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Genetic Evaluation of Maize (*Zea mays* L.) genotypes at seedling stage under moisture stress condition

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Abstract: Maize (*Zea mays* L.) is one of the leading cereal crops in Pakistan. It is also extensively grown as fodder crop for livestock consumption. Drought is an inevitable and recurring feature of agriculture in Pakistan. Therefore, present study was designed to evaluate the genotypes of maize which performed better under moisture stress at seedling stage. Fourteen maize genotypes collected from these sources were planted in Complete Randomized Design (CRD) using the irrigated and water stress environment with three replications. All tested maize accessions were found to be dissimilar from one another for both normal and drought conditions. Dry biomass had positive association at genotypic level for both fresh and dry weight of shoots, fresh root weight and fresh biomass under normal conditions while it had the prominent association with dry shoots weight and shoot length under drought condition. The parameter like length of shoot was found to have the prominent association and in positive direction at the phenotypic levels with the parameters like germination percent, fresh shoots weight, dry roots weight, dry and fresh weight of shoot.
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Key words: Maize, Association, Drought Stress, Quantitative Characters.

Introduction

Maize *(Zea mays* L.) is widely cultivated grain crop of developed and under developed world. A short duration crop, especially for tropical area, however it can be grown effectively and efficiently in sub-tropical and temperate areas of world (Brutnell et al., 2015). From centuries in the conventional system of farming, maize is considered as chief crop due to its multiple uses and is essential for food security worldwide (Ramírez-Moreno et al., 2015). Maize is among the most significant cultivated crop next to rice and wheat and is grown in spring and autumn season in Pakistan (Rahman et al., 2015). According to Pingali (2001) by 2020 need of maize crop would be higher than other cereals because of fast increasing in population and to compensate the food requirement of people. Maize also called as corn and its seed contain ash, oil, starch, fiber protein and sugar (Chaudhry, 1983). Maize is broadly cultivated for livestock in the form of feed and for human as food and now it has become the staple food of many countries of world (Araus *et al*., 2008). In many industries role of maize is significant such as in beverages industry for production of drinks like alcohol and non-alcohol (Alahdadi *et al*., 2011). In bakery industry, maize is utilized for production of bread, cake and porridge. Maize seed contain oil (2.17-4.43%) and this oil is used as fuel, cooking and as a fabricate (Elsgaard *et al*., 2012) reported that consumption of maize is helpful for stomach health and can enhance the capacity of the gall bladder. It has been reported that maize crop has better yield potential but yield potential is affecting due to many factors such as biotic and abiotic factors, methods of sowing or inappropriate sowing strategies, competing with weeds, potential of cultivar used and non proper use of fertilizer (Tabassum *et al*., 2007; Rasheed *et al*., 2004 & Abdullah *et al*., 2008).

From total cultivated area of Pakistan which is about twenty million ha, the fifteen million ha is cultivated through proper irrigation and other remaining five million ha is rain fed. In Pakistan agriculture support is about 70% of total population and add about 35- 40% economy. Water is a limited asset utilized in different sectors such as household or domestic purpose, agriculture/livestock and in almost every industry (Pereira *et al*., 2009). With the passage of time demand for better quality and quantity of water is expanding very quickly due to urbanization, climate change, rapid growth in population and pollution (Pereira *et al*., 2009). The ecological assets like land

and water are restricted and start diminishing because of over exploitation, global warming, contamination and change of environment (FAO, 2011).

Abiotic stresses, for example, dry season, temperature, salinity, flooding and toxins, these all stress that badly influence corn yield, hence it is vital to contemplate maize ability to endure abiotic stress but drought is real constraining component for yield of crops (Tester & Basic, 2005), seriously influence the plant development & at last yield (Araus *et al*., 2002). Water shortage is an emerging problem worldwide so to manage this problem the emergence of new maize varieties having drought stress with better yield traits is necessary for improvement of food supplies. Studies related to the drought stress environment activate different genetic and physiological mechanisms operated under these environments. Thus, in the process of development of hybrids which would be tolerant to drought, it is required to know the behavior of correlation for different drought relating characters. Keeping in mind the present research was planned with the following outcomes expected.

I. To isolate the lines which were tolerant and susceptible.

II. To assess the genotypic response of new maize genotypes compared to local check under drought stress at seedling stages.

