Genetic association among various morpho-physiological traits of *Zea mays* under drought condition

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Abstract: Genetic association among various morpho-physiological attributes of maize under water stressed conditions was carried out in the research area of Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan during 2009-10. Six generations of maize cultivars were grown under two moisture stress levels i.e., 100% and 50% of the field capacity to checkout their morphological and physiological traits under water stressed conditions. Significant genotypic and phenotypic correlations were reported among grain yield and its contributing traits. It was concluded from results that stomata frequency, stomata size, cell membrane thermostability, leaf temperature, excised leaf water loss, plant height, leaf area, biomass per plant, cob girth, 100-grain weight, grain yield per plant may be helpful for the development of higher grain yield maize genotypes under drought conditions. Grain yield per plant and its attributes may be used for the improvement of crop yield and production under water stress conditions.

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1. Introduction

Zea mays is an important cereal crop consumed as livestock feed, human food and as a raw material in various industrial products. It ranks third after wheat and rice for its grain production in Pakistan. Maize is grown in almost all the provinces of the country. In Pakistan, It was grown on an area of 1083 thousand hectares with the annual production of 4271 thousand tons (Anonymous, 2012). Maize grain is rich source of starch 72%, protein 10%, oil 4.8%, fiber 5.8%, sugar 3.0% and ash 1.7% (Chaudhary, 1983). Maize is cultivated two times in a year in Pakistan (autumn and spring). With the active involvement of multinationals in Pakistan, the cultivation of spring maize has been increased. Although the climatic and soil conditions of Pakistan are most responsive for maize production but there is still very low grain yield as compared to other maize producing countries of the world. As it was an established fact that management inputs like improved seed, irrigation, varieties, planting pattern, sowing time, plant population and balanced use of fertilizers have an effective role in the improvement of crop yield. Maize is generally grown under irrigated condition in Pakistan and due to shortage of rains, water has become scarce. Limitation on water use is being imposed in every crop (Ali *et al*., 2011a,d,f; Hussain *et al*., 2012 and Hussain *et al*., 2013). Maize is suffers from drought stress between anthesis and grain filling (40-80% yield loss). Drought is considered to be a major factor affecting plant growth and yield. There is a need to recognize suitable executive techniques in maize that can resist stress conditions. It is a high water demanding crop and can give high production when water and nutrients are in sufficient amount. Additionally, maize is sensitive to water stress (Ali *et al*., 2011a,b,c; Ali *et al*., 2012a,b; Ali *et al*., 2013d; Ali *et al*., 2013a,b,c; Ahsan *et al*., 2013 and Ali *et al*., 2014) and other environmental stresses around anthesis period (Ali *et al*., 2012b). Present study was conducted to estimate genotypic and phenotypic correlation for various morpho-genetic traits of crosses and parents of maize under normal and water stress conditions.

2. Material and methods

The present study was conducted in the research area of Department of Plant Breeding and Genetics, University of Agriculture Faisalabad. Two lines (one drought tolerant and one susceptible) were selected as parent P_1 (WFTMS) and P_2 (Q66) respectively. Each entry was planted by keeping row/row and plant/plant distances of 75 and 25 cm respectively, in each replication. Normal agronomic and crop husbandry practices were followed to raise the crop.

2.1. Development of F_1 generation

The P_1 and P_2 were sown in the field under optimum conditions during spring 2009. Normal agronomic practices were followed to raise the crop. Tolerant and susceptible parents were crossed to develop F_1. Parent P_1 was used as male because it was found good pollen producer; while parent P_2 was used as female.

2.2. Development of F_1, F_2, BC_1, BC_2 generation

The P_1, P_2 and F_1 were grown in the next cropping season autumn 2009. At maturity F_1 plants were selfed.

This selfed seed was the source of F_2 population. The F_1 plants were also crossed with the parents P_1 and P_2 to develop BC_1 and BC_2 respectively. F_1 was also be developed by crossing P_1 and P_2.

