Biological and Clinical Sciences Research Journal
ISSN: 2708-2261
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v2020i1.28
Biol. Clin. Sci. Res. J., Volume, ***2020****: 28*
Original Research

EFFECTS OF WATER DEFICIT ON MAZE SEEDLINGS GROWTH TRAITS

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(Received, 11th March 2020, Revised 12th September 2020, Published 16nd September 2020)

Abstract: *Many biotic and abiotic factors affect plant growth and its development. Maize growth usually increased under excess water availability but less tolerant against water deficit stress condition. In this study, we investigated the effects of water stress on the growth and yield of maize. We found that severe water stress during the seedling stage had a greater effect on the growth and development of maize. Three maize varieties (Pak afghoi, Neelum, White corn) were used to find out the effects on growth of plant under drought or water deficit environmental conditions. Different drought stress treatments (Control, 20% irrigation water, 40% irrigation water, 60% irrigation water, 80% irrigation water) were imposed to growing seedlings after germination. The treatments were applied after 4 times each after 7 days interval and data for different morphological traits was recorded each time. The recorded data was pooled and analyzed for analysis of variance to access the significance of results. The ANOVA indicated the differences among five different genotypes and 5 different treatments for all parameters were significant. Tukey's test indicated that maize genotype White corn was more tolerant while genotype Neelum was more sensitive for drought stress conditions therefore, white corn maize genotype may be helpful for the development of drought tolerance maize varieties and hybrids. Positive and significant correlation was found for shoot length with all other studied traits under drought stress conditions. Treatment control, 80% and 60% irrigation water was less adverse for maize growth while treatment 20% irrigation water highly affected all maize genotypes, therefore maize genotypes may be grow under treatment 60% irrigation water.*

Keywords: water stress, maize, irrigation, genotypes, tolerant, sensitive, growth traits

Introduction

The crop yield decreased due to biotic and abiotic stresses like drought, heat, flooding, wind and cold. Agriculture scientists have to face drought stress due to water shortage. Drought situation takes place in result moisture loss from soil surface and short water supply to the soil. Drought conditions decrease the turgor pressure that affects normal plant functions (Hsiao, 1973). Under water stress root weight increased while shoot weight decreased (Bänziger et al., 2002). Drought stress interfere the plant growth, organ development and flower production. Stomata opening depend upon water availability. Under drought stomata activity disturbed that affect physiological processes of plant. The enzyme activity is also dependent on water availability. It decreases the production of reactive oxygen species (ROS) which damages the chloroplast and cell membrane. Under stress condition chloroplast produce high amount of ROS (Asada, 2000; Foyer et al., 1994; Vranová et al., 2002) that cause necrosis and chlorosis in plants. Among the three major cereal grain crops (maize, sorghum and pearl millet) maize crop produces the maximum yield as compare to others under excess water quantity but the maize crop is least tolerance to drought stress than others (Muchow, 2000). During low rain fall maize is being removed by sorghum and pearl millet. Maize is one an energy rich crop but more sensitive to drought stress. Insufficient availability of soil water can affect the metabolic activities and biomass production of maize. Maize production becom limited due to unavailability of water (Jones and Thornton, 2003). Drought is a serious problem that other abiotic stresses that decrease the photosynthetic rate and leading to reduce chlorophyll contents in leaves (Chang et al., 2008). However, during the early vegetative growth maize can tolerate under water stress because under this stage less water is available for maize growth but at flowering stage full irrigation is required for maize growth (Kang et al., 2000). Objective of this study was to understand the effects of severe water stress (no water supply) on maize growth and development. Drought stress reduce the leaf area index (LAI) and biomass production that leads to reduce photosynthetic activity, reduce kernel weight even after the application of irrigation water (Kirda, 2002; Tariq and Usman, 2009).

Material and methods

The pot experiment was performed during 2018 to 2019 in the Green House of The University of Lahore, Lahore. Three different maize genotypes (Pak afghoi, Neelum, White corn) were purchased during July 2018 from seed market. Seeds were sterilized with distilled water to remove contamination before sowing into the soil. After it, pots were filled with nitrogen rich soil for better growth. Total nine seeds of all maize genotypes were sown in each pot. Different concentration of irrigation water (20%, 40%, 60%, 80%) was applied to understand the affect of drought stress on maize seeding. One set considered as control in which 100% irrigation water was applied. After germination, three plants were harvested from each pot at a time and data was recorded carefully. Different growth parameters such as shoot length, leaves per plant, shoot water content, root water content, root-shoot fresh weight and root-shoot dry weight was recorded carefully in physiology lab. Data was recorded with the interval of 15 days. Shoot length was measured by using meter rod. Water contents in shoot and root was determined by using formula

