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Effect of Potassium Fertilizer on Corn Yield (*Jeta* cv.) Under Drought Stress Condition

[1]*S. Tabatabaii Ebrahimi,* [2]*M. Yarnia,*
[3]*M.B. Khorshidi Benam and* [4]*E. Farajzadeh Memari Tabrizi*

[1]Department of Agronomy, Islamic Azad University, Tabriz Branch, Iran
[2]Department of Agronomy, Faculty of Agriculture, Islamic Azad University, Tabriz Branch. Iran
[3]Islamic Azad University, Miyaneh Branch, Iran
[4]Islamic Azad University, Malekan Branch, Iran

Abstract: In order to consider yield changes and some characteristics of corn cv. Jeta reaction to water deficit stress and potassium fertilizer, a randomized complete block design base split plot experiment with three replications was conducted during 2009 at Agricultural Research Station, Islamic Azad University, Tabriz branch, Iran. Water deficit stress in four levels after 50, 90, 130 and 170 mm evaporation from class A in main plot and potassium sulfate in five levels 0, 50, 100, 150 and 200 kg/ha in sub plots. The obtained results indicated that increasing water deficit lead to reduce leaves number, stem diameter, biomass, grain numbers per row, grains weight per ear, 1000 grains weight, leaf area duration, grains effective filling period and grains yield. Increasing application of potassium fertilizer from 0 to 200 kg/ha increased number of leaves, stem diameter and biomass. The highest plant biomass was obtained by irrigation after 50 mm evaporation from head and application potassium fertilizer at the rate 200 kg/ha and the lowest by irrigation after 170 mm evaporation and lack potassium fertilizer. Also, application of 200 kg K/ha increased grains number per row, grains weight per row and 1000 grains weight that increased grains yield. The highest grains yield was 15.9 t/ha resulted in by application potassium fertilizer at the rate of 200 kg/ha and the lowest at lack application fertilizer equal 10 t/ha. Application of 200 kg K/ha increased leaves number, stem diameter, biomass, grains number per row, grains weight per row, 1000 grains weight relation lack application the rate 6.5, 92.49, 66.82, 24.96, 48.4, 13.92%, respectively. Increase in the application of potassium fertilizer caused to augmentation leaf area duration and in this way effective seed filling period find to increase. Base on the results of this experiment, application potassium fertilizer under water deficit condition decreased grains yield from 19.96 to 48.37%.

Key words: Corn · Water deficit · Potassium sulfate · Effective filling period

INTRODUCTION

Seasonal dryness is an important limitation factor in corn cultivation and it decreases corn annual yield as 17%. In Mediterranean semi arid condition corn high seed yield need to complement irrigation. Regarding to irrigation high expenses, deleting unnecessary irrigation may cause economic produce in corn [1]. Potassium consumption distinguished that corn roots developed well and it was powerful enough to absorb water from soil. Therefore, potassium increased resistance capacity against drought that increased growth of corn plant [2]. Potassium deficit have harmful effect in dry weather condition. Water layer inside soil components was very tender in dry condition, whereas highest amount of potassium element flow through this layer to plant roots. Therefore, drought created highest difficulties in absorption of this element in cultivated plants. Potassium deficit decreased ATP and plant transfer system is disturbance and result phosphorus assimilation assembling and decreased photosynthesis rate which led to unusual resources organization development [3]. Potassium is necessary to protect turgor pressure in order to create maximum expand of leaf and stem length. This accelerates canopy formation and therefore increased sun light absorption rate to extend to maximum growth during

Corresponding Author: M. Yarnia, Department of Agronomy, Faculty of Agriculture, Islamic Azad University, Tabriz Branch, Iran, E-mail: yarnia@iaut.ac.ir & m.yarnia@yahoo.com.