2.3. Breeding from basic sex generations, P_1, P_2, F_1, F_2, BC_1 and BC_2

The experiment was sown at the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during the year 2010. The experimental material was planted in field. The seeds of all the generations such as P_1, P_2, F_1, F_2, BC_1 and BC_2 were planted in nested block design with three replications. Two contrasting water levels i.e., normal and water stressed were applied to all generations in nested block design. Each entry was planted by keeping row/row and plant/plant distances of 75 and 25 cm respectively in each replication. Normal agronomic and crop husbandry practices were followed to raise the crop. Data was recorded for cell membrane thermostability, stomata conductance, stomata frequency, stomata size, excised leaf water loss, leaf temperature, plant height, cobs per plant, cob girth, cob length, 100-grain weight, grains per ear row and grain yield per plant.

2.4. Statistical analysis

Data was statistically analyzed by using Kwon and Torrie (1964) correlation analysis technique.

3. Results and discussions

The estimates of correlation among traits are useful for planning a breeding program to synthesize a genotype with desirable traits. Correlation was determined among agronomic and the traits related to normal and drought condition. One very large F_2 segregating population (150 plants from population) involving parents with contrasting traits were used in correlation studies. In F_2 generation, alleles of parental traits are recombined so, the correlation among the traits reflects linkage relationship. Generally the correlation from the pair of traits among the generations was consistent. However, in a few cases correlation was significant for a traits in cross but was non-significant in the other. This may be due to difference in allele combinations of the parents involved in the generations. Correlation matrix among the traits in various crosses is given in tables. Correlation matrix is show only for the traits showing significant differences among the generations in a cross. Cell membrane thermostability was positively correlated with stomata conductance, leaf water potential, excised leaf water loss, plant height, leaf area, cob length, cob girth, rows per ear, grain per ear row, biomass per plant, 100-grain weight and grain yield and it had negatively correlated with stomata size under normal condition at genotypic and phenotypic level (Table 1 and 2). Under drought condition it had positively correlated with stomata conductance, leaf water potential, Excised leaf water loss, leaf temperature, plant height, leaf area, cob length, cob girth, rows per ear, grain per ear row, biomass per plant, 100-grain weight and grain yield and it was negatively correlated with stomata frequency and stomata size at genotypic and phenotypic level (Table 3 and 4). Similar results were found by Aslam *et al*. 1999; Ali *et al*., 2011a,b,c; Ali *et al*., 2012a,b; Ali *et al*., 2013d; Ali *et al*., 2013a,b,c; Ahsan *et al*., 2013 and Ali *et al*., 2014).

Stomata conductance had positive correlation with leaf temperature, plant height, leaf area, cob length, cob girth, rows per ear, grain per ear row, biomass per plant, 100-grain weight and grain yield while negatively correlated with stomata frequency and stomata conductance under normal condition at genotypic and phenotypic level (Table 1 and 2). Under drought condition showed positively correlated with leaf water potential, Excised leaf water loss, leaf temperature, plant height, leaf area, cob length, cob girth, rows per ear, biomass per plant, 100-grain weight and grain yield per plant and it had negatively correlation with stomata frequency and stomata size at genotypic and phenotypic level (Table 3 and 4). Similar results were found by Aslam *et al*. (1999); Kumar *et al*. (2005); Ali *et al*., (2011a,b,c); Ahsan *et al*., (2013) and Ali *et al*., (2014). The control of leaf stomata conductance is a crucial mechanism for plants, since it was essential for both CO2 acquisition and desiccation prevention. Studies with maize have shown that some drought tolerant genotypes reduce stomata conductance more on the onset of drought (Ali *et al*., 2011a,b,c; Ali *et al*., 2012a,b; Ali *et al*., 2013d; Ahsan *et al*., 2013 and Ali *et al*., 2014).