Materials and Methods

The study was carried out in college of agriculture, university of Sargodha, Sargodha during growing season 2018 to estimate the genetics of corn lines under both the irrigated as well as drought environments. Fourteen Maize genotypes were collected from AARI, Faisalabad and MMRI, Sahiwal and planted by using Complete Randomized Design and replicated three times by using two treatments levels i.e100% Field capacity taken as (Normal) and 50% Field capacity (Drought). These genotypes were planted in iron trays filled with sand (pH was 7.8 and EC was 1.7 dSm^{-1}) in three replications under Completely Randomized Design. Moisture level was kept normal on alternative days by using the instrument called as moisture meter at 50% field capacity. At the stage of five leaves, ten randomly selected plants were taken and the data were recorded for different parameters like dry weights and fresh weights of roots, dry weights and fresh weights of shoots, roots and shoots ratio, shoot length fresh weight, root length freshly weighed, biomass freshly and dry weighed. The recorded data were subjected to analysis of variance, phenotypic variances, heritability and genotypic variances (Steel *et al*., 1997). Genotypic as well as phenotypic correlation coefficients were known by techniques of Kown & Torrie (1964). Heritability percentage was categorized as 0-30% - Low, 30-60% - Moderate and Above 60% - High.

Results and Discussion

Table 1: Pooled variance of different parameters of corn under irrigated & drought environments.

SOV	DF	GER	FRW	DRW	FSW	DSW	RL	SL	FB	DB
Genotypes	13	668.72**	0.349**	0.3329**	0.179**	0.1761**	32.16**	35.513**	0.277**	0.2697**
Treatment (Tr)	1	1331.44**	0.219**	0.1692**	0.0067*	0.0044**	12.92**	4.366**	0.302**	0.2283**
(I x Tr)	13	93.79	0.003**	0.0042**	0.0072*	0.007**	0.0876*	0.007*	0.011**	0.0140**
Error	54	30.667	0.001	0.001	0.009	0.010	0.329	0.197	0.011	0.012

** Significant at one percent level of probability * Significant at five percent level of probability

DF = Degree of freedom, **GER** = Germination (%), **FRW** = Fresh root weight, **DRW** = Dry root weight, **FSW** = Fresh shoot weight, **DSW** = Dry shoot weight, **RL** = Root length, **SL** = Shoot length, **FB** = Fresh biomass, **DB** = Dry biomass

Table 2: Analysis of variance of various traits of maize under irrigated & drought environment.

SOV	DF	GER	FRW	DRW	FSW	DSW	RL	SL	FB	DB
Irrigated Condition										
Genotypes	13	429.47**	0.20**	0.19**	0.09**	0.08**	17.4**	17.9**	0.14**	0.14**
Error	26	43.17	0.000	0.001	0.000	0.001	0.01	0.006	0.000	0.001
Drought Condition										
Genotypes	13	372.8*	0.14**	0.14**	0.09**	0.09**	14.8**	17.5**	0.14**	0.13**
Error	26	243.2	3.99	0.000	0.013	0.013	0.11	0.01	0.013	0.014

** = Significant at 0.01 level of probability * = Significant at 0.05 level of probability

DF = Degree of freedom, **GER** = Germination (%), **FRW** = Fresh root weight, **DRW** = Dry root weight, **FSW** = Fresh shoot weight, **DSW** = Dry shoot weight, **RL** = Root length, **SL** = Shoot length, **FB** = Fresh biomass, **DB** = Dry biomass

The analysis of variance for all the parameters for which the data was recorded was carried out under both the conditions i.e. the dry and the irrigated. Results showed that all the accessions were significantly different from one another for all the treatments as given in the table 2. In order to have a closer look of variability for the material that was being used in the experiment, the isolated analysis was carried out for both the environments i.e. the irrigated as well as the dry environment. Results of the analysis were given in the table 1. The significant variation was observed for all the parameters among the lines or accession under study under both the environments i.e. the irrigated and stress. The prominent variation was also reported for seedlings characteristics of maize such as germination percentage, dry weights and fresh weights of roots, dry weights and fresh weights of shoots, root length, shoot length, fresh biomass & dry biomass (g) by several scientists Ahmad *et al.* (2015), Golbashy *et al*. (2010), Ibni-Zamir *et al.* (2015), Ali *et al*. (2016), Reddy *et al*. (2004) and Babar *et al.* (2014).

