56	I.278×Giza2	32
I.280×TWC310	8			I.280×TWC310	8	I.280×TWC310	3
C.1	54			Giza2	15	I.278×Giza2	23
I.279	62			I.280×TWC310	11	Giza2	12
I.278×Giza2	32			Giza2	13		

Principal component analysis

The coefficients of the principal components of the formed LP, MP and HP groups by the cluster analysis under normal and stress conditions are presented in Table (3). The principal components are derived from the original data and had residual sources greater than one according to scree plot (Fig.2). Under stress regime four, three and three components are derived for groups A, B and C, respectively according to scree plot. The components under normal conditions contributed nearly 68.94%, 80.04% and 76.85%, whereas under stressed regime showed 77.84%, 70.37% and 90.86% of the total variation.

The first factor under normal included KI, GYP and STI for each group A, B and C which recorded 30.85%, 36.96% and 37.33% of the total variability for each groups, respectively. The suggested name of this factor was yield components with highly STI. On another hand, factors 2, and 3 which recorded (21.72 and 16.37%), (26.13 and 16.95%) and (22.20 and 17.32%) of variability among all studied factors under each groups, respectively. Thus suggested name for factors 2 and 3 were flowering traits with grain moisture and proline content with SSI, respectively.

On the other side, under stress watering regime, the components are 4, 3 and 3 for groups A, B and C, respectively. The first factor for group A and B included KI, GYP and STI plus SD for group B only, which showed 28.64 and 30.40% of the total variability, respectively. So the suggested name of this factor was yield components with STI. However for HP group C, the first factor included GYP, GMC and STI which contribute about 44.39% of total variability wherefore it will namely yield with drought tolerance.

Similar trend for factor 2 for group A and B which included SD, ASI and (proline content just for group A) and (GMC just for group B). The factor 2 of HP group C included SD, KI, GMC and proline which contribute by about 30.11% of total variability. We suggest critical traits as a name of this factor. ASI only become in the factor 3 of group C which contribute 16.35% of total variability so it may name critical period of maize life.

According to PCA results it could be noticed that STI play a great role with GYP and KI (yield and yield component) under either normal and stress conditions which consider the main factor (factor 1) and that contributes the higher value from total variations. So selection according these traits may be effective.

Table 3. Component matrix for studied traits of 60 maize genotype under normal (N) and stressed (S) trails during 2019 season.

Traits	Normal: Components of Medium Group (A)			Components of Lower Group (B)			Components of Higher Group (C)		
	1	2	3	1	2	3	1	2	3
SD	0.10	0.86	-0.13	0.39	0.76	-0.01	0.47	-0.06	0.43
ASI	0.29	0.22	-0.55	0.47	0.70	0.30	-0.52	0.62	-0.45
KI	0.81	-0.02	0.22	0.78	-0.44	0.02	0.72	0.34	0.49
GYP	0.79	-0.12	0.47	0.91	-0.29	-0.10	0.75	0.46	-0.22
GMC	0.09	0.81	0.33	0.42	0.68	-0.25	0.24	0.81	0.14
Proline	0.08	0.50	-0.17	0.19	-0.37	0.81	-0.65	0.48	-0.14
SSI	-0.41	0.12	0.76	0.26	-0.35	-0.73	-0.50	0.41	0.61
STI	0.96	-0.10	-0.08	0.93	-0.15	0.10	0.83	0.12	-0.54
Factor Var.%	30.85	21.72	16.37	36.96	26.13	16.95	37.33	22.20	17.32
Cumm. Var. %	30.85	52.57	68.94	36.96	63.09	80.04	37.33	59.54	76.85

Traits	Stress: Components of Medium Group (A)				Components of Lower Group (B)			Components of Higher Group (C)		
	1	2	3	4	1	2	3	1	2	3
SD	-0.02	0.66	-0.01	-0.27	0.61	0.56	-0.13	-0.64	0.71	-0.21
ASI	0.29	0.77	0.08	-0.22	0.47	0.61	-0.39	-0.79	0.19	0.55
KI	0.68	-0.33	0.30	-0.09	0.70	-0.29	-0.26	-0.72	0.65	0.15
GYP	0.78	-0.19	-0.06	-0.48	0.67	-0.63	-0.19	0.76	0.43	0.46
GMC	0.29	-0.18	0.75	0.39	0.37	0.72	0.01	0.85	0.50	-0.15
Proline	0.19	0.57	0.51	0.20	0.34	-0.15	0.22	0.08	0.72	-0.69
SSI	0.39	0.24	-0.51	0.72	0.17	0.32	0.88	0.10	-0.57	-0.34
STI	0.93	0.01	-0.31	0.07	0.79	-0.35	0.42	0.81	0.40	0.34
Factor Var.%	28.64	19.79	16.10	13.31	30.40	24.21	15.75	44.39	30.11	16.35
Cumm. Var. %	28.64	48.43	64.54	77.84	30.40	54.61	70.37	44.39	74.51	90.86