Stomata frequency had positively correlated with stomata size and negatively correlation with Excised leaf water loss, plant height, leaf area, cob length, cob girth, rows per ear, grain per ear row, biomass per plant, 100-grain weight and grain yield per plant under normal condition at genotypic and phenotypic level (Table 1 and 2). Under drought condition it was positively correlated with stomata size but negatively correlated with leaf water content, excised leaf water loss, leaf temperature, plant height, leaf area, cob length, cob girth, rows per ear, grain rows per ear and 100-grian weight at genotypic and phenotypic level (Table 3 and 4). Aslam *et al*. (1999) studied ten elite maize inbred lines to estimate genotypic and phenotypic correlation coefficients and concluded that stomata frequency showed significant and positive genotypic correlation with grain yield while it had non significant and positive phenotypic correlation with grain yield. Stomata size showed negatively correlation with leaf area, cob length, cob girth, rows per ear, grain rows per ear, biomass per plant and 100-grian weight under normal condition at genotypic and phenotypic level (Table 1 and 2). It had negatively correlation with excised leaf water loss, leaf temperature, plant height, leaf area, cob length, cob girth, rows per ear, grain rows per ear and 100-grian weight under drought condition at genotypic and phenotypic level (Table 3 and 4). The negative genotypic and phenotypic correlations indicated that the overall effects of stomata size on grain yield were adversely harsh to reduce grain yield per plant. Similar results were obtained by Aslam *et al*. (1999); Jabeen *et al*. (2008) and Kumar *et al*. (2005).

Leaf water potential was found to be positively correlated with cell membrane thermostability, excised leaf water loss, leaf area, plant height, cob length, cob girth, rows per ear, grains per ear row, leaf temperature, biomass per plant, 100-grian weight and grain yield per plant at genotypic and phenotypic level under normal (Table 1 and 2). Leaf water potential had positive correlation with cell membrane thermostability, excised leaf water loss, stomata conductance, plant height, cob length, cob girth, rows per ear, leaf temperature, grain per ear row, biomass per plant, 100-grain yield and yield per plant at genotypic and phenotypic level under drought conditions (Table 3 and 4). Similar results were reported by Ahmad *et al*. (2006). Higher leaf water potential indicated effect of drought on plant that caused cell plant to manage to be turgid under drought at earlier stages. Selection on the basis of leaf water potential may be helpful for the improvement of grain yield under drought conditions.

Excised leaf water loss was positively correlated with cell membrane thermostability, plant height, cob length, cob girth, rows per ear, grains per ear row, biomass per plant, 100-grian weight and grain yield per plant at genotypic and phenotypic level under normal (Table 1 and 2). Excised leaf water loss had positive correlation with plant height, cob length, cob girth, rows per ear, grain per ear row, biomass per plant, 100-grain yield and yield per plant at genotypic and phenotypic level under drought conditions (Table 3 and 4). Similar results were reported by Kumar (2005); Ahmad *et al*. (2006); Ali *et al*., (2011f); Ali *et al*., (2012a,b) and Ali *et al*., 2014. Higher excised leaf water loss indicated effect of drought on plant that caused cell damage and death of plant under drought at earlier stages. Ahmed *et al*. (2006) analyzed the parents, F2 and backcross generations from two wheat crosses to determine correlation of physio-morphic traits (excised leaf water loss, relative water content, plant height and 100-grain weight under drought conditions and estimated positive correlation for traits excised leaf water loss and plant height which indicated that selection should lead to a fast genetic improvement. Leaf temperature had negative correlation with plant height, cob length, cob girth, rows per ear, grain per ear row, biomass per plant and yield per plant under normal condition. Results of the study in drought conditions presented positive correlation of leaf temperature with plant height, leaf area, cob length, cob girth, rows per ear, grain per ear row, biomass per plant, 100-grian weight and grain yield per plant. Correlation analysis indicated that leaf temperature response to water stress played an integral role in maize biomass accumulation (Ali *et al*., 2012a,b; Ali *et al*., 2013d; Ali *et al*., 2013a,b,c; Ahsan *et al*., 2013 and Ali *et al*., 2014).