The compared values for various maize accessions for percent germination under different water levels was presented in Fig 1. The highest germination (93.3%) was measured from genotype G-1710 when grown under normal condition while the genotypes G-1710 and G-1262 produced maximum germination (73.3%) when grown under drought condition. However, among all the tested genotypes the minimum germination (53.3%) was recorded from genotypes G-1705 and G-1703 under normal condition, whereas, the genotype G-1703 recorded lowest germination (33.3%) under drought condition. These results are in accordance with the findings of Babar *et al.* (2014) who indicated that various maize genotypes respond variously under both the levels of irrigations. Similarly, Ahmad *et al*. (2015) also stated that maize genotypes produce better germination % in normal conditions.

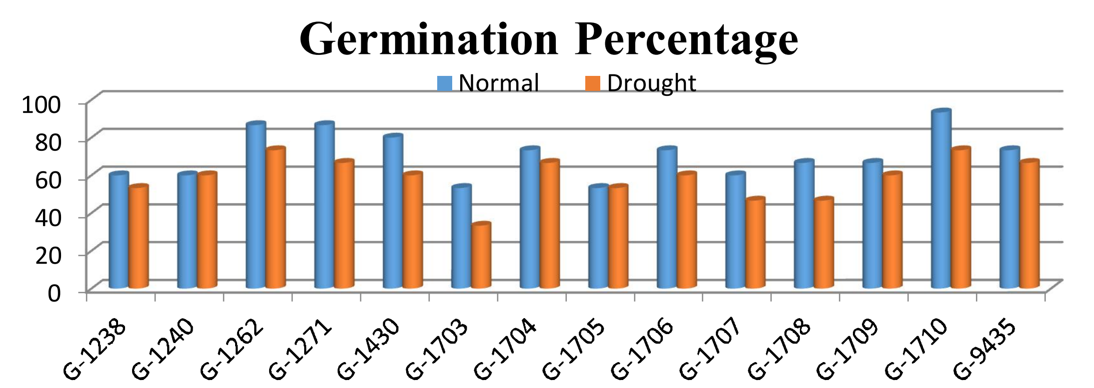

Fig. 1

Data regarding the mean comparison of fresh weight of roots of various maize lines presented in Fig 2 which indicated that highest fresh roots weight (1.73 g) was noted from genotype G-1703 when grown under normal condition. In case of drought stress, the maximum value of fresh root weight (1.53 g) was also measured from this genotype G-1703. The minimum fresh roots weight (0.77 g) was observed from G-1262 which was followed by G-1705 that produced 0.78 g fresh root wt. where drought stress was employed and under normal condition, the least figures of fresh roots weights (0.82 g) were found from genotype G-1705. It was observed that among all tested maize genotypes G-1703 perform better under both water regimes.

Among all the maize genotypes G-1703 produced maximum dry roots weight (1.50 g) when grown under normal condition (Fig 3), while in case of drought condition the same genotype G-1703 produced maximum dry roots weight (1.34 g). The least values of dry roots weights (0.57 g) were measured from G-1705 which was followed by G-1262 that produced (0.58 g) of dry root weights under drought. However, in case of normal conditions, the maize genotypes G-1262 and G-1705 produced lowest 0.63 g dry root weight. It was observed from the above results under both water levels (normal and drought) maize genotype G-1703 performed better than all other lines. These calculations were further supported by Lipiec *et al.* (2013) & Souza *et al.* (2016). They revealed that maize genotypes responds differently under drought conditions and some maize genotypes were drought tolerance and performed better under both water regimes (normal and drought).