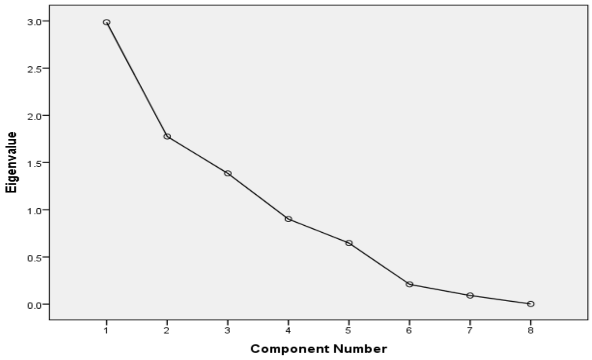

Fig. 2. Scree Plot showing eigenvalues response to number of components for the studied traits of means of 60 maize inbreds.

Correlation coefficients

The simple correlation coefficients among the traits of different constructed of groups under either normal or stressed conditions are display in Table (4).

Similar significant positive correlations are detected among SD with (ASI and GMC), ASI with (GMC), KI with (GYP and STI) and GYP with (STI) of lower performed (LP) groups under normal and stress conditions.

However, different correlations are exhibited in medium performed (MP) groups between normal and stress conditions. Under normal conditions significant positive correlations are present between SD with GYP, KI with each of GYP and STI, and GYP with STI. However, negative significant correlation coefficient is calculated between SSI with STI (r = -0.55**). But this medium performed group under stressed, the traits recorded significant positive correlation among ASI with proline, KI with each of GYP, GMC and STI, GYP with STI and SSI with STI.

For the higher performed group of maize inbreds under normal condition, the traits showed significant positive correlations between ASI with proline and GYP with STI, whereas it is negatively significant between SSI with STI (r = -0.71*). However, under stress condition recorded significant positive correlation coefficients between SD with each of KI and GYP with STI.

The interrelationships among the traits of formed groups due to per se performance by cluster analysis are variable with an obvious common highly significant positive correlation between GYP and STI. Thus it could be concluded that these inbred lines exhibited distinct clusters with sufficient genetic variation for upgrading by selection according the first part of published work (Darwish *et al*., 2020).

It's obvious that cluster analysis seems to be effective for classifying the maize inbred lines during the early generation of development. This finding is in harmony with reports of Tanavar *et al.* (2014), Ali *et al.* (2015&2016), Bin Mustafa *et al.* (2015), Suryanarayana *et al.* (2017), Hefny *et al.* (2017) Rafique *et al.* (2018) and Mounika *et al.* (2018)

The selection among these inbred lines may be effective either under stressed or normal watering regimes for grain yield will be reflected positively on drought tolerance. However, it's required to check general combining ability as the main tasks of screening inbred lines for the validity in maize hybrid programs.

Table 4. Correlation coefficients among different traits of variable clustered maize inbred lines groups under normal (N) and stressed (S) trials during 2019 season.

	LP Group (B) in Normal							**LP Group (B) in Stress**						
Traits	**SD**	**ASI**	**KI**	**GYP**	**GMC**	**Proline**	**SSI**	**SD**	**ASI**	**KI**	**GYP**	**GMC**	**Proline**	**SSI**
ASI	.64**							.54**						
KI	-.12	.10						.28	.21					
GYP	.16	.15	.76**					.07	.00	.53**				
GMC	.47*	.55*	.10	.16				.48*	.48*	-.03	-.13			
Proline	-.17	.10	.28	.14	-.32			.02	.01	.16	.18	.11		
SSI	-.08	-.22	.29	.35	-.01	-.22		.18	.01	-.08	-.30	.18	.04	
STI	.28	.28	.71**	.94**	.23	.25	.14	.22	.02	.45*	.75**	.07	.24	.39
	MP Group (A) in Normal							MP Group (A) in Stress						
ASI	.25							.34						
KI	.03	.11						-.01	-.03					
GYP	-.09	.07	.58**					-.11	.14	.44*				
GMC	.58**	-.04	.04	.11				-.11	-.04	.38*	.03			
Proline	.22	.07	.10	-.07	.20			.12	.36*	-.03	.02	.23		
SSI	-.03	-.20	-.12	.08	.17	-.06		.04	.09	.02	-.08	-.02	.05	
STI	.04	.19	.65**	.74**	.02	.01	-0.55**	-.03	.21	.46*	.74**	.07	.06	.56**
	HP Group (C) in Normal							HP Group (C) in Stress						
ASI	-.32							.56						
KI	.47	-.39						.93*	.81					
GYP	.17	.06	.54					-.26	-.25	-.18				
GMC	-.03	.16	.49	.37				-.16	-.67	-.31	.79			
Proline	-.11	.68*	-.31	-.37	.19			.61	-.31	.31	.04	.53		
SSI	-.09	.30	.01	-.14	.19	.25		-.25	-.24	-.37	-.20	-.17	-.18	
STI	.23	-.11	.35	.78**	.20	-.35	-0.71*	-.26	-.34	-.23	.99**	.84	.12	-.08