Moisture percentage= Dry weight/Wet weight×100

Root and shoot fresh weight was measured by using electric balance while dry weight was measured by placing the sample in oven at 40^{o}C for 48h at physiology lab The University of Lahore, Lahore. After it, sample was weighted in grams by using electric balance to find out dry weight. Root shoot dry weight ration can determine by given formula:

root/shoot weight ratio =Dry weight for roots/dry weight for top of plant

Results and Discussion

Analysis of variance indicated that there were significant difference among maize genotypes, treatments of drought stress and interactions between maize genotypes and treatments of drought stress, as shown in table 1. It was found that there was very low coefficient of variation for all growth parameters indicated that there was higher consistency for all these growth parameters.

Table 1. Analysis of variance for different growth parameters of maize seedlings under drought stress treatments Probability level=5%

Growth parameters	Average value	Coefficient of variation	Statistical analysis
Shoot length	18.543±1.0241	0.96	Significant
Shoot water contents	69.085±2.414	1.05	Sig.
Root water contents	64.832±3.078	0.56	Sig.
Root shoot fresh weight ratio	0.9816±0.0003	1.52	Sig.
Root shoot dry weight ratio	1.0481±0.0003	1.39	Sig.

Tukey's test indicated that White corn maize genotype is more tolerant than others and Neelum genotype is more sensitive under drought stress condition. In white corn genotype shoot length, shoot water contents, root shoot fresh weight ratio androot shoot dry weight ratio was not affected under drought condition while shoot length and root shoot dry weight ratio were highly affected under drought stress condition in maize genotype Neelum, as shown in table 2.

Table 2: All pairwise comparison among different maize accessions for different growth parameters ($p \leq 0.05$)

Growth parameters	Maize accessions		
	Neelum	Pak afghoi	White corn
Shoot length	-		+
Shoot water contents		-	+
Root water contents	+	-	
Root shoot fresh weight ratio		-	+
Root shoot dry weight ratio	-		+

Tukeys test indicated that treatment control highly affected maize genotypes which affected shoot length and root water contents. While treatment 60% irrigation water was less affected maize genotypes which did not affected shoot length and root water contents. 60% irrigation water may be used to for next generation.

Table 3: All pairwise comparison among different drought stress treatments for different growth parameters

Growth parameters	Heavy metal treatments				
	Control	20% irrigation water	40% irrigation water	60% irrigation water	80% irrigation water
Shoot length		-		+	
Shoot water contents		-		+	
Root water contents		+			
Root shoot fresh weight ratio				-	+
Root shoot dry weight ratio		-			

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Negative sig (-)= Highly affected
Positive sig(+)=Less affected

Shoot length:

From figure 1 it was found that higher shoot length was observed in maize genotype Neelum under treatment 20% irrigation water (18.46cm) while lower shoot length was observed under treatment 60% irrigation water (17.34cm). The genotype Pak afghoi showed higher shoot length under treatment 60% irrigation water (19.26cm) while lowest shoot length was observed under treatment of 20% irrigation water and control (16.14cm). For genotype White corn the shoot length was found higher under the 80% irrigation water (21.84cm) while lowest shoot length was found under treatment control (18.53cm). The higher shoot length of White corn under drought stress environmental conditions indicated that White corn showed more tolerance than other genotypes under drought stress conditions therefore white corn maize genotype may be helpful for the development of drought tolerance maize genotypes and hybrids (Aaliya et al., 2016; Ali et al., 2017; Seki et al., 2007; Yordanov et al., 2000).