growth season. Growth may delay in potassium intensive deficit and canopy may not close fully [4]. While potassium consumption lead to accelerate canopy formation and cause to more available water use by plant and even plant early maturating [5]. Consumption of potassium increased absorption consequent from osmosis potential and expand cell pressure and length, on the other hand, consumption of potassium with increasing dry matter production and leaf area extension the large rate produced and improve water in plant tissue at intension water stress condition [3]. Corn leaf green parts decreased because of water pressure deficit in particular in lack consumption of potassium in soil. This reduction is 25% whereas consumption of potasium decreased corn green leaf parts only 3%. Consumption of potassium was caused to increase the rate (46.1 until 101.4%) under the water deficit condition Consumption of potassium was caused to increase leaf area rate (61.4 until 86.4%) as compared with unconsumption of potassium under the suitable soil water condition [2]. Water leaf potential and osmosis force indicated more reduction in millet dry resistant and potential force of leaf increased with increasing potassium content under water deficit condition. Rate of supplied potassium do not have effect in leaf sugar solution or protein but osmosis regularity observed in the plant under water deficit condition and supplied potassium [6]. Potassium fertilizer in corn increased biological yield more than nitrogen. In other hand sufficient supply of water decreased much of potassium and nitrogen fertilizer and these results indicated that nitrogen and potassium adding have more share in improvement protective activation of fat metabolism enzyme and peroxide [7].

The aim of this research was reaction evaluation of Jeta variety with different consumptive level of potassium sulfate against deficit water with different intensities.

MATERIALS AND METHOD

In this experiment mid season corn Jeta variety cultivated during 2008- 2009 sessions at Agricultural Research Station, Faculty of Agriculture, Islamic Azad University, Tabriz branch, Iran located in 5 kilometer from Tabriz with 46° and 17` E and 38° and 5` N and 1360 meter altitude. Annual rainfall and temperature and maximum temperature were 7/4mm, 13/2°C, 40/6°C, respectively. Soil pH is limited poor until middle alkaline and with no salinity risk. This consideration was conducted in randomized complete block design based split plot and with three replications. Treatments in this study consisted of four levels for irrigation (50, 90, 130, 170 mm after evaporation of A class pan and potassium fertilizer level (0, 50, 100, 150, 200 kg/ha) in sub plot. Distance of sub plots was one no planting row and distance of main plots was two no planting rows and distance of replication was two meters. Sowing date was in the mid May. Sprayed of need phosphor fertilizer, disked and mound prepared. No pesticide accomplished for nonexistence of pests and specific disease in field. Weeding and weed control accomplished in equal manner in the duration of growth season. According to results of soil test (Table 1) and corn need nitrogen distributed rate (75 kg/ha) at the planting time for all treatments and 75 kg/ha dressed in 25-30 cm corn height. All treatment of experiment irrigated every week until appearance tassel time and after this section irrigation accomplished on experiment treatments basis and evaporation of A class pan.

After the appearance of corn silk hairs and pollination samples were taken from each plot in all experiment treatment in order to evaluate the seed filling period. One competitive plant takes off each plot, while measuring leaf area, four rings of corn grains separated. Average of seed weight obtained after weighing dried seed in electrical oven with 75 Celsius after 24 hours. Taking samples of all plots accomplished in a regular manner each 7 days until final growth period. Velocity and seed filling period and leaf area duration calculated by below relation [8]:

$$b=\frac{\Sigma xy-(\Sigma x)(\Sigma y)/n}{\Sigma x^2(\Sigma x)^2/n} \quad \text{Effective filling period} = \frac{\text{weight of grain}}{\text{grain filling Rate}} \quad LAD=LA_2+LA_{\frac{1}{2}}\times(T_2-T_1)$$

After harvest characteristics such as leaf number, biomass, grains yield, grains number per row, 1000 grains weight, grains weight per ear and stem diameter were measured. Data normal test before statistical analysis was done and MSTAT-C used for ANOVA and charts drew by Excel software. Duncan multi range comparison used for comparing means (p<5%).

Table 1: Physicochemical analysis for soil in 0-30 cm depth

Depth (cm)	Percent of saturation SP%	Electrical Conductivity EC*10^3	Total nitrogen%T.N	Absorptive phosphorus ppm	Absorptive potassium ppm
0-30	2.52	8.26	0.138	50.5	300

RESULTS AND DISCUSSION

Analysis of variance showed that different levels of water stress and potassium had significant effect on evaluated characteristics. Interaction effect of water stress and consumptive potassium was significant on grain filling period (Table 2).

