Genetic variability of maize genotypes under normal and water stress conditions

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Abstract: The prescribed study was conducted in the glasshouse of Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan during crop growing season of 2013 under normal and drought condition. It was found that the genotypes OH8, K55TMS and A495-2 performed better under normal and drought stress conditions. Higher heritability and genetic advance was recorded for shoot length, root weight and biomass of seedling. It was concluded that significant correlation was found for root length with shoot length, fresh biomass, dry root length and dry shoot weight. Significant correlation of root length and shoot length indicated the genotypes with higher root and shoot length showed drought stress resistance. It was suggested that selection on the basis of root and shoot length may be helpful to improve maize yield under drought stress conditions.

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Introduction

Increasing population has enlarged the demand of food and energy which becomes necessary for the enhancement of maize production. Unluckily, ecological stresses such as water scarcity and High temperature stresses are going to confine the maize production (Battisti *et al*,. 2000). Water Deficiency occurs in most part of the world every year having overwhelming effect on maize production (Ludlow *et al*,. 1990). Drought causes the reduction in CO_2/O_2 ratio in leaves that inhibit the photosynthesis. (Jason *et al*,. 2004). Drought is particularly severe in those countries, where irrigation water is often scarce and where rainfall represents the main source of crop-available water. Water unavailability can impact maize production at all developmental stages, such as seedling, pre-flowering, flowering, and grain-filling stages. There have been many reports of drought tolerance evaluation between different superior genotypes at the seedling stage (Liu *et al*,. 2004), which revealed the variation of drought tolerance among various genotypes. Different genes were encouraged and intricate in the drought stress response in many plants (Ingram and Bartels 1996). These inducible genes play roles not only in drought tolerance but also in the regulation of gene expression and signal transduction in stress responses (Yamaguchi-Shinozaki and Shinozaki 2006). Conventional breeding is long term and difficult process for improving yield under drought condition because field conditions are hard to manage properly. There is also a reduction in genetic variability and heredity of quantitative traits that equals an increase in biotic and abiotic stress (Blum, 1988). Reduction in yield due to drought mainly depend on two factors, the drought vulnerability of plant and over effects of yield prospective, that increase the number of chances that a plant performed better in well irrigation conditions will performed well under drought condition, even the yield reduction for that plant is large

Materials and Methods

The present study was conducted in the glasshouse of Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan during winter 2013. The experimental material was taken from Department of plant breeding and Genetics and comprised on thirty maize inbred lines viz .M14, A50-2, A239, A427-2, A495, A509, A521-1, A545, A556, A638, AES204, Antigua 1, OH8, OH28, OH33-1, OH41, OH54-3A, W64SP, W64PMS, WM13RA, WF-9, WFTMS, W187R, W10, WA3748, W82-3, K55TMS, GPF-9, USSR40, USSR150, The seed of each inbred line were grown in iron trays filled with sand at 2.5cm depth. The pH 7.8 and EC 1.7dSm^{-1} was maintained before sowing. The data of 10 seedlings was recorded for the following traits after 30 days of seedling emergence *viz*., shoot length (cm), root length (cm), fresh shoot weight (g), fresh root weight (g), fresh root/shoot weight ratio dry root weight (g), dry shoot weight (g). On the basis of the above data, Least Critical differences (LDS) and analysis of variances was used for genotypic variance, phenotypic variances, heritability and genetic advance were calculated (Steel, *et al* 1997; Kwon and Torrie 1964).

Result and Discussion

It was assessed from Table 1 that higher heritability was reported for shoot weight (79%) and fresh Biomass (60%) while low heritability for dry root weight (46%), root length, root weight, shoot length and dry shoot weight. Higher genetic advance was recorded for biomass (24.55%) and shoot length (26.16%) under normal conditions. Table 2 showed the higher heritability for shoot length (92%), fresh biomass (77%), dry root weight (83%), shoot weight (77%), root weight (89%) while low heritability for root length (30%) and dry shoot weight (50%) under drought conditions(Ahsan *et al,*. 2011) ,Higher heritability was observed for shoot weight (79%) and fresh biomass (60%) while low heritability for root length (10%), dry root weight (30%), dry shoot weight (36%), shoot length (35%) and root weight (45%). Higher heritability and genetic advance indicated that selection of drought resistant maize genotypes maybe effective on the basis of shoot length, root length and biomass under drought conditions.