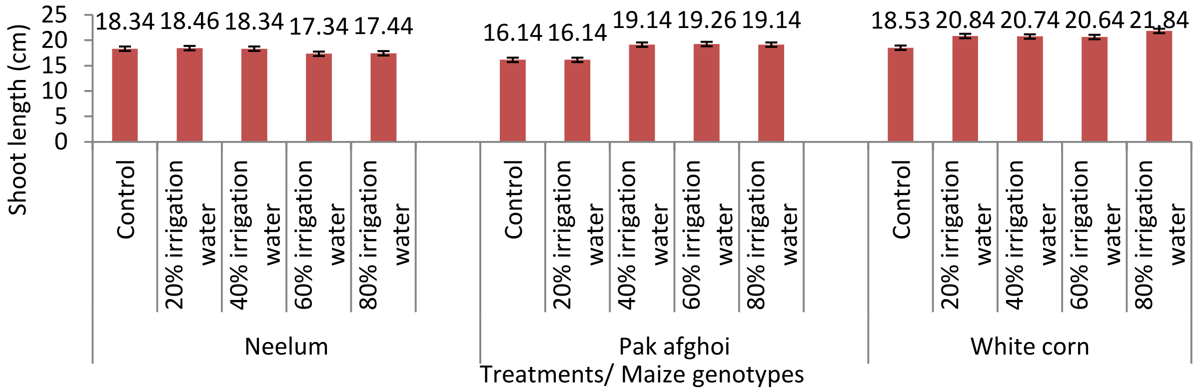

Figure 1. Shoot length of maize genotypes under different drought treatments

Shoot water contents

Figure 2 showed that higher shoot water contents were observed in maize genotype Neelum under treatment 20% irrigation water (72.02%) while lower shoot water contents were observed under treatment 60% irrigation water (69.71%). The genotype Pak afghoi showed higher shoot water contents under treatment 60% irrigation water (69.96%) while lowest shoot water contents were observed under treatment of 20% irrigation water and control (68.19%). For genotype White corn the shoot water contents were found higher under the treatment 20% irrigation water (72.10%) while lowest shoot water contents were found under treatment 80% irrigation water (67.33%). The higher shoot water contents were found in maize genotype White corn than others under drought stress environmental conditions (Ali et al., 2015; Ali et al., 2013; Hütsch et al., 2014; Kang et al., 2000).

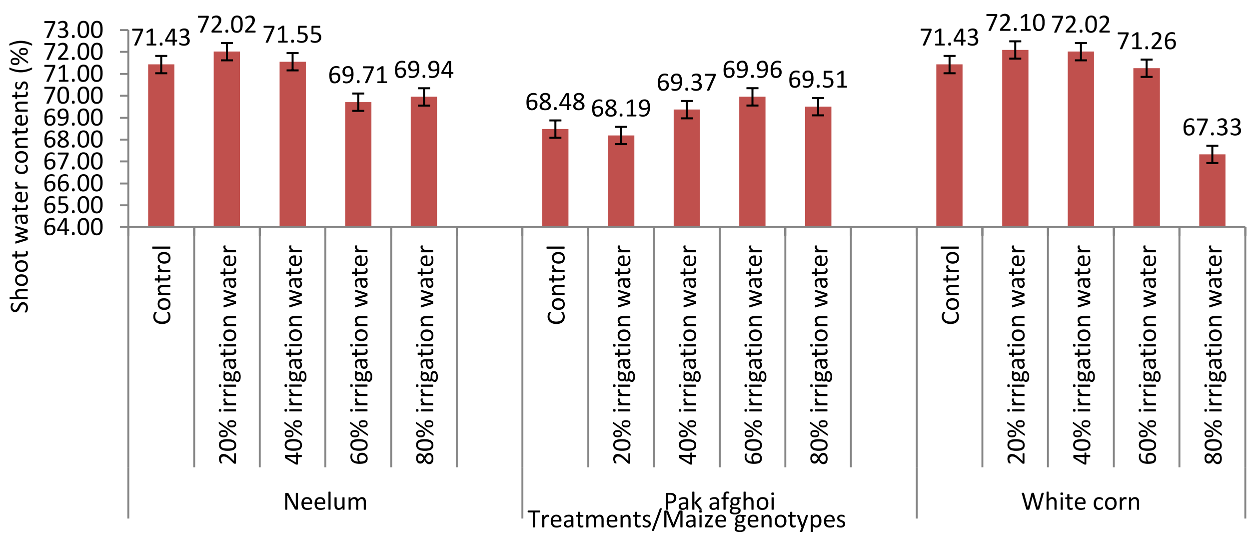

Figure 2. Shoot water contents of maize genotypes under different drought treatments

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Root water contents

Figure 3 showed that higher root water contents were observed in maize genotype Neelum under treatment control and 20% irrigation water (68.20%) while lower root water contents were observed under treatment 60% irrigation water (66.35%). The genotype Pak afghoi showed higher root water contents under treatment40% irrigation water and 60% irrigation water (66.30%) while lowest root water contents were observed under treatment 20% irrigation water and control (64.48%). For genotype White corn the root water contents were found higher under the treatment 80% irrigation water (65.42%) while lowest root water contents were found under treatment 60% irrigation water (64.95%). The higher root water contents were found in Maize genotype Neelum than others under drought stress conditions (Ali et al., 2016; Ali et al., 2012; Kanwal et al., 2019; Nadeem et al., 2006; Zubair et al., 2016).