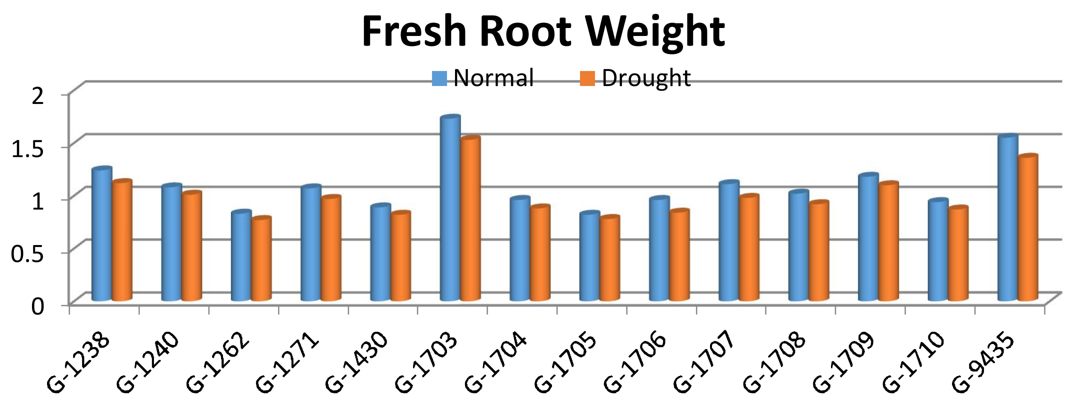

Fig. 2

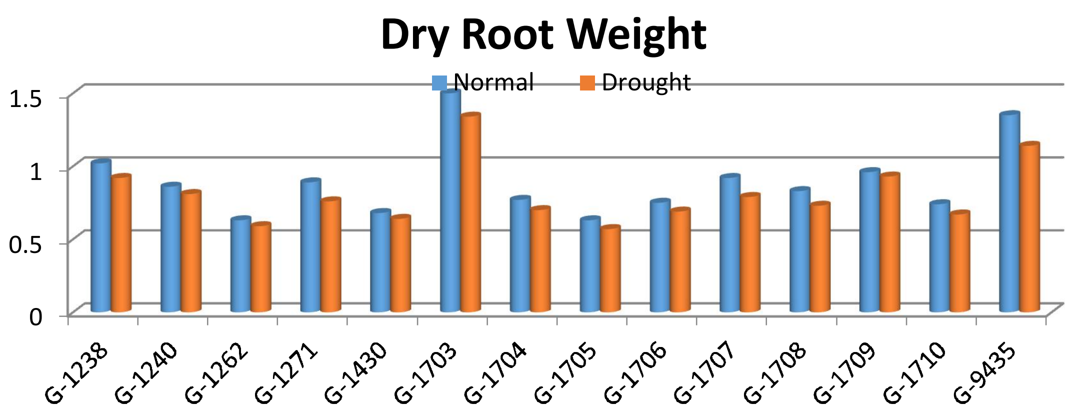

Fig. 3

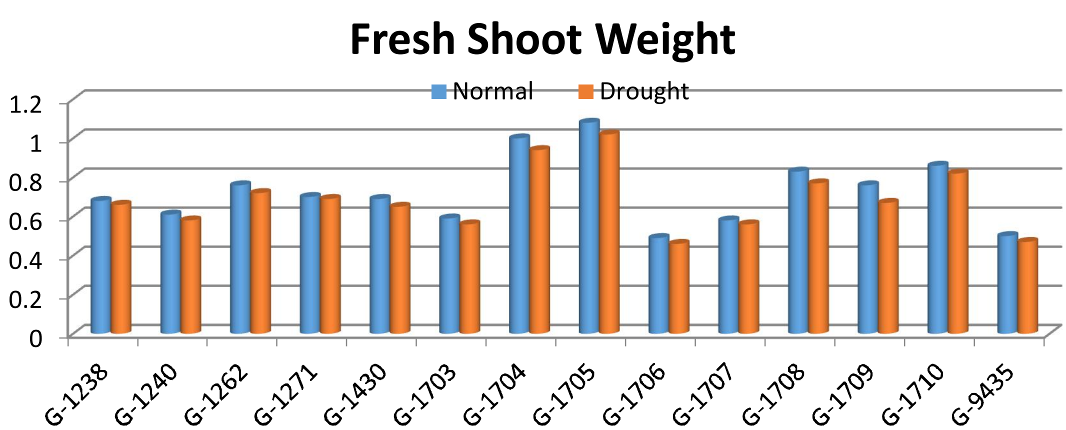

Fig. 4

Data of Fig 4 revealed that maximum value of fresh shoots weight (1.08 g) was observed from genotype G-1705 when grown under normal environment. However, for drought stress, the highest fresh shoot weight (1.02 g) was also measured from the same genotype G-1705. The minimum fresh shoots weight (0.46 g) was found from G-1706 which was followed by G-9435 that produced 0.47 g when drought stress was applied and under normal condition, the least values of freshly weighed shoots (0.49 g) were recorded from genotype G-1706. It was observed that among all tested maize genotypes, the G-1705 performed better under both normal & drought environments. Similar values were also found by Golbashy *et al*. (2010) who revealed that maize hybrids varied significantly for both normal & drought environments. Khodarahmpour and Hamidi (2011) also indicated the significant differences under drought stress for fresh shoots weight in maize genotypes.

