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Influence of variety on biological yield, harvest index, Percent of protein in *Zea mays*

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ABSTRACT: Maize (*Zea mays* L) is the third most important cereal after wheat and rice all over the world as well as in Pakistan. Maize is grown on an area of 9622000 ha with an annual average production and yield of 1665000 tones and 1730Kg ha^{-1}, respectively. Among the abiotic stresses, drought is the most severe limitation to maize production. To a careful estimate, only drought reasons for 50% or more reduction in average yields worldwide. Water stress reduces crop yield regardless of the growth stage at which it occurs. Drought causes numerous physiological and biochemical changes in plants like reduced leaf size, stem extension, root proliferation, reduced water use efficiency. K application can improve drought tolerance in plants by regulating a variety of processes, such as osmoregulation, charge balance, energy status, and protein synthesis. The field experiment was laid out in randomized split plot design with factorial design with four replications. Treatments included irrigation (7, 10 and 13 days) as main plot and potassium fertilizer (0, 30, 60 kg/ha) as sub plot. Analysis of variance showed that the effect of irrigation and potassium on all characteristics was significant.

Key words: Irrigation, Biological yield, Harvest Index

INTRODUCTION

Maize (*Zea mays* L) is the third most important cereal after wheat and rice all over the world as well as in Pakistan. Maize is grown on an area of 9622000 ha with an annual average production and yield of 1665000 tones and 1730Kg ha^{-1}, respectively (Anonymous 2000). Maize had its origin in a semi-arid area but it is not a reliable crop for growing under dry land conditions, with limited or erratic rainfall (Arnon 1972). Maize is apparently more drought resistant in the early stages of growth than when fully developed. Extreme water stress at different stages of crop development has been reported to reduce the yield significantly (Dhillon *et al.* 1995). Maize is cultivated in both spring and autumn seasons and it is best suited in existing cropping scheme. However, yield potential of maize is highly prone a biotic stresses (Drought, salinity, extreme temperatures, flooding, pollutants & poor or excessive irradiation) which are important factors towards limiting the crop productivity (Misovic, 1985; Lawlor, 2002). Among the abiotic stresses, drought is the most severe limitation to maize production (Sallah *et al.,* 2002). To a careful estimate, only drought reasons for 50% or more reduction in average yields worldwide (Wang *et al.,* 2003). Water stress reduces crop yield regardless of the growth stage at which it occurs (Jensen & Mogensen, 1984). Drought causes numerous physiological and biochemical changes in plants like reduced leaf size, stem extension, root proliferation, reduced water use efficiency (Farooq *et al.,* 2009), alteration in metabolic activities (Lawlor & Cornic, 2002), inhibition of enzymatic activities (Ashraf *et al.,* 1995), ionic imbalance and disturbances in solute accumulation (Khan *et al.,* 1999) or a combination of all these factors. In maize, drought reduces leaf area, leaf chlorophyll contents, photosynthesis and ultimately lowers the grain yield (Athar & Ashraf, 2005). At flowering, drought widens the anthesis silking interval (ASI) in maize, which severely reduces the kernel set (Emeadeas *et al.,* 2000). Under drought leaf senescence is also accelerated to decrease the canopy size (Moony & Duplesis, 1970) severely affecting the crop yield. However delayed leaf senescence affects positively for reducing the harmful effects of drought on crop yield (Rivero *et al.,* 2007). Water stress has been found to reduce leaf area; photosynthesis, leaf chlorophyll contents and consequently grain yield (Jun-Chen and Dai-Junying 1996).

