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Evaluation of drought stress effects on germination and seedling growth of *Zea mays* L.

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Abstract

Water deficit is an unavoidable and frequent feature of world agriculture and this condition globally and particularly in Pakistan had led scientist to study drought in economically important crops in Pakistan. The principal aim of current study was to compare the two varieties of maize in response to the water stress condition. This investigation was performed as factorial experiment under completely randomized design (CRD) with three replications. The seeds of the two maize varieties (Islamabad gold and sawan) were germinated in the petri dishes at 25 °C. After germination at specific interval (3, 5, 7 and 10 days) seedling were divided in two halves, first half was taken as control and second half subjected to drought in air tight desicators which contain 20 % $MgSo_4$ solution. Results indicated that significant decrease was observed in germination index, seedling vigour index, fresh and dry weight of seedling. Seedling shoot length affected due to water shortage but root length show slight increase in response to stress conditions. The total protein contents It was concluded that both varieties were drought sensitive. Based on the results, the Islamabad gold was the most resistant in stress conditions.

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Introduction

Drought is one of the most disturbing environmental stresses and it is multidimensional stress effecting plants at various levels of their organization and one of the most important environmental factors in reduction of growth, development and production of plants. Drought stress causes loss of water use efficacy, induction of heat stress and reduces stem extension. About one third of the world potentially arable land facing water shortage problem and mostly crop yields are often reduced by drought(Kramer, 1980; Farooq *et al.*, 2009). Pakistan and its neighboring countries have experienced wide spread a severe drought, due to severe drought condition food production were reduced from normal production (Singh *et al.*, 2000). Pakistan is an agricultural country and total cultivated area of Pakistan is 20 million ha, out of which 15 million is irrigated and 5 million ha is rainfed. Agriculture contributes about 35- 40% Pakistan economy and support 70% population directly or indirectly (Alam and Naqvi, 2003). Maize is being nutritionally a chief crop has multiple functions in the traditional farming system. Maize is a C4 species and third main cereal crop after wheat and rice. Maize cultivated twice a year. Maize crop is extensively grown as grain for humans and fodder for livestock consumption (Araus*et al.*, 2008; Wattoo*et al.*, 2009). In Pakistan about 48 % cropped area under maize and it is planted on an estimated area of 0.9 million ha with the annual production of 1.3 million ha tones and 173kg/ha.

Maize yield is very susceptible to abiotic stresses such as drought, temperature fluctuations, salinity, flooding and pollutants. Therefore it is important to study maize capacity to tolerate abiotic stress(Wattoo*et al.*, 2009). Seed germination and early seedling growth stages of the plant life cycle are more sensitive to water shortage. These stages are most important in the survival and growth of plants (Hadas, 2004). Germination is regulated by amount of moisture in the growth medium (Gill *et al.*, 2002). Water stress acts by decreasing the germination percentage, rate of germination and seedling growth (Delachiave and De Pinho, 2003). Water stress in maize plants not only affects on seed germination however also increases mean germination time. Any unfavorable environmental factor such as drought, high salt level and high temperature during germination may hinder synchronism (Willanborb*et al.*, 2004; Farsiani and Ghobadi, 2009; Khayatnezhad*et al.*, 2010; Mostafavi*et al.*, 2011; Khodarahmpour, 2012). Under drought condition plant has a mechanism to produce compatible solute which can also be protein, which protect it from desiccation and enhances water uptake. So, the purpose of present study to evaluate the effects of drought stress on germination and early seedling growth of two maize varieties.

Materials and methods

The research was carried out in plant physiology lab at the Arid Agriculture University to study the effect of drought stress on germination and early seedling growth of maize varieties (Islamabad gold and Sawan). This study was performed in Petriplates containing filter paper. The selected seeds of each variety were first sterilized in sodium hypochlorite (1%) solution and then washed twice in distilled water. Then Petriplates containing double layer filter paper were moistened. Thereafter, a selected number of seeds of each variety were soaked in these Petri-dishes and then kept in an incubator (40% relative humidity) at 25°C. Daily germination rate was measured and filter papers were replaced when needed. Seeds were considered germinated when the emergent radical reached to 5mm length. After 10 days germination index and seedling vigour index was measured by International Seed Testing Association (ISTA, 1996). After germination at specific interval (3, 5, 7 and 10 days) seedling were divided in two halves, first half was taken as control and second half subjected to drought in air tight desicators which contain 20% $MgSO_4$ solution. The stress was given for four days.

Germination Parameter

Germination Index

n/d; where n= no of seedlings emerged on day'd' and d= days after planting.

Seedling vigor index

(Abdulbaki and Anderson, 1973).

S. V. I = Seedling length (cm) x germination % age

Where; germination % age = Total seeds germinated x 100.Total no of seeds planted.