Among all the maize genotypes G-1705 produced highest dry shoot weight (0.89 g) when grown under normal condition, while in case of drought condition the same genotype G-1705 produced maximum dry shoots weight (0.84 g). The lowest figure of dry shoots weight (0.29 g) was noted from G-9435 which was followed by G-1706 that produced 0.30 g of dry shoot weight under drought environment. Whereas, for the normal conditions, the maize genotypes G-9435 and G-1706 produced minimum 0.31 g dry shoot weight. Results indicated that under both water levels (normal and drought) maize genotype G-1705 performed better than all other lines. The nearly same values had been found by Ibni-Zamir *et al.* (2015) who described that various maize genotypes produced higher dry roots and shoots weight for both water levels (normal and stressed). According to Ali *et al.* (2014) the prominent differences were calculated for dry roots and shoots weight in maize accessions under drought situation.

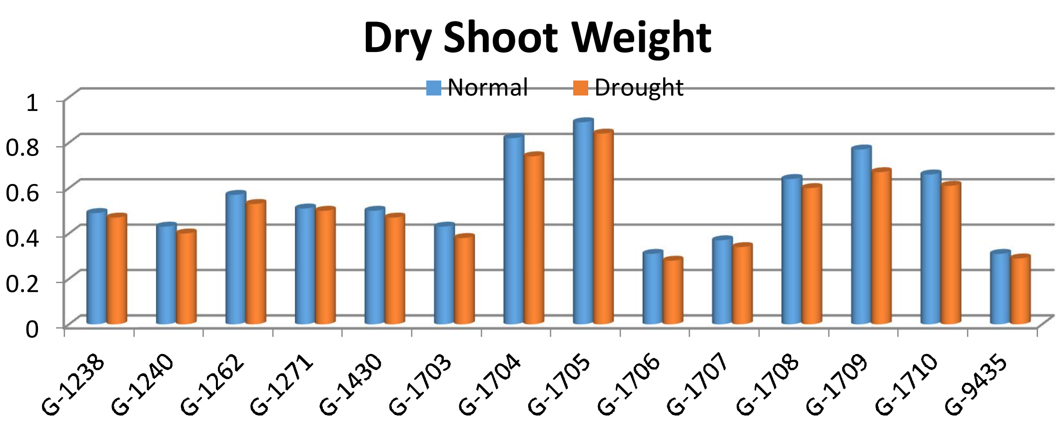

Fig. 5

Mean comparison of root length of various maize genotypes in Fig. 6 indicated that highest value of root length (13.76 cm) was found from G-1271 followed G-1262 under irrigated environment. However, under drought environment, the highest value for root length (12.60 cm) was recorded from genotype G-1271. The lowest shoot length (5.85 cm) was measured from G-1240 where drought stress was applied. Under normal situation, the lowest figure of shoot length (5.96 cm) was noted from genotype G-1240. Under both normal and stressed environments, the maize genotype G-1271 found most effective in term of root length of maize. The rise in root length for dry environment indicated tolerance to water stress. The work of the other researchers like Souza *et al*. (2016) and Ali *et al.* (2016) also found the prominent diversity for root length in corn hybrids under drought conditions.