Drought stress is one of the most important environmental factors in reduction of growth, development and production of plants. It can be said that it is one of the most devastating environmental stresses. Iran, with an annual rainfall of 240 mm, is classified as one of those dry regions (Jajarmi, 2009). According to Hayat and Ali (2004), Moisture stress is a limiting factor for crop growth in arid and semi-arid regions due to low and uncertainty precipitation. Water stress due to drought is probably the most significant abiotic factor limiting plant and also crop growth and development (Hartmann *et al.*, 2005). Maize plays a great role in human nutrition (20-25%) (Emam, 2004), Water shortage is a critical problem limiting maize growth through impact on anatomical, morphological, physiological and biochemical processes. Drought is one of three abiotic factors, most responsible for limiting maize production and productivity in the developing world; other two are the problems of waterlogging and low soil fertility (Zaidi, 2002).The severity of drought damage depends on stress duration and crop growth stage (Setter *et al.,* 2001). Drought occurs when moisture around the roots is so reduced that a plant is not able to absorb enough water, or in other words with transpiration of water absorption (Benjamin, 2007). Drought stress is physiologically related, because induced osmotic stress and most of the metabolic responses of the affected plants are similar to some extent (Djibril *et al.,* 2005). In a study on corn and sorghum grain, under drought stress conditions it was shown that high levels of nitrate lowered grain quality (McWilliams, 2001). Under drought stress, a plant's ability to absorb and transfer materials is disturbed which affects the access to food (Lauer, 2003). Terbea and Ciocazanu (1999) reported the response of some maize crop inbred lines seedlings sown under limited water availability. Such kind of evaluation declared that under normal supply of soil moisture, the variability of maize genetics for above given parameters was less marked than under limited moisture supply. Grzesiak (2001) reported the effects of soil water deficit conditions on growth in a glasshouse experiment and found that in maize different varieties have different potential for drought tolerance against drought and salinity. Early stage of seedling growth and establishment is very sensitive to drought. Thus cessation of elongation and expansion of cell stops growth of seedling (Anjum *et al.,* 2003a; Bhatt and Rao, 2005; Kusaka *et al.*, 2005; Shao *et al.*, 2008). The low quantity of potassium in the plant body decreases the photosynthetic carbon metabolism and the consumption of fixed carbon resources (Mengel and Kirkby, 2001) as a result of this huge deposition of carbohydrates take place in the source leaves.

Because of these changes of photosynthetic C metabolism excess of non-utilized light energy and photoelectrons are there in the plant bodies, which create photo oxidative damage to plant body. The plants with potassium paucity under drought are highly susceptible to light with high intensity and become necrotic and chlorotic quickly. Impairment in stomatal regulation, transfer of light energy into chemical energy, transport of assimilates from source to sink and disturbance in photosynthetic CO_2 fixation are the main disorders of potassium deficiency. Potassium has greater ability to produce tolerance in plant body. Hence, potassium can improve production and quality (Cakmak, 2010) to fulfill the current food requirements under ever reducing irrigation water scenario. Potassium is important in the growth of crops and an important ion in the physiology of plant water relations. Management practices have a direct effect on P, K, S and Ca availability and utilization by crops. Manure, as opposed to inorganic fertilizers, supplies nutrients over time through mineralization. Also, the addition of organic matter with manure or with the use of an efficient crop rotation will affect soil properties such as cation exchange capacity and pH, and therefore root and nutrient interactions (Hickman, 2002). In addition, the presence or absence of certain elements can affect the general soil quality. For example, K is a soil aggregating agent which is known to have a positive effect on soil physical properties and subsequently crop yields (Hamza and Anderson, 2003). Recommendations of Wortmann *et al.* (2009) for P, K, and S were evaluated using results from 34 irrigated corn (*Z. mays* L.) trials conducted in diverse situations across Nebraska. The results indicate a need to revise the current recommendation for P, to maintain the current K and S recommendations, and to use soil organic matter and pH in addition to soil test nutrient values in estimating applied nutrient requirements for irrigated high yield corn production. Abundant amounts of K are required by most plants. However, its uptake by plants is significantly affected by soil moisture content, which affects rates of root growth and of K+ diffusion from soil to the root. Hence, K uptake efficiency is rather low in dry-land regions. Thus, it becomes a major limiting factor for attaining optimal crop yield and quality (Ge *et al.,* 2012). Despite acting as an essential macronutrient, K serves as a primary osmoticum to maintain turgor in plants, particularly under stressful environments. Therefore, abundant K+ accumulation in plant tissues under DS may play a vital role in water uptake from the soil (Cakmak, 2005).