Table 1. Genetic components for various traits of maize under Normal condition

SOV/Traits	Biomass	Shoot Weight	Dry Root Weight	Root Length	Root Weight	Shoot Length	Dry Shoot Weight
Grand Mean	4.52	1.77	0.54	30.44	2.78	26.05	0.35
Environmental variance	0.42	0.04	0.02	14.15	0.25	6.56	0.01
Genotypic variance	0.63	0.16	0.01	1.63	0.21	3.84	0.01
Phenotypic variance	1.04	0.20	0.03	15.78	0.46	10.39	0.02
Genotypic Coefficient of Variance	13.83	9.02	1.69	5.36	7.51	14.74	2.21
Phenotypic Coefficient of Variance	23.05	11.40	5.57	51.84	13.33	39.90	6.19
Heritability%	60	79	30	10.34	46	36.93	35.73
Genetic advance %	24.55	16.01	3.00	9.51	16.44	26.16	3.927173

Table 2. Genetic components for various traits of maize under Drought condition

SOV/Traits	Biomass	Shoot Weight	Dry Root Weight	Root Length	Root Weight	Shoot Length	Dry Shoot Weight
Grand Mean	2.21	0.83	0.41	25.14	1.67	12.04	0.12
Environmental variance	0.11	0.04	0.01	11.17	0.04	1.62	0.01
Genetic Variance	0.44	0.13	3.84	4.69	0.32	0.09	0.01
Phenotypic Variance	0.55	0.17	0.01	33.14	0.35	75.72	0.01
Genotypic Coefficient Variance	13.49	15.50	2.17	18.67	18.94	6.78	0.16
Phnotypic Coefficient of Variance	23.95	20.21	2.58	63.12	21.19	10.22	0.29
Heritability%	80.19	76.70	83.89	29.58	89.37	91.51	49.6
Genetic advance %	16.83	27.52	0.01	15.87	33.62	9.30	3.25

It is shown in fig.1 higher dry root weight for OH8, K55TMS and A495-2 was noted while OH28, WF9 and WM13RA shows the lower dry root weight was recorded under normal conditions. High dry root weight was recorded for M4, W82-3 and WFTMS while the low dry root weight for WF9, A239 and A427-2 was recorded. The higher dry root weight of M4, W82-3 and WFTMS shows that these lines may be selected for breeding program. The higher biomass was recorded for OH8, K55TMS, G.P.F-9 and A495-2 while low biomass was observed from OH28, WF-9, WM13RA and USSR150 in normal condition (Akhigbe, *et al*,. 2009). The high biomass was recorded for M4, W82-3, WFTMS, W64SP and USSR150 while low biomass for A239, A427-2, WF-9 and A556 was observed under drought conditions. The higher biomass of OH8, K55TMS, M4 and W82-3 indicated that these lines may be selected for development of drought tolerant genotypes. It is persuaded from fig. 3 that higher dry shoot weight was recorded for OH-8, K55TMS, A495-2, GPF-9 and A427-2 while lower dry root for OH-28, A556,WF-9 and WM13RA under normal condition. Higher dry root were observed for M-4, W64SP, W82-3, USSR150 and oh33-1 while low for A239, A556, OH-28 and WF-9 under drought condition (Ali, and Ahsan, 2011b). It is clear from fig.4 that higher shoot length were recorded for A50-2, K55TMS, A521-1, W-10 and USSR40 while low shoot length for M-4, 509, W187R and USSR150 under normal conditions. Higher shoot length were recorded for A509, A521-1, A50-2 and OH-41 while lower shoot length were recorded for OH-8, K55TMS, AND GPF-9 under drought conditions. It is clear from Fig. 6 that higher root length were recorded for OH-8, K55TMS, A495-2 and A427e-2 while low root length were recorded for OH-28, WF-9,WM13 and USSR150 under normal conditions. Higher root length was recorded for M-4, USSR150, W82-3 and W64SP while lower root length was recorded for A239, A427-2, OH-28 and K55TMS under drought condition. It is clear from Fig. 5 that higher shoot weight were recorded for OH-8, K55TMS, A495-2 and A427e-2 while low shoot weight were recorded for OH-28, WF-9, WM13 and USSR150 under normal conditions. Higher shoot weight were recorded for M-4, USSR150, W82-3 and W64SP while lower shoot weight were recorded for A239, A427-2, OH-28 and K55TMS under drought condition (Ali, *et al*,. 2013). It is clear from fig. 7 that higher root weight were recorded for OH-8, K55TMS, GPF-9 and A495-2 while lower root weight for OH-28, WF-9, WM13RA and USSR150 under normal condition. Higher root weight was recorded for M-4, USSR15, W64SP and WFTMS while for WF-9, A556, A495, A427 and A239 (Ali et al 2013a and Ali et al,. 2013b).