Plant height showed positive genotypic and phenotypic correlations with cell membrane thermostability, stomata conductance, leaf water potential, excised water loss, rows per ear, biomass per plant, cob girth, grain rows per ear, 100-grain weight, cob length, leaf area and grain yield per plant under normal condition (Table 1 and 2). A positive genotypic and phenotypic correlation was found for plant height with grain yield per plant, leaf water potential, leaf temperature, rows per ear, cob length, biomass per plant, grain rows per ear, cob girth, leaf temperature, leaf area and 100-grain weight under drought condition (Table 3 and 4). Similar results were reported by Bruce *et al*. (2002); Afarinesh *et al*. (2006); Ahmad *et al*. (2006); Kumar *et al*. (2006) and Hussain *et al*. (2013). Higher genotypic and phenotypic correlation of plant height with its contributing traits indicated that grain rows per ear, grain size, cob weight, cob length, 100-grain yield, grain yield per plant, cob girth, photosynthetic rate, stomata conductance, leaf temperature and leaf water potential increased that caused to increase grain yield per plant. Selection of higher gain yielding genotypes may be helpful on the basis of grain yield per plant under normal and drought conditions (Bruce *et al*. (2002); Afarinesh *et al*. (2006); Ahmad *et al*. (2006) and Hussain *et al*. (2012)). Ahmed *et al*. (2006) analyzed the parents, F_2 and backcross generations from two wheat crosses and estimated that plant height positively correlated with 100-grain weight, which revealed that height of plant contributed to higher yield under drought conditions. Leaf area was found to be positively correlated with cell membrane thermostability, plant height, cob length, cob girth, rows per ear, grains per ear row, biomass per plant, 100-grian weight and grain yield per plant at genotypic and phenotypic level under normal (Table 1 and 2). Higher correlation of leaf area with plant height, cob length, biomass per plant, and grain yield per plant indicated the higher rate of photosynthesis and accumulation of organic compounds in plant body to enhance grain yield. A positive genotypic and phenotypic correlation of leaf area was found with cell membrane thermostability, plant height, cob length, cob girth, rows per ear, leaf temperature, grains per ear row, biomass per plant, 100-grian weight and grain yield per plant under drought conditions (Table 3 and 4). The higher positive correlations of leaf area with various traits under normal and drought conditions indicated that leaf area is a potential trait for the improvement of grain yield in maize. Results for leaf area are in contradiction with those of

Cob length showed a positive genotypic and phenotypic correlation with cell membrane thermostability, stomata conductance, leaf water potential, plant height, leaf area, cob girth, rows per ear, grains per ear row, excised water loss, biomass per plant, 100-grian weight and grain yield per plant under normal conditions (Table 4.5 and 4.6). A positive genotypic and phenotypic correlation of cob length with cell membrane thermostability, stomata conductance, leaf temperature, leaf water potential, plant height, leaf area, cob girth, rows per ear, grains per ear row, excised water loss, biomass per plant, 100-grian weight and grain yield per plant under drought conditions (Table 4.7 and 4.8). The higher correlation of cob length with morphological and physiological traits indicated the great influence of contributing traits on grain yield per plant. Higher cob length indicated the large number of grain rows per cob, higher cob weight and higher grain yield per plant. The selection of higher yielding maize genotypes on the basis of cob length may be helpful to improve yield. Cob girth was positively correlated with cell membrane thermostability, stomata conductance, leaf water potential, excised water loss, plant height, grain per ear row, biomass per plant, cob length, leaf area, 100-grain weight and grain yield per plant under normal condition at genotypic and phenotypic levels (Table 1 and 2). Similar results were reported by Eissa *et al*. (1983); Saeed *et al.* (2012); Ahmad *et al*. (2006); Golparvar *et al*. (2012); Naveed *et al*. (2012) and Ahsan *et al*. (2013). A higher positive genotypic and phenotypic correlation of cob girth was found with cell membrane thermostability, stomata conductance, leaf water potential, plant height, grain per ear row, biomass per plant, cob length, leaf area, 100-grain weight and grain yield per plant (Table 3 and 4). Higher genotypic and phenotypic correlation of cob girth with its contributing traits indicated that number of grain rows per cob were increased, higher cob weight and number of grains per cob were also higher that caused to increase grain yield per plant. Selection of higher gain yielding genotypes may be helpful on the basis of cob girth under normal and drought conditions. Similar results were obtained by Ahmad *et al*. (2006) and Ali *et al*. (2011a,b,c,d).