In view of several reports, it is now evident that the exogenous application of K can alleviate drought-induced negative effects on plant growth (Andersen *et al.*, 1992; Abdelvahab and Abdalla, 1995; Sudama *et al.*, 1998; Tiwari *et al.*, 1998; Sangakkara *et al.*, 2001; Singh and Kuhad, 2005; Fanaei *et al.*, 2009; Ezzat *et al.*, 2010; Mohammad and Mahmood, 2011). K application can improve drought tolerance in plants by regulating a variety of processes, such as osmoregulation, charge balance, energy status, and protein synthesis (Maathuis and Sanders, 1996). Reduced water loss of plants grown under adequate K supply is dependent on the osmotic potential of mesophyll cells (Cakmak, 2005). Several studies, often under short durations of DS, have provided evidence of the role of K in mitigating DS by enhancement of NRA and accumulation of K^+, glycine betaine, FP, and SP (Maathuis and Sanders, 1996; Fanaei *et al.*, 2009; Ezzat *et al.*, 2010; Mohamma and Mahmood, 2011). Most past studies have dealt with the effects of K on plant physiological responses to mitigate DS during a single growth stage and a sudden simulated DS, mainly in terms of single factorial effects of a cultivar, water, or fertilizer. Hence, there is a need to investigate the influence of K supplementation on the response of maize cultivars exposed to long-term DS and to elucidate the specific role of K in modulating plant physiological responses to mitigate DS, as well as in the overall improvement of plant vigor by optimal K fertilization, which in turn facilitates enhanced tolerance to DS (Zhu *et al.*, 2005; Fanaei *et al.*, 2009; Ezzat *et al.*, 2010; Mohamma and Mahmood, 2011).

MATERIAL AND METHODS

A. Location of experiment
The experiment was conducted at the mirjave (In Iran) which is situated between 29° North latitude and 61° East longitude.

B. Composite soil sampling
Composite soil sampling was made in the experimental area before the imposition of treatments and was analyzed for physical and chemical characteristics.

C. Field experiment
The field experiment was laid out in randomized split plot design with factorial design with four replications.

D. Treatments
Treatments included irrigation (7, 10 and 13 days) as main plot and potassium fertilizer (0, 30, 60 kg/ha) as sub plot.

E. Data collect
Data collected were subjected to statistical analysis by using a computer program MSTATC. Least Significant Difference test (LSD) at 5 % probability level was applied to compare the differences among treatments` means.

RESULTS AND DISCUSSION

A. Harvest Index
Analysis of variance showed that the effect of irrigation on harvest index was significant (Table 1). The maximum of harvest index (38.97) of treatments 7 day was obtained (Table 2). The minimum of harvest index (33.92) of treatments 10 day was obtained (Table 2). Analysis of variance showed that the effect of potassium on harvest index was significant (Table 1). The maximum of harvest index (38.94) of treatments 60 kg was obtained (Table 2). The minimum of harvest index (33.57) of treatments 0 kg was obtained (Table 2). Analysis of variance showed that the effect of variety on harvest index was significant (Table 1). The maximum of harvest index (36.15) of treatments 704 was obtained (Table 2). The minimum of harvest index (35.69) of treatments 703 was obtained (Table 2).

Table 1: Anova analysis of the corn affected by Irrigation and potassium.