Stem Diameter: Comparison of means indicated that different levels of drought stress had significant on stem average diameter. With increasing drought stress (50-170 mm evaporation) stem diameter showed significant decrease. So that the highest stem diameter was obtained with irrigation after the 50 mm evaporation equal 2.12 cm and the lowest with irrigation after the 170 mm evaporation equal 1.82 cm that was non-significant with stress level (90 and 130 mm evaporation). Thus irrigation after 90, 130, 170 mm evaporation decreased stem diameter relative to irrigation after of 50 mm evaporation as 7.4, 8.91 and 14.33%, respectively. One of water deficit effects is reducing cell development by incomplete cell turgid and therefore water stress caused diameter reduction [9]. Mean comparison indicated that effects of different potassium level on stem diameter was significant. Consumption of potassium at the rate 50, 100 kg/ha and control did not have significant different. Also consumption of potassium fertilizer at the rate 150, 200 kg/ha and 50, 100 kg/ha was not different. But both showed significant difference with control on stem diameter. So that the highest and lowest stem diameter was obtained with consumption of potassium fertilizer at rate 200 kg/ha equal 2.07 cm and control equal 1.84 cm, respectively (Table 3). In a study on corn, decrease in below epidermis scloranchim tissue and xylem vascular cell was reported to become thin as a result of deficit potassium [10].

Leaves Number: The maximum leaves number was obtained after 50 mm evaporation as 12.84 without significant difference with irrigation after 90 mm evaporation and the minimum leaves number was obtained with 170 mm evaporation as 11.8 that were significant with other irrigation levels (Table 3). Therefore, reduced water availability from 50 to 170 mm evaporation decreased leaves number by 80.9%. Bajji *et al*. [11] reported that water stress effects leaf production in durum wheat because leaves number under studied varieties was reduced in drought period end. Consumptive levels of

Table 2: Result of analysis variance on studies characteristics in cornMean square

S.OV	df	Filling grains period	Leaves number	Stem diameter	Biomass	Grains number per row	Grains weight per ear	1000 grains weight	grains yield
Replication	2	42.518	0.494	0.009	955.42	11.971	287.768	6.588	19896.9
Irrigation	3	79.821	2.858**	0.236*	18102.678**	239.856**	7891.535**	61.329**	541995.763**
Error 1	6	37.8	0.118	0.051	1047.403	14.908	405.774	8.335	27966.613
Potassium	4	244.116**	1.356*	0.105*	20421.597**	115.053**	5924.9**	40.938**	407811.693**
Irrigation× potassium	12	145.618*	0.172	0.008	1870.377	21.122	963.015	5.166	66361.24
Error 2	32	57.201	0.504	0.35	1080.302	22.463	853.207	8.542	58716.986
CV (%)		11.23	5.73	9.54	11.83	12.78	18.93	9.12	18.92

Table 3: Mean comparisons on studies characteristics in corn

Experiment factor	Leaves number	Stem diameter (cm)	Biomass per plant (g)	Grains number per row	Grains weight per ear (g)	1000 grains weight (g)	Grains yield (ton/ha)
Irrigation after the							
50 mm evaporation	12.84^{a}	2.12^{a}	329.9^{a}	43^{a}	188^{a}	340.05^{a}	15.6^{a}
90 mm evaporation	12.55^{ab}	1.963^{ab}	262.4^{b}	35.97^{b}	149.9^{b}	330.51^{a}	12.44^{b}
130 mm evaporation	12.39^{b}	1.931^{ab}	262.1^{b}	34.79^{b}	139.8^{b}	300.77^{b}	11.600^{b}
170 mm evaporation	11.8^{c}	1.81^{b}	257.2^{b}	34.54^{b}	139.7^{b}	290.93^{b}	11.59^{b}
Potassium fertilizer							
control	12^{b}	1.841^{b}	225.3^{e}	33.21^{c}	122.5^{c}	290.29^{a}	10.17^{c}
(50 Kg/ha)	12.18^{ab}	1.91^{ab}	253.9^{d}	35.46^{bc}	147^{b}	310.13^{ab}	12.200^{bc}
(100 Kg/ha)	12.32^{ab}	1.933^{ab}	276^{c}	37.04^{bc}	153.5^{b}	320.73^{a}	12.74^{ab}
(150 Kg/ha)	12.7^{a}	2.033^{a}	303.7^{b}	38.17^{ab}	166.8^{ab}	330.42^{a}	13.84^{ab}
(200Kg/ha)	12.78^{a}	2.071^{a}	330.8^{a}	41.5^{a}	181.8^{a}	330.74^{a}	15.09^{a}

Mean followed by similar letters in each column are not significantly different at the 1% level.

potassium as 50 and 100 kg/ha increased non-significantly leaves number in comparison with control, while potassium applying at the rate of 150 or 200 kg/ha had significant difference with control. Applying potassium at the rate of 50, 100, 150 and 200 kg/ha increased leaves number by 1.5, 2.66, 5.8 and 6.5%, respectively. Aslam [12] indicated that application of potassium in canola increased inter-node length. Attentive affection of potassium in plant growth, cell division and hydrocarbon synthesis [13], increased leaves number with increasing applying of potassium is more explanation able.