Grain rows per ear showed positive genotypic and phenotypic correlations with cell membrane thermostability, stomata conductance, leaf water potential, excised water loss, plant height, grain per ear row, biomass per plant, cob length, leaf area, 100-grain weight and grain yield per plant under normal condition (Table 1 and 2). A positive genotypic and phenotypic correlation was found for grain rows per ear with cell membrane thermostability, stomata conductance, leaf water potential, excised water loss, leaf temperature, plant height, grain per ear row, biomass per plant, cob length, leaf area, 100-grain weight and grain yield per plant under drought condition (Table 3 and 4). Similar results were reported by Saeed *et al*. (2012); Ahmad *et al*. (2006); Kumar *et al*. (2006) and Hussain *et al*. (2013). Higher genotypic and phenotypic correlation of grain rows per ear with its contributing traits indicated that number of grain rows per cob was increased, higher cob weight that caused to increase grain yield per plant. Selection of higher gain yielding genotypes may be helpful on the basis of grain rows per ear under normal and drought conditions. Leaf temperature was also significantly and linearly related to yield reduction ratio under stress and non-stress conditions at the ear emergence stage (Ali *et al*. (2011a,b,c,d)).

Grain per ear row showed positive genotypic and phenotypic correlations with cell membrane thermostability, stomata conductance, leaf water potential, excised water loss, plant height, rows per ear, biomass per plant, cob length, leaf area, 100-grain weight and grain yield per plant under normal condition (Table 1 and 2). A positive genotypic and phenotypic correlation was found for grain rows per row with cell membrane thermostability, stomata conductance, leaf water potential, excised water loss, leaf temperature, plant height, rows per ear, biomass per plant, cob length, leaf area, 100-grain weight and grain yield per plant under drought condition (Table 3 and 4). Similar results were reported by Ahmad *et al.* (2006) and Hussain *et al.* (2012). Higher genotypic and phenotypic correlation of grain per ear row with its contributing traits indicated that grain weight per cob was increased, higher cob girth that caused to increase grain yield per plant. Selection of higher gain yielding genotypes may be helpful on the basis of grain rows per ear under normal and drought conditions (Ahmad *et al.* (2006) and Hussain *et al.* (2013)). Biomass per plant showed positive genotypic and phenotypic correlations with cell membrane thermostability, stomata conductance, leaf water potential, excised water loss, plant height, rows per ear, cob length, leaf area, 100-grain weight and grain yield per plant under normal condition (Table 1 and 2). A positive genotypic and phenotypic correlation was found for biomass per plant with grain rows per row cell membrane thermostability, stomata conductance, leaf water potential, leaf temperature, plant height, rows per ear, cob length, leaf area, 100-grain weight and grain yield per plant under drought condition (Table 3 and 4). Higher genotypic and phenotypic correlation of biomass per plant with its contributing traits indicated that photosynthetic rate, stomata conductance, leaf temperature and leaf water potential increased that caused to increase green fodder and grain yield per plant. Selection of higher gain yielding genotypes may be helpful on the basis of biomass per plant under normal and drought conditions (Bruce *et al.* (2002); Ahmad *et al.* (2006) and Ali *et al.* (2013a,b)).

100-grain yield showed positive genotypic and phenotypic correlations with cell membrane thermostability, stomata conductance, leaf water potential, excised water loss, plant height, rows per ear, biomass per plant, cob length, leaf area and grain yield per plant under normal condition (Table 1 and 2). A positive genotypic and phenotypic correlation was found for 100-grain yield with cell membrane thermostability, stomata conductance, leaf water potential, leaf temperature, plant height, rows per ear, biomass per plant, cob length, leaf area and grain yield per plant under drought condition (Table 3 and 4). Higher genotypic and phenotypic correlation of 100-grain yield with its contributing traits indicated that grain rows per ear, grain size, cob weight, cob length, cob girth, photosynthetic rate, stomata conductance, leaf temperature and leaf water potential increased that caused to increase grain yield per plant. Selection of higher gain yielding genotypes may be helpful on the basis of 100-grain yield under normal and drought conditions (Bruce *et al.* (2002); Afarinesh *et al.* (2006); Ahmad *et al.* (2006); Ali *et al.* (2011a,b,c,d); Ali *et al.* (2012a,b); Bibi *et al.* (2012) and Ali *et al.* (2012a,b)). Grain yield per plant showed positive genotypic and phenotypic correlations with cell membrane thermostability, stomata conductance, leaf water potential, excised water loss, plant height, rows per ear, biomass per plant, 100-grain weight, cob length and leaf area under normal condition (Table 1 and 2). A positive genotypic and phenotypic correlation was found for grain yield per plant with cell membrane thermostability, stomata conductance, leaf water potential, leaf temperature, plant height, rows per ear, biomass per plant, cob length, leaf area and 100-grain weight under drought condition (Table 3 and 4). Higher genotypic and phenotypic correlation of grain yield per plant with its contributing traits indicated that grain rows per ear, grain size, cob weight, cob length, 100-grain yield, cob girth, photosynthetic rate, stomata conductance, leaf temperature and leaf water potential increased that caused to increase grain yield per plant. Selection of higher gain yielding genotypes may be helpful on the basis of grain yield per plant under normal and drought conditions (Bruce *et al.* (2002); Afarinesh *et al.* (2006); Ahmad *et al.* (2006) and Ali *et al.* (2013a,b,c,d)).