It was evaluated that significant correlation was found for root length with shoot length, fresh biomass, dry root length and dry shoot weight while negative and non-significant correlation with shoot weight and non-significant with root weight. Strong and significant correlation were found of root weight with fresh biomass, dry root weight, shoot length while non-significant with root length and shoot weight. It was evaluated that strong correlation was reported of shoot weight with shoot length while non-significant for dry root weight, root weight but negative and non-significant with dry shoot weight and root length under drought conditions (Ali *et al*,. 2011a; Ali *et al*,. 2011b; Ali, *et al*,. 2012 and Ali *et al*,.2011c). It was reported that significant correlation for root weight with root length while non-significant for fresh biomass, shoot length, shoot weight but negative

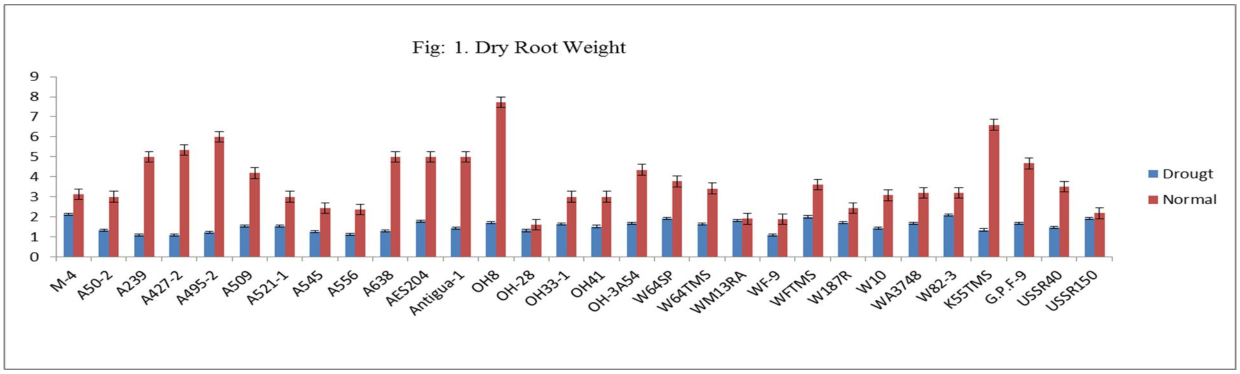


Fig: 1. Dry Root Weight

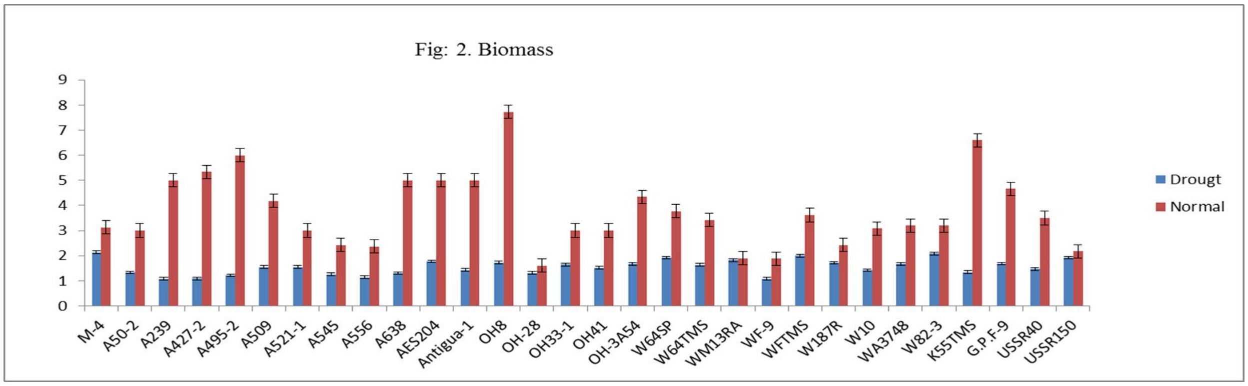


Fig: 2. Biomass

Fig. 3. Dry Shoot Weight

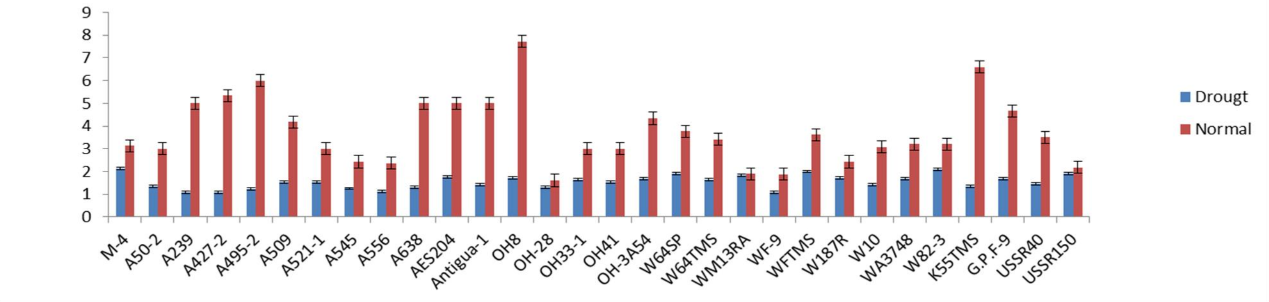


Fig. 4. Shoot Length

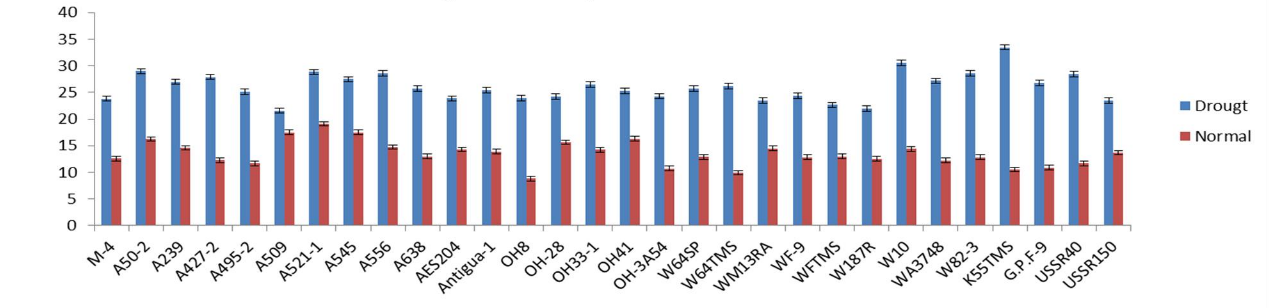


Fig. 5. Shoot Weight

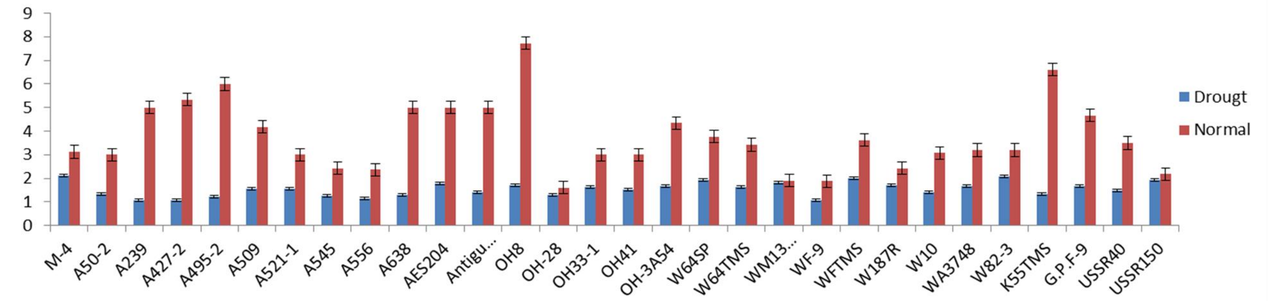


Fig. 6. Root Length

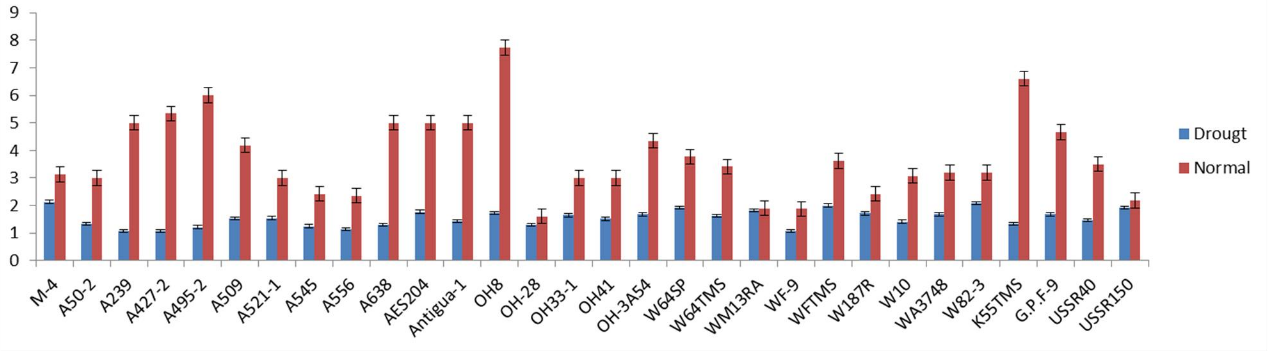
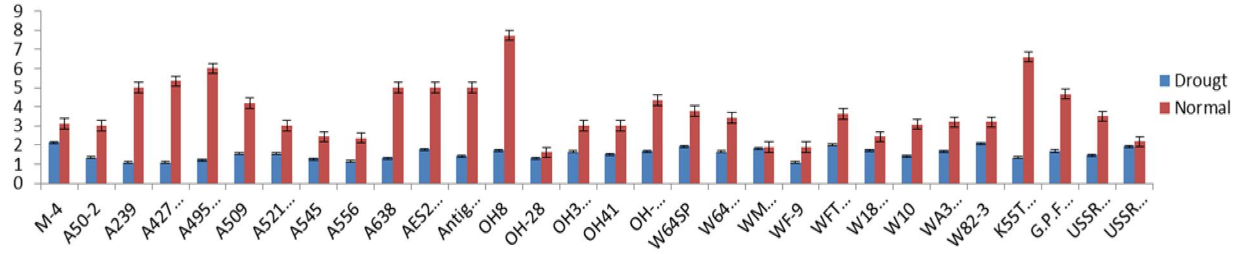