Morphological and Biochemical parameter

In control and stressed seedlings following morphological (fresh, dry weight, root, shoot length, root/shoot ratio) and total protein (Lakes, 1979; Bradford, 1976) were measured. For statistical analysis, analyses were done using Statistix 9 software.

Results

Germination index

Drought significantly ($p < 0.05$) affected Germination index (figure 1). The result showed that highest germination index was observed in Islamabad gold and germination index was considerably reduced under stress condition as compared to control. Under drought stress plant showed highest percentage 43.34% and 30.68% germination index. Highest germination index was observed at three days seedling as compared to five, seven and ten days (fig.1).

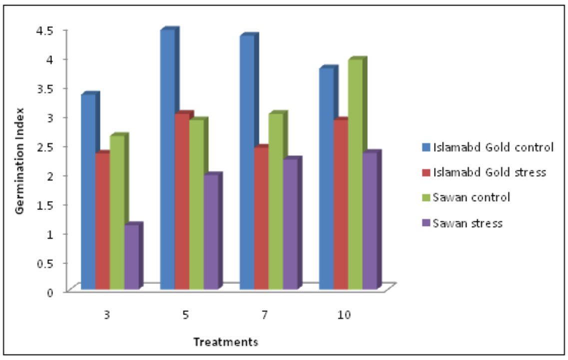

Fig. 1. Effect of drought on germination index of two maize varieties under drought stress.

Seedling Vigour Index

The results were significant ($p \le 0.05$) when subjected to ANOVA. A very drastic effect of stress was seen on seedling vigour index. Seedling vigour index percentage is varying among i.e. 53.9% and 29% under drought stress (fig.2). The highest seedling vigour index was reserved to Islamabad gold.

Shoot Length (cm)

When subjected to ANOVA, it was found that results remained significant ($p \le 0.05$). Decrease in shoot length was observed in stress condition as compared to control plants (fig. 3). Shoot cells growth depends upon water availability and when cell was exposed to water shortage as result shoot growth decrease. Mean comparison depict that Sawan shoot length more drastically affected than Islamabad gold.

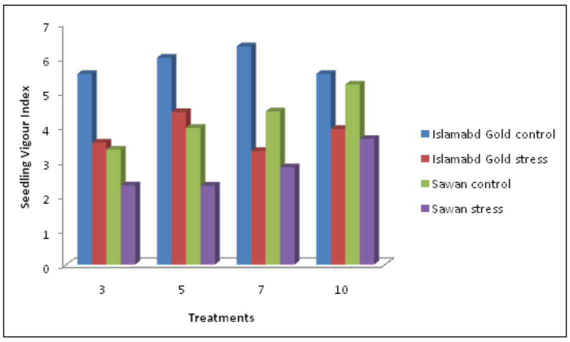

Fig. 2. Effect of drought on seedling vigour index of two maize varieties under drought stress.

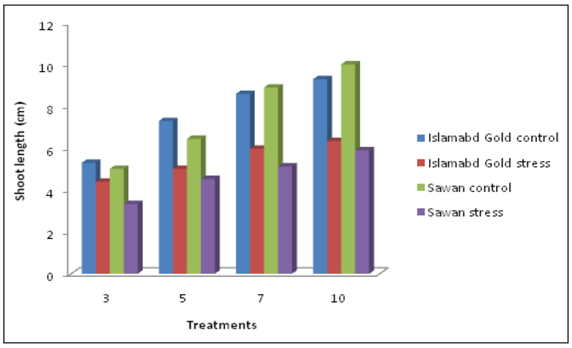

Fig. 3. Effect of drought on shoot length of two maize varieties under drought stress.

Root length (cm)

When subjected to ANOVA, it was found that effect of drought stress remained significant ($p \le 0.05$). Under stress conditions, slight increase in root length was observed as compared to control plants. Under drought stress 45.83% and 80% increase in root length as compared to control (fig.4).

Seedling Fresh and Dry weight (gm)

Significant ($p \le 0.05$) results were observed during statistical analysis.Seedling fresh weight decreased with the application of stress and 85% and 55.1% (fig. 5). Seedling dry weight also decreased as followed by 39.28% and 27.79% (fig.6). Result showed that highest rate of dry weight was observed in Islamabad gold.

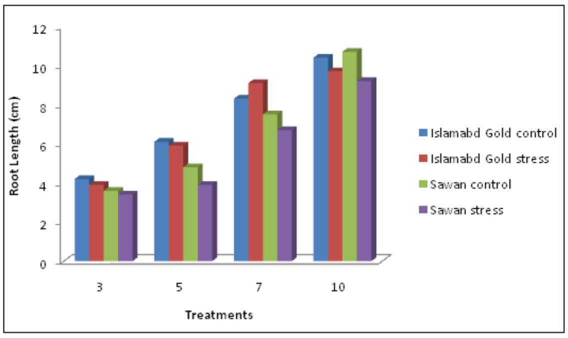

Fig. 4. Effect of drought on root length of two maize varieties under drought stress.