***and ** designated significant correlation coefficients at 5% and 1% levels, respectively.**

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التحليل متعدد المتغيرات لسلالات الذرة الشامية تحت أنظمة الري العادي والإجهادى

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تم تقييم خمسين سلالة من الذرة الشامية البيضاء في الجيل الذاتى الثالث، مقارنة مع عشر سلالات من مركز البحوث الزراعية منتخبة فى الجيل العاشر لتحمل لجفاف، وذلك تحت ظروف الري العادي وظروف الرى الجفافى خلال الموسم الصيفى للعام ٢٠١٩ بغرض دراسة صفاتها الانتاجية و تحملها او حساسيتها للجفاف و ذلك بإستخدام طرق التحليل الإحصائي متعدد المتغيرات و على الخصوص التحليل العنقودي و تحليل المكونات الرئيسية . حيث تم دراسة صفات عدد الايام حتي طرد ٥٠% من الحريرة والفترة بين انتشار اللقاح وطرد الحريرة، دليل وزن الحبوب (وزن الـ ١٠٠ حبة) و محصول النبات و محتوي الحبوب من الرطوبة ومحتوي الورقة من البرولين ودليل الحساسية للجفاف و دليل تحمل الجفاف. قَسم التحليل العنقودي الستون سلالة إلي ثلاث مجموعات تحت كل من الري الري العادي والاجهادى. وأمكن تحديدهم كمجموعة منخفضة الأداء LP ومجموعة متوسطة الأداء MP والأخيرة عالية الأداء HP بالنسبة لمحصول الحبوب ومكوناته. أظهرت نتائج التحليل العنقودى لبيانات تجربة الرى العادى ان تقسيم السلالات الى مجموعات (العنقدة) تتم على اساس مكونات المحصول و مواعيد ظهور الحراير و الفترة من انتشار اللقاح الى ظهور الحريرة، بينما كانت العنقدة لبيانات سلالات تجربة الاجهاد الرطوبى مبنية على اساس مدى تحمل او قابلية السلالات للإجهاد الرطوبى إضافة إلى خصائص التزهير و غلة الحبوب. إلا أنه لوحظ أن ٧٦ % و ٨٤% و ٥٠% من السلالات كانت مشتركة بين المجموعات المنخفضة و المتوسطة و المرتفعة الأداء بين كل من تجربتى الرى العادى و الرى الجفافى وذلك يشير إلى فاعلية متوقعة للأنتخاب فى أى من الظروف العادية الرطوبة أو ذات الاجهاد الرطوبى لتحسين أداء السلالات و تحملها للإجهاد الرطوبى.أظهر تحليل المكونات الرئيسية أن دليل تحمل الجفاف يلعب دورا كبيرا مع غلة الحبوب و مكوناتها سواء تحت ظروف الرى العادى او الرى الإجهادى و ذلك نتيجة مساهمته العالية فى التباينات الكلية.أظهرت معاملات الارتباط البسيط بين صفات كل مجموعة من مجموعات التحليل العنقودى تباينات فى طبيعة علاقات الصفات بين تجربتى الرى العادى و الرى الاجهادى إلا انه كان هناك علاقة مشتركة فى كل الحالات و هى الارتباط الموجب بين محصول الحبوب و دليل تحمل الجفاف بما يدل الى ضرورة تأهيل السلالات المتميزة من تلك المجموعة الى أختبار القدرة العامة على التآلف وذلك للوقوف على إمكاناتها لإستنباط هجن مبشرة من الذرة الشامية.