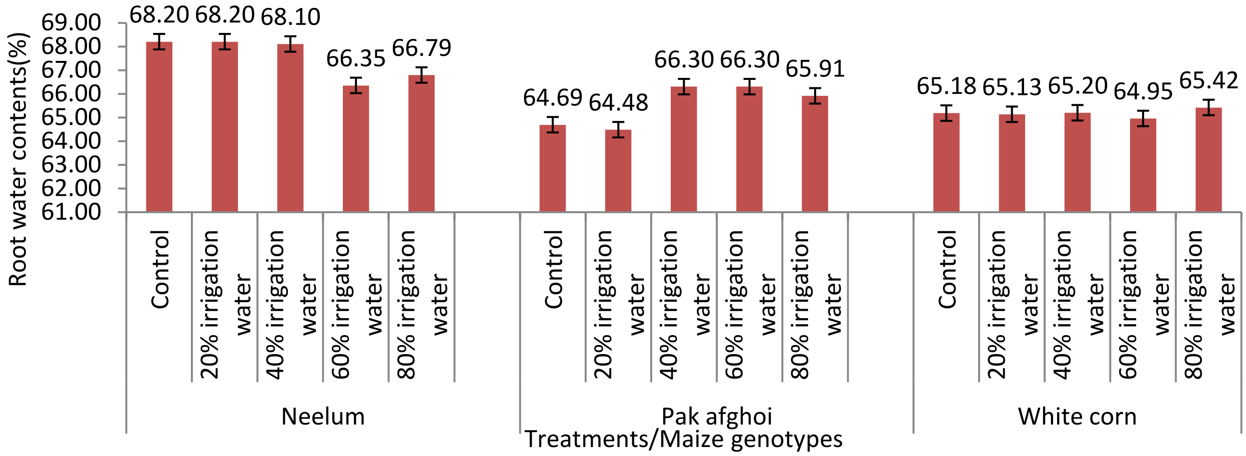

Figure 3. Root water contents of maize genotypes under different drought treatments

Root/shoot fresh weight ratio

Figure 5 showed that higher root shoot fresh weight ratio was observed in maize genotype Neelum under treatment 60% irrigation water (0.96) while lower root/shoot fresh weight ratio was observed under treatment control (0.93). The genotype Pak afghoi showed higher root/shoot fresh weight ratio was under treatment 20% irrigation water (0.96) while lowest root shoot fresh weight ratio was observed under treatment 40% irrigation water (0.92). For genotype White corn the root stem fresh weight was found higher under the treatment 80% irrigation water (0.99) while lowest root stem fresh weight was found under treatment control (0.87). The higher root/shoot fresh weight ratio was found in maize genotype White corn than others under drought stress environmental conditions (Ali et al., 2014a; Ali et al., 2014b; Jones and Thornton, 2003; Tariq and Usman, 2009).

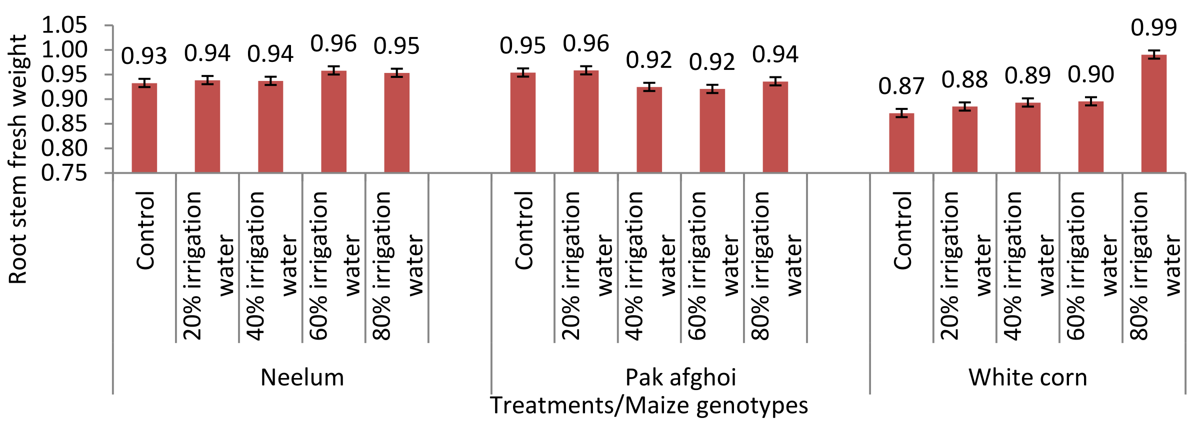

Figure 4. Root/shoot fresh weight ratio of maize genotypes under different drought treatments