Fig.7. Root Weight



correlation for dry root weight. Significant and strong correlation were found for shoot length, shoot weight, fresh biomass and dry shoot weight while non-significant for dry root weight and root length. It was persuaded from table 4 that significant and strong correlation was reported for dry root weight with dry shoot weight while significant correlation was found for fresh root and shoot weight, fresh biomass and shoot length but negatively and non-significantly correlated with root length (Ludlow and Muchow. 1990). Strong correlation of dry root weight with dry shoot weight indicated that the accumulation of organic compound was higher in root and shoot under normal conditions. The results suggested that selection of higher maize genotypes for drought tolerance may be effective on the basis of root weight (Ali, *et al*,. 2012 and Ali *et al*,.2011 and Blum, 1988). It was suggested from table 3 that strong correlation was found for dry root weight with fresh root weight while significant correlation was found for dry shoot weight, fresh biomass and shoot length. Strong correlation of dry root weight with fresh root weight indicated that the accumulation of organic compound was higher in root under drought conditions that reflecting the ability of root to develop under drought condition to with stand the crop plant while tolerating drought effects (Lobell, 2011). A positive and significance correlation was found for fresh biomass with dry root weight, root length, shoot length and dry shoot weight while strong correlation was reported for fresh shoot weight. Positive and significance correlation suggested that fresh biomass increased under normal conditions. It was suggested from results that a positive and significance correlation was found for fresh biomass with dry root weight, root length, shoot length and fresh shoot weight while strong correlation was reported for fresh root weight (Mishra, and Cherkauer. 2010). Positive and significance correlation suggested that fresh biomass increased under drought condition as most of compounds were accumulated in the seedlings. Selection of drought tolerant genotypes may be helpful to improve crop yield and production under drought conditions (Shinozaki and Yamaguchi-Shinozaki. 1997). Dry shoot weight was significantly correlated with dry root weight, root length and shoot length under drought conditions while strong and significant correlation was found for dry root weight, fresh shoot weight and fresh biomass and significantly correlated with fresh root weight and shoot length under normal conditions. The significant correlation of dry shoot weight with root weight and shoot length indicated that under drought conditions the seedling remains to continue vegetative growth. Selection of drought tolerance genotypes may be fruitful to improve crop yield under drought condition as well as under normal conditions (Wu *et al*,. 2007).

Table 3. Correlation matrix for various maize traits under drought condition

Traits/Probability value	**Biomass**	**Dry root weight**	**Dry shoot weight**	**Root length**	**Root weight**	**Shoot length**
Dry root weight	0.6660					
P	0.0001					
Dry shoot weight	0.1416	0.2682				
P	0.4554	0.1519				
Root length	0.3549	0.4200	0.4565			
P	0.0543	0.0209	0.0112			
Root weight	0.8757	0.7095	0.1208	0.3786		
P	0.0000	0.0000	0.5247	0.0391		
Shoot length	0.2509	0.3937	0.6523	0.6374	0.3316	
P	0.1810	0.0314	0.0001	0.0002	0.0734	
Shoot weight	0.5598	0.1601	-0.1825	-0.1232	0.2872	0.3287
P	0.0013	0.3982	0.3344	0.5167	0.1238	0.0762

Table 4. Correlation matrix for various maize traits under normal condition

Traits/Probability value	Biomass	Dry root weight	Dry shoot weight	Root length	Root weight	Shoot length
Dry root weight	0.4748					
P	0.0070					
Dry shoot weight	0.6488	0.8210				
P	0.0001	0.0000				
Root length	0.3990	-0.0639	0.0787			
P	0.0262	0.7327	0.6740			
Root weight	0.9805	0.4259	0.6001	0.4680		
P	0.0000	0.0169	0.0004	0.0079		
Shoot length	0.6326	0.4294	0.5507	0.1778	0.5260	
P	0.0001	0.0159	0.0013	0.3385	0.0024	
Shoot weight	0.9552	0.4865	0.6852	0.2689	0.8878	0.6978
P	0.0000	0.0055	0.0000	0.1435	0.0000	0.0000

Conclusions

It was concluded that the genotypes OH8, K55TMS and A495-2 performed better under normal and drought stress conditions. Higher heritability and genetic advance was recorded for shoot length, root weight and biomass of seedling. Significant correlation was found for root length with shoot length, fresh biomass, dry root length and dry shoot weight. Significant correlation of root length and shoot length indicated the genotypes with higher root and shoot length showed drought stress resistance. It was suggested that selection on the basis of root and shoot length may be helpful to improve maize yield under drought stress conditions.

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