Table 1. Correlation coefficients (r_P= phenotypic) under normal condition

Trait	r	SC	SF	SZ	LWP	EWL	LT	PH	LA	CL	CG	RPE	GPER	BPP	HSW	GYP
CMT	rp	0.3911**	-0.41624**	-0.36685**	0.155834	0.15213	0.0735	0.313282**	0.450522**	0.430971**	0.436727**	0.48832**	0.399275**	0.50656**	0.291235**	0.51048**
SC	rp		-0.21725**	-0.34356**	-0.03509	0.08638	0.1549	0.246568**	0.219666**	0.170266	0.208539**	0.21619**	0.197881*	0.22219**	0.249885**	0.232665**
SF	rp			0.31308**	0.000735	-0.1226	0.0315	-0.19379*	-0.26654**	-0.28873**	-0.30315**	-0.32782**	-0.30033**	-0.33482**	-0.17937*	-0.31069**
SZ	rp				-0.07032	-0.02396	-0.07303	-0.01642	-0.19768*	-0.16923	-0.19831*	-0.15631	-0.15706	-0.19359*	-0.10566	-0.20408**

HSW	BPP	GPER	RPE	CG	CL	LA	PH	LT	EWL	LWP
rp	rp	rp	rp	rp	rp	rp	rp	rp	rp	rp
										0.05181
									-0.00774	-0.04974
								-0.14301	0.036614	0.27232**
							0.358152**	-0.02573	-0.00243	0.05863
						0.493082**	0.394271**	-0.19398*	0.014123	0.214831**
					0.726498**	0.524661**	0.550493**	-0.16883	0.013749	0.196061*
				0.61057**	0.60724**	0.5785**	0.42794**	-0.16872	0.00654	0.17534*
			0.556689**	0.586221**	0.525436**	0.526965**	0.488193**	-0.24325**	0.001495	0.10558
		0.6399**	0.62526**	0.61048**	0.56059**	0.66056**	0.57257**	-0.12064	0.02412	0.16164
	0.509582**	0.425323**	0.504676**	0.600833**	0.474824**	0.42437**	0.447522	-0.07507	0.017192	0.149517
0.645495**	0.779256**	0.706513**	0.702373**	0.837234**	0.75351**	0.633478**	0.671687**	-0.18026*	0.026283	0.283769**

CMT: Cell Membrane Thermostability **PH:**Plant Height **LWP:** Leaf Water Potential **RPE:**Rows per Ear
SC: Stomata Conductance **LA:**Leaf Area **LT:** Leaf Temperature **GYP:**Grain per Ear Row
SF: Stomata Frequency **CL:** Cob Length **HGW:**100-grain Weight **GPER:** Grain Yield per Plant
SZ: Stomata Size **CG:** Cob Girth **BPP:** Biomass per Plant **EWL:** Excised Leaf Water Loss