		Ms			
S.O.V	**df**	**Harvest Index**	**Biological Yield**	**Seed yield**	**Percent of protein**
R	3	3.537^{ns}	1442.6^{ns}	55743.27^{ns}	0.575^{**}
Irrigation (I)	2	172.679^{**}	62041322.1^{**}	12320510.76^{**}	0.578^{*}
Error a	6	1.499	15497.7	15383.69	0.572
Potassium (K)	2	180.912^{**}	50859946.4^{**}	19225161.933^{**}	4.802^{**}
Variety (V)	1	3.832^{**}	1184517.0^{**}	440391.12^{**}	0.026^{ns}
I*K	4	25.823^{*}	7303515.1^{**}	2091302.45^{**}	0.122^{ns}
I*V	2	6.489^{**}	330884.3^{*}	14540.54^{**}	0.017^{ns}
K*V	2	4.165^{**}	462550.1^{**}	4349.04^{ns}	0.007^{ns}
I*K*V	4	12.506^{**}	2052914.5^{**}	8995.27^{**}	0.067^{ns}
Error b	45	0.231	7390.1	2358.57	0.177
CV	-	1.339	0.675	11.55	7.630
*, **, ns: significant at p<0.05 and p<0.01 and non-significant, respectively.					

B. Biological yield

Analysis of variance showed that the effect of irrigation on biological yield was significant (Table 1). The maximum of biological yield (13999.42) of treatments 10 day was obtained (Table 2). The minimum of biological yield (10925.42) of treatments 13 day was obtained (Table 2). Analysis of variance showed that the effect of potassium on harvest index was significant (Table 1). The maximum of biological yield (14285.42) of treatments 60 kg was obtained (Table 2). The minimum of biological yield (11397.83) of treatments 0 kg was obtained (Table 2). Analysis of variance showed that the effect of variety on biological yield was significant (Table 1). The maximum of biological yield (12863.25) of treatments 704 was obtained (Table 2). The minimum of biological yield (12606.72) of treatments 703 was obtained (Table 2).

Table 2: Comparison of different traits affected by Irrigation and potassium.

Treatment	**M**			
Irrigation	**Harvest Index**	**Biological Yield**	**Seed yield**	**Percent of protein**
7	38.97a	13280.04a	52150.04a	5.66a
10	33.92c	13999.42a	4780.67b	5.55ab
13	34.87b	10925.42b	3818.50c	5.35b
potassium				
0kg	33.57c	11397.83c	3818.50c	5.08c
30kg	35.26b	12.521.42b	4414.25b	5.50b
60 kg	38.94a	14285.42b	5578.21a	5.98a
verity				
703	35.69b	12606.72b	4525.44b	5.54a
704	36.15a	12863.25a	4681.86b	5.50a
Any two means not sharing a common letter differ significantly from each other at 5% probability				

C. Seed yield

Analysis of variance showed that the effect of irrigation on seed yield was significant (Table 1). The maximum of seed yield (52150.04) of treatments 7 day was obtained (Table 2). The minimum of seed yield (3818.50) of treatments 13 day was obtained (Table 2). Analysis of variance showed that the effect of potassium on seed yield was significant (Table 1). The maximum of seed yield (5578.21) of treatments 60 kg was obtained (Table 2). The minimum of seed yield (3818.50) of treatments 0 kg was obtained (Table 2). Analysis of variance showed that the effect of variety on seed yield was significant (Table 1). The maximum of seed yield (4681.86) of treatments 704 was obtained (Table 2). The minimum of seed yield (4525.44) of treatments 703 was obtained (Table 2).

D. Percent of protein

Analysis of variance showed that the effect of irrigation on percent of protein was significant (Table 1). The maximum of percent of protein (5.66) of treatments 7 day was obtained (Table 2). The minimum of percent of protein (5.35) of treatments 13 day was obtained (Table 2). Analysis of variance showed that the effect of potassium on percent of protein was significant (Table 1). The maximum of percent of protein (5.98) of treatments 60 kg was obtained (Table 2). The minimum of percent of protein (3818.50) of treatments 0 kg was obtained (Table 2). Analysis of variance showed that the effect of variety on percent of protein was not significant (Table 1). The maximum of percent of protein (4681.86) of treatments 704 was obtained (Table 2). The minimum of percent of protein (5.08) of treatments 703 was obtained (Table 2).

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