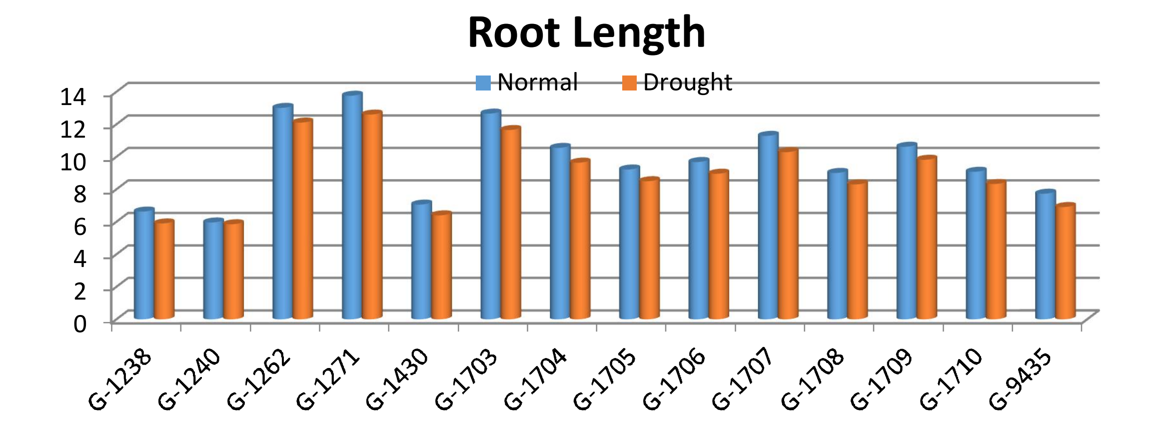

Fig. 6

In case of shoot length Fig. 7 genotype G-1271 showed more values of shoots length (12.85 cm) when grown for normal condition, while in case of drought condition same genotype produced highest shoot length (12.46 cm). The minimum value of shoot length (4.17 cm) was measured from G-1240 for dry environment. Whereas, for normal condition, maize genotypes G-1240 produced minimum 4.43 cm of maize shoot length. It was concluded that maize genotype G-1271 was performed better than all other accessions under water dry environment. The findings were same as by Reddy *et al*. (2004) who found that plant growth traits such as shoot length reduced significantly under drought stress that also causes reduction in the productivity of crop plant. The results were further matched by the work of pervious researcher Ali *et al*. (2016), who stated that under normal conditions maize genotypes produced higher shoot length than drought condition.

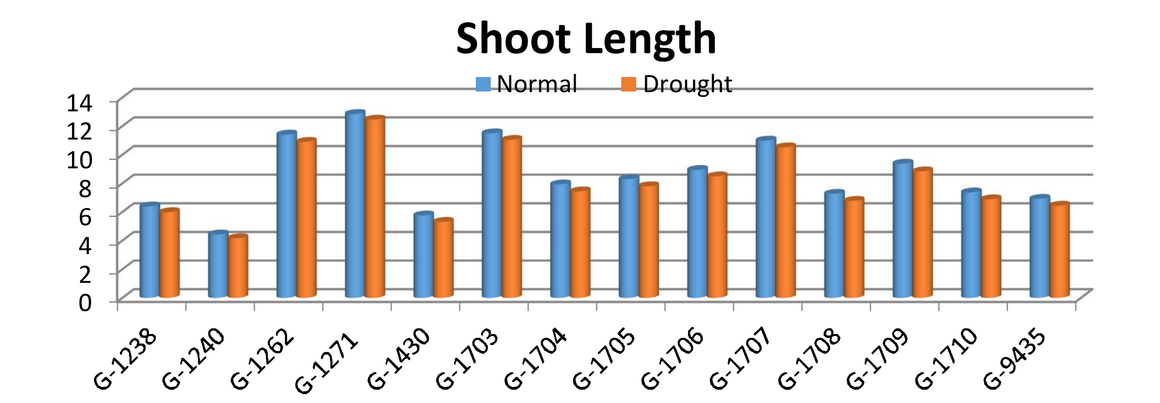

Fig. 7

Mean comparison of fresh biomass of various maize genotypes presented in Fig. 8 indicated that maximum value of fresh biomass (2.33 g) was observed from genotype G-1703 which was followed by G-9435 under irrigated conditions. However, for drought, the maximum fresh biomass (2.10 g) was observed from genotype G-1703. The minimum fresh biomass (1.34 g) was recorded from G-1706 which was followed by G-1430 where drought stress was applied. Under normal condition, the lowest value fresh biomass (1.46 g) was measured from genotype G-1706. For both the environments, the irrigated as well as the dry or stressed the corn lines G-1703 was found most effective in term of fresh biomass of maize. The similar calculations were given by Yordanov *et al*. (2003) who found that under water limited conditions maize accessions respond differently and fresh biomass and productivity of crop decreased. The results were same as by Bibi *et al.* (2012).