Root/shoot dry weight ratio

Figure 5 showed that lower root shoot dry weight ratio was observed under treatment 40% irrigation water (1.03). The genotype Pak afghoi showed higher root/shoot dry weight ratio was under treatment 20% irrigation water (1.08) while lowest root stem dry weight was observed under treatment 80% irrigation water (1.03). For genotype White corn the root/shoot dry weight ratio was found higher under the treatment control and 80% irrigation water (1.09)

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while lowest root/shoot dry weight ratio was found under treatment 20% irrigation water and 40% irrigation water (1.05). The higher root/shoot dry weight ratio was found in Maize genotype White corn than others under drought stress environmental conditions (Chang et al., 2008; Khalil et al., 2020; Mazhar et al., 2020; Tahir et al., 2020).

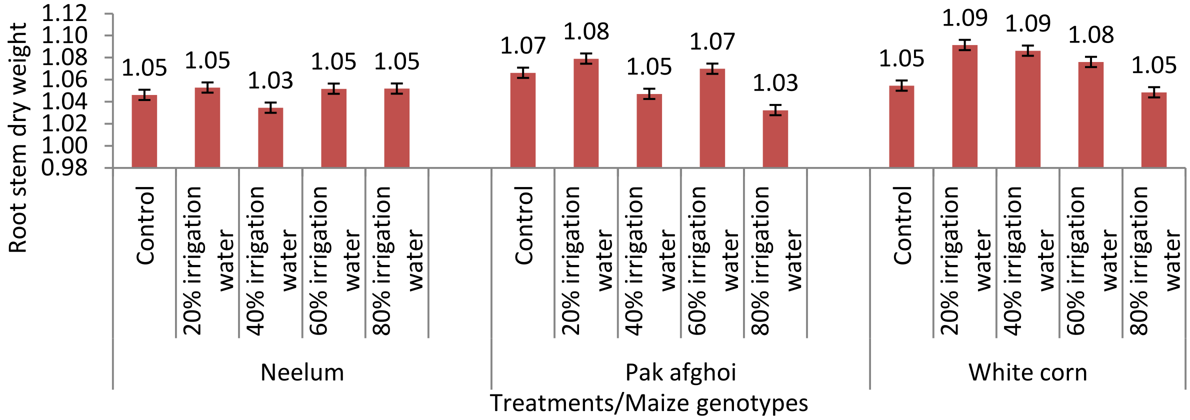

Figure 5. Root/shoot dry weight ratio of maize genotypes under different drought treatments

The results from table 4 about correlation analysis among the studied traits showed that a positive and significant correlation was found for shoot length with all other studied traits under drought stress conditions. The results indicated that the selection of maize genotypes on the basis of shoot length may be used for the improvement of drought stress tolerance in maize genotypes (Ali et al., 2016; Ali et al., 2014b; Ashraf et al., 2020; Khalil et al., 2020).

Table 4. Pooled correlation among different traits of maize under drought stress conditions

Traits	Shoot length	Shoot water contents	Root water contents	Root shoot fresh weight ratio
Shoot water contents	0.4249*			
Root water contents	0.3871*	0.1530		
Root shoot fresh weight ratio	0.6713*	-0.2455	0.1924	
Root shoot dry weight ratio	0.8342*	0.2140	-0.0924	0.5723*

* =Significant at 5% probability level

Conclusion

It was concluded from analysis of variance and Tukey's test that White corn genotype was more tolerant than other under drought stress because under drought stress shoot length, Shoot water contents, root stem fresh weight, root/shoot dry weight ratio was high. While Neelum maize genotype was more sensitive under drought stress because most of the growth traits such as shoot length, shoot water contents, root water contents, root/shoot dry weight ratio and root/shoot fresh weight ratio were badly affected under drought stress conditions therefore white corn maize genotype may be helpful for the development of drought tolerance maize genotypes and hybrids. Treatment control was more affected for maize growth but treatment 60% irrigation water was less affected for maize growth therefore maize genotypes may be grow under treatment 60% irrigation water.

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