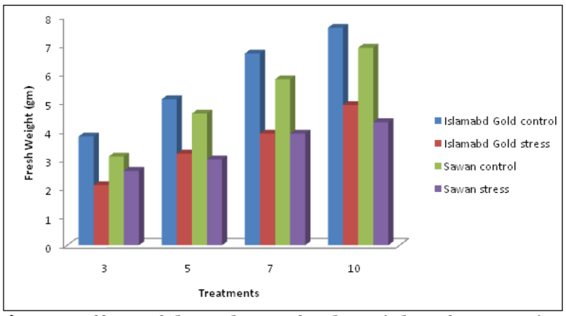

Fig. 5. Effect of drought on fresh weight of two maize varieties under drought stress.

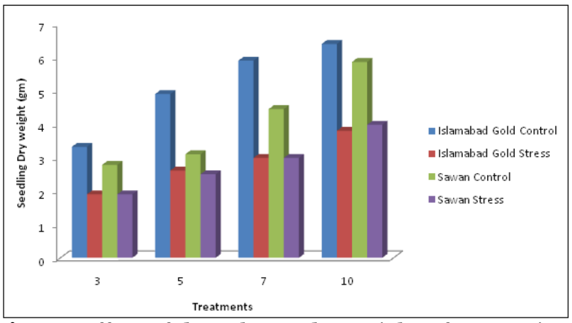

Fig. 6. Effect of drought on dry weight of two maize varieties under drought stress.

Protein Content (g/mg)

Significant ($p \leq 0.05$) results were observed during statistical analysis. Increased amount of protein was observed under drought stress conditions as compared to control. Under drought showed 14.57% and 55.10% increase in protein as compared to stressed plants (fig.7). Under drought highest concentration of protein was shown at 10 days seedlings as compared to 3, 5 and 7 days seedling.

Discussion

In this study, we concluded that osmotically induce water stress adversely affected the germination and seedling growth of maize varieties. Distinct genetic differences were found among the varieties with respect to germination and seedling growth subjected to water stress. Drought stress is physiologically related because induce water stress and Islamabad gold in drought stress condition had more tolerant than sawan. Water potential significantly reduced germination index, root length, shoot length, seedling length and seed vigour (Khodarahmpour, 2011). Under drought stress, germination was decreased due to shortage of water required for early processes of germination. Water stress had a lethal effect on germinating seeds and excessive water shortage hinders seeds water uptake during germination due to the decreased water potential. High range of temperature caused a reduction in seed germination rate and seedling growth because high temperature effects enzyme functions and initiates drought. In the present study, negative effects of water were found on shoot length and root length. Reason behind this effect may be the disturbance in the physiology due to increase in osmotic stress, which affects metabolism and eventually reduced plant expansion (Abdul, 2009; Khayatnezhad*et al.*, 2010) InPresent study revealed that high amount of protein produced under drought conditions. Present research also depicted increase amount of protein in seedling with increasing stressed condition. Mostafavi*et al.* (2011) study four maize hybrids in drought stress conditions reported that hybrid KSC704 was tolerant, while KSC500 was sensitive to drought. Some studied referred that stress can contribute to improve germination rate and seedling emergence in different plant species by increasing the expression of aquaporins (Gao*et al.*, 1999 also by increase of amylases, proteases or lipases activity (Ashraf and Foolad, 2005; Li *et al.*, 2014) Water stress due to drought is most likely the significant abiotic factor limiting plant and also crop growth and development (Hartmann *et al.*, 2005). Water deficit affects the germination of seed and the growth of seedlings negatively (Van-Den-Berg and Zeng, 2006). Results of present study reveal that Islamabad gold shows tolerance to water stress conditions as compared to sawan.

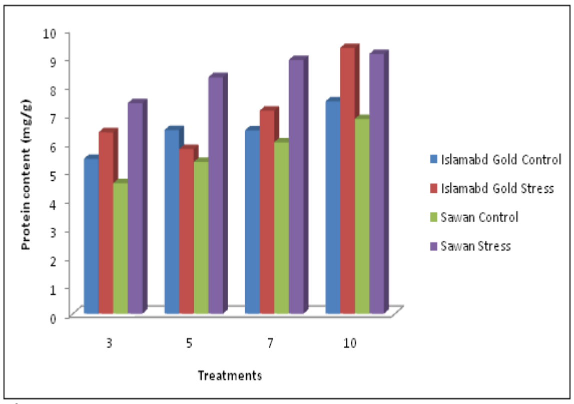

Fig. 7. Effect of drought on protein content of two maize varieties under drought stress.

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