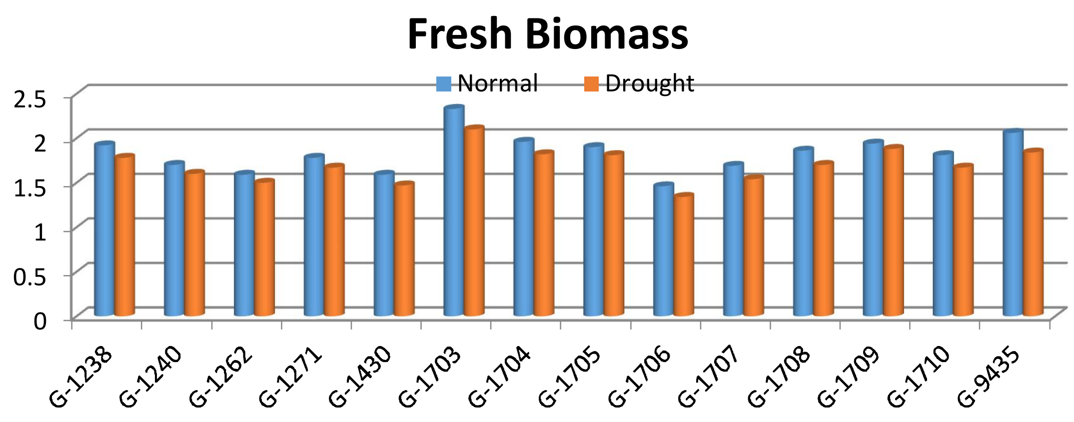

Fig. 8

Under normal condition genotype G-1703 produced highest value of dry biomass (1.93 g) while in case of drought condition same genotype produced maximum dry biomass (1.72 g) which was followed by G-1709 that produced 1.71 g dry biomass. The lowest dry biomass (0.99 g) was observed from G-1706 which was followed by G-1430 under drought conditions. Whereas, in case of normal conditions, the same maize genotypes G-1706 produced minimum 1.07 g of maize dry biomass. From the results it was revealed that among all tested maize genotypes, the G-1703 performed better under both normal and drought conditions. These findings were same as confirmed by Bibi *et al.* (2012) and Babar *et al.* (2014).

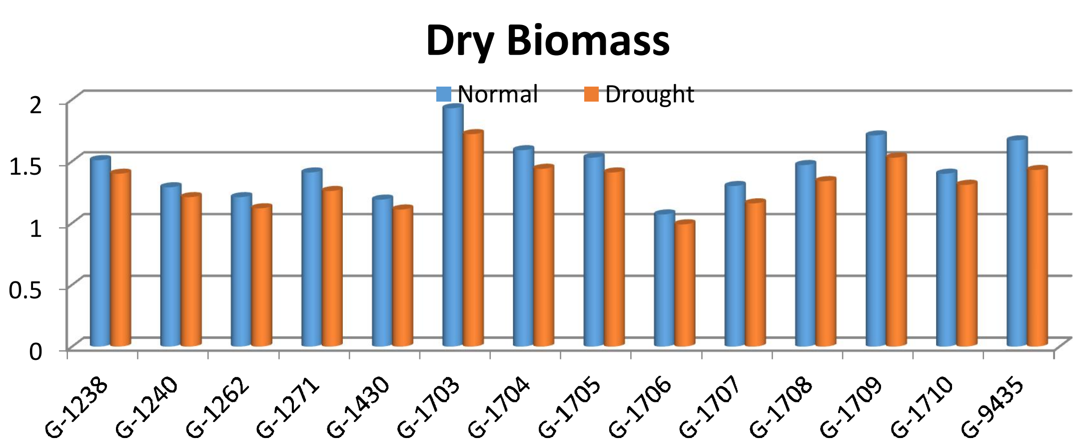

Fig. 9

Genotypic (G) and phenotypic (P) variances and heritability for the irrigated and stressed environments were represented in table 1.1 shown. All the parameters studied show higher values of heritability under irrigated and drought conditions and the parameters like dry and fresh shoots weight were not significant. the dry and fresh weights of shoot showed moderate values of heritability under drought environment. For both normal & irrigated conditions, due to higher and moderate heritability, there are more opportunities to transfer these traits to the next generation. The research of Qayyum et al. (2012), Wannows et al, (2010), Li et al. (2015) and Babar et al. (2014) were similar to our results. They observed higher figures of heritability for seedling traits of maize under studied.

Table 1.1: Genotypic variance (Vg), phenotypic variance (Vp) and heritability in maize genotypes under Normal and Drought irrigation.

		GER	FRW	DRW	FSW	DSW	RL	SL	FB	DB
Irrigated Condition										
Vg		128.76	0.068	0.064	0.029	0.029	5.684	5.898	0.048	0.047
Vp		171.94	0.069	0.066	0.03	0.03	6.081	6.141	0.051	0.051
H^2_{bs} (%)		74.88	98.37	97.62	98.18	96.05	93.46	96.03	94.28	92.41
Drought Condition										
Vg		11.686	0.048	0.046	0.026	0.025	4.848	5.81	0.04	0.038
Vp		289.58	0.049	0.047	0.044	0.043	5.109	5.961	0.059	0.058
H^2_{bs} (%)		85.24	98.71	97.13	59.52	58.11	94.89	97.47	67.9	65.46