Table 2. Correlation coefficients (r_G= genotypic) under normal codition

Trait	CMT	SC	SF	SZ	LWP	EWL	LT	PH	LA	CL	CG	RPE	GPER	BPP
r	rg	rg	rg	rg	rg	rg	rg	rg	rg	rg	rg	rg	rg	rg
SC	0.4939													
SF	-0.69867	-0.52283												
SZ	-0.42609	-0.42555	0.52497											
LWP	0.170729	-0.04029	0.005065	-0.07342										
EWL	0.17966	0.14245	-0.13849	-0.06121	0.04753									
LT	0.29524	0.56412	0.15966	-0.0601	-0.09193	-0.05813								
PH	0.359209	0.326283	-0.2468	-0.02022	0.3058	0.245445	-0.36562							
LA	0.492345	0.291189	-0.37447	-0.20282	0.05951	-0.0201	-0.09914	0.377349						
CL	0.507336	0.193877	-0.52411	-0.19195	0.249791	0.08374	-0.38806	0.443547	0.549171					
CG	0.497892	0.374955	-0.46492	-0.23693	0.218295	0.105345	-0.41326	0.658794	0.58324	0.951986				
RPE	0.58723	0.25195	-0.47631	-0.1904	0.19768	0.02719	-0.47	0.4794	0.62674	0.74643	0.69499			
GPER	0.519433	0.286835	-0.73683	-0.20898	0.138242	0.036806	-0.5413	0.574622	0.661115	0.700809	0.763756	0.709975		
BPP	0.55252	0.3056	-0.49549	-0.21137	0.1628	0.13708	-0.24539	0.61775	0.6746	0.6316	0.66623	0.67988	0.75728	
HSW	0.390923	0.336399	-0.42443	-0.13071	0.17295	0.134468	-0.13546	0.53612	0.499405	0.60217	0.759085	0.619249	0.420813	0.586471
GYP	0.581017	0.290842	-0.44569	-0.23328	0.294115	0.150112	-0.51992	0.753161	0.676805	0.873802	0.97808	0.749987	0.926913	0.835415

Trait	r	SC	SF	SZ	LWP	EWL	LT	PH	LA	CL	CG	RPE	GPER	BPP	HSW	GYP
HSW	rg															0.779463

CMT: Cell Membrane Thermostability **PH:** Plant Height **LWP:** Leaf Water Potential **RPE:** Rows per Ear
SC: Stomata Conductance **LA:** Leaf Area **LT:** Leaf Temperature **GYP:** Grain per Ear Row
SF: Stomata Frequency **CL:** Cob Length **HGW:** 100-grain Weight **GPER:** Grain Yield per Plant
SZ: Stomata Size **CG:** Cob Girth **BPP:** Biomass per Plant **EWL:** Excised Leaf Water Loss

Table 3. Correlation coefficients (r_P= phenotypic) under drought condition

Trait	r	SC	SF	SZ	LWP	EWL	LT	PH	LA	CL	CG	RPE	GPER	BPP	HSW	GYP
CMT	rp	0.4364**	-0.4315**	-0.46093**	0.196872*	0.21273**	0.38848**	0.563471**	0.5619**	0.582306**	0.375049**	0.48995**	0.545732**	0.39978**	0.379507**	0.586327**
SC	rp		-0.27415**	-0.27984**	0.197824*	0.13209	0.37066**	0.230263**	0.243257**	0.174201*	0.239906**	0.21327**	0.25875**	0.25997**	0.20329*	0.240699**
SF	rp			0.41313**	-0.23569**	-0.21685**	-0.20203*	-0.19308*	-0.1765*	-0.14754	-0.16777	-0.13429	-0.28717**	-0.05726	-0.15914	-0.09601
SZ	rp				-0.01888	-0.22979**	-0.29205**	-0.27069**	-0.22089**	-0.21129*	-0.15411	-0.19737*	-0.20945**	-0.18825*	-0.2034*	-0.24322**
LWP	rp					0.23876**	0.13345	0.115478	0.083737	0.095726	0.147577	0.18666*	0.15256	0.13969	0.238819**	0.083661
EWL	rp						0.02893	0.019542	0.004299	0.016172	0.005966	0.02854	0.024338	-0.00497	0.019653	0.023533
LT	rp							0.235018**	0.188659	0.159359*	0.132592	0.09925	0.276429**	0.11212	0.283495**	0.211653**
PH	rp								0.583325**	0.589784**	0.455373**	0.5634**	0.606505**	0.50567**	0.411165**	0.676928**
LA	rp									0.774503**	0.545473**	0.64564**	0.694611**	0.45745**	0.480705**	0.791284**
CL	rp										0.601165**	0.67533**	0.673603**	0.4327**	0.520039**	0.868536**