DF = Degree of freedom, **GER** = Germination (%), **FRW** = Fresh root weight, **DRW** = Dry root weight, **FSW** = Fresh shoot weight, **DSW** = Dry shoot weight, **RL** = Root length, **SL** = Shoot length, **FB** = Fresh biomass, **DB** = Dry biomass

1.2Genotypic and Phenotypic Correlation among Various Traits of Maize Under Normal and Drought Irrigation

The results of correlation were found to be significant and positive at genotypic level as dry roots weight with germination %, dry shoots wt with fresh shoots wt, roots length with fresh roots wt and dry roots weight, shoots length with germination % and dry roots wt, fresh biomass with fresh roots wt and roots length (Table 1.2a). Dry biomass had significantly positive association to fresh root wt, fresh shoot wt, dry shoot wt and shoots length genotypic level. Fresh root wt with germination % and fresh root wt and dry biomass with fresh root wt, dry shoot wt and shoot length had positively significantly correlation with one other at phenotypic level in irrigated environment (Table 1.2a).

Under drought environment dry root wt with germination %. Dry shoot wt with germination % and fresh shoot wt, root length with fresh root wt, fresh biomass with fresh root wt, dry root wt and dry biomass with dry shoot wt and shoot length showed prominent association positive side to each other at both the levels i.e. the phenotypic as well as genotypic (Table 1.2b). These calculations were close found by Maleki et al. (2014) and Bibi et al. (2012) who revealed that a positive association of fresh shoot wt was recorded with dry shoots wt and shoot length and root and shoot length, fresh and dry biomass were positively associated under water limited environment respectively.

Table 1.2a: Genotypic (G) and Phenotypic (P) Correlation among germination % (G), fresh root weight (FRW), dry root weight (DRW), fresh shoot weight (FSW), dry shoot weight (DSW), root length (RL), shoot length (SL), fresh biomass (FB), dry biomass (DB) under normal irrigation

Traits		G%	FRW	DRW	FSW	DSW	RL	SL	FB
FRW	P	0.19							
	G	0.21							
DRW	P	0.41**	0.28*						
	G	0.43*	0.30						
FSW	P	0.07	-0.04	0.05*					
	G	0.09	-0.06	0.06					
DSW	P	0.09*	-0.49*	-0.33	0.61*				
	G	0.11	-0.52*	-0.37	0.67**				
RL	P	-0.08	0.61*	0.56	0.09	-0.41			
	G	-0.09	0.62*	0.59*	0.12	-0.51			
SL	P	0.28*	0.09	0.38*	-0.09*	0.07*	0.15		
	G	0.31*	0.13	0.15*	-0.14*	0.09	0.13		
FB	P	0.06	0.52**	0.60*	-0.39	-0.81	0.49	0.08	
	G	0.10	0.58**	0.63	-0.44	-0.77	0.55*	0.09	
DB	P	0.12	0.42*	0.09	0.21	0.50*	0.33	0.39*	-0.06*
	G	0.14	0.46*	0.11	0.24*	0.53*	0.36	0.41*	-0.08*

Table 1.2b: Genotypic (G) and Phenotypic (P) Correlation among germination % (G), fresh root weight (FRW), dry root weight (DRW), fresh shoot weight (FSW), dry shoot weight (DSW), root length (RL), shoot length (SL), fresh biomass (FB), dry biomass (DB) under drought conditions.

Traits		G%	FRW	DRW	FSW	DSW	RL	SL	FB
FRW	P	-0.15							
	G	-0.16							
DRW	P	0.37*	0.31						
	G	0.39*	0.32						
FSW	P	0.04	-0.03	0.04					
		G	0.06	-0.03	0.0				
DSW	P	0.08*	-0.46*	-0.30	0.58*				
	G	0.09*	-0.48*	-0.33	0.60*				
RL	P	-0.05	0.65**	0.57	0.09	-0.33			
	G	-0.06	0.68**	0.55*	0.10	-0.40			
SL	P	0.22	0.07	0.44	-0.08	0.09	0.17		
	G	0.26	0.09	0.12	-0.11	0.06	0.10		
FB	P	0.05	0.49*	0.58*	-0.37	-0.85*	0.45	0.06	
	G	0.07	0.52*	0.60**	-0.39	-0.83	0.49*	0.08	
DB	P	0.13	0.41	0.11	0.18	0.51*	0.31	0.40*	-0.03
	G	0.11	0.43	0.09	0.21	0.49*	0.32	0.39*	-0.04

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