	CG	RPE	GPER	BPP	HSW
	rp	rp	rp	rp	rp
	0.51501**				
	0.492968**	0.657123**			
	0.34022**	0.4264**	0.45945**		
	0.367839**	0.392145**	0.519986**	0.301556**	
	0.539198**	0.715046**	0.70764**	0.492402**	0.556063**

CMT: Cell Membrane Thermostability **PH:** Plant Height **LWP:** Leaf Water Potential **RPE:** Rows per Ear
SC: Stomata Conductance **LA:** Leaf Area**LT:** Leaf Temperature **GYP:** Grain per Ear Row
SF: Stomata Frequency **CL:** Cob Length **HGW:** 100-grain Weight **GPER:** Grain Yield per Plant
SZ: Stomata Size **CG:** Cob Girth **BPP:** Biomass per Plant **EWL:** Excised Leaf Water Loss

Table 4. Correlation coefficients (r_G= genotypic) under drought condition

Trait	CMT	SC	SF	SZ	LWP
r	rg	rg	rg	rg	rg
SC	0.4939				
SF	-0.56921	-0.29827			
SZ	-0.79168	-0.35559	0.58561		
LWP	0.250699	0.217973	-0.27702	-0.02508	
EWL	0.29315	0.1666	-0.29042	-0.3283	0.36615
LT	0.54787	0.45338	-0.26363	-0.5707	0.18585
PH	0.802667	0.284303	-0.20058	-0.48822	0.150817
LA	0.640335	0.259003	-0.24009	-0.32537	0.07209
CL	0.703032	0.194884	-0.21955	-0.33291	0.125255
CG	0.442515	0.244481	-0.18676	-0.19592	0.16879
RPE	0.64104	0.25676	-0.19833	-0.24796	0.18727
GPER	0.734233	0.315667	-0.35244	-0.25422	0.203944
BPP	0.48898	0.28008	-0.00635	-0.28494	0.1781
HSW	0.448585	0.218803	-0.16699	-0.26432	0.265652
GYP	0.712092	0.246975	-0.1025	-0.27983	0.114613

HSW	BPP	GPER	RPE	CG	CL	LA	PH	LT	EWL
rg	rg	rg	rg	rg	rg	rg	rg	rg	rg
									0.30816
								0.370195	0.143996
							0.766689	0.240158	0.057297
						0.851023	0.896731	0.193518	0.172692
					0.678247	0.576124	0.563297	0.153814	0.073015
				0.60463	0.85421	0.74187	0.86599	0.13146	0.24698
			0.952525	0.627219	0.83128	0.896163	0.984025	0.431538	0.258983
		0.58487	0.59808	0.3672	0.48479	0.53704	0.65099	0.12189	-0.0052
	0.336087	0.650321	0.475099	0.389705	0.581972	0.530312	0.556256	0.37583	0.216668
0.615122	0.531814	0.87063	0.853949	0.56001	0.960781	0.846242	0.906289	0.247421	0.258023

CMT: Cell Membrane Thermostability **PH:** Plant Height **LWP:** Leaf Water Potential **RPE:** Rows per Ear
SC: Stomata Conductance **LA:** Leaf Area **LT:** Leaf Temperature **GYP:** Grain per Ear Row
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Conclusion

The present study was undertaken to generate genetic information which can help to breed maize inbred lines with improved drought tolerance. Phenotype is interaction of genotype and environment. To breed a cultivar which may produce better yield under drought stress conditions, breeder needs the information about the gene action of the traits related to yield and quality under drought stress environment. The information about linkage relationships of the traits related to yield and quality as well as the traits which help plant to tolerate drought are also needed. Grain yield per plant and its attributes may be used by a plant breeder for the improvement of crop yield and production under water stress conditions.

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