Grains Number per Row: Irrigation after 50 mm evaporation recorded the highest grains number per row as 43 and the lowest was obtained with irrigation after 170 mm evaporation as 32.54. Therefore, the reduction in available water from 50 to 170 mm decreased grains number per row by 19.67%. On the results, stress levels (90, 130 and 170 mm evaporation) did not indicate significant difference with each other in grains number per row. Whereas, all evaporative levels (90, 130, 170 mm), had significant difference with 50 mm evaporation level (Table 3). Drought stress delayed flowering,therefore silks appear after tasseling and there was no exist alive pollen for inoculation. So severely reduction happen and thus ovules didn't fecundate and seed didn't formed,finally fewer grains number was formed [14]. Also Nesmith and Ritchie [9], Bolanas and Edmeads [15] reported grains number reduction per row as a result of drought. Mean comparison showed that application of potassium at the rate of 200 kg/ha produced the highest grains number per row as 41.5 that was not different with 150 kg/ha. Control produced the lowest grains number per row 33.31 with significant difference with 50 and 100 kg/ha. Therefore applying potassium as 200 kg/ha increased grains number per row as 24.96%. Potassium affected cell metabolism and enzyme activity and regulates cell osmosis and increase absorption of water and photosynthesis. Material transition in phloem vascular effected transition of growth stimulation material and increased cell division grains number per row [16].

Seed Weight per Ear: Analysis of variance showed that water deficit stress had no significant effect on total grains weight per row at 90, 130 and 170 mm). Nevertheless, all levels of water deficit stress showed significant difference with control (50 mm evaporation). Result showed that maximum total grains weight per row was obtained total grains weight per row was decreased by 26, 20, 25.63 and 25.69% as levels of water stress rate increased from 50 to 90, 130 and 170 mm, respectively (Table 3). Edmeads *et al*. [1] showed that drought stress decreased grains initiation in corn. Drought stress at grains filling period limited growth and development of grains for the reason of assimilation lack or unsuitable condition of water in embryo and or endosperm as a result of that effective filling grains period shorted and grains weight decreased happen [9]. On basis of Table 3 existed significant differences was found among potassium application levels at total grains weight per ear. Also data in Table 3 showed that the highest total grains yield obtained with 200 kg/ha as 181.8 g and the lowest was with control as 122.5 g. On other hand, total grains yield was increased with 200 kg/ha in relative to control as 48.4%. Mentionable rate of total grains yield didn't have significant difference in 50, 100 and 150 kg/ha. Total grains yield increased with 50, 100, 150 kg/ha in relative to control as 16, 31 and 25.3 and 20%. Increase in potassium application increased CO_2 assimilation and photosynthesis. Important role of potassium in material transfer, leaf made assimilates transfer to productive organs and caused better seed filling and weight [16].

1000 Grains Weight: The highest 1000 grains weight was produced with 50 mm evaporation as 340.05 g. and the lowest was with 170 mm evaporation as 290.93 g. 170 mm evaporation showed no significant difference with 130 mm. Reduction of available water in the rate 50 – 100 mm evaporation decreased 1000 grains by 144.4%. Reduction of grains wieght as a result of drought reported by Bismillah khan *et al*. [17]. Also Pandy *et al*. [8] showed that water stress reduced grains yield and 1000 grains weight in corn. Results showed that significant difference exist among different potassium fertilizer levels from on 1000 grains weight. The highest 1000 grains weight was with consumption rate of potassium 200 kg/ha equal 330.74 g and the lowest was with control equal with 290.29 g. This affair indicated that 1000 grains weight was increased with consumption of 200 kg/ha relative to control as 13.93% (Table 3). Potassium has important role in water use efficiency and improves in growth plant condition and cell division and make of hydrocarbon, protein and quick transportation toward grains [16].

Biomass: The highest and lowest biomass was obtained after the 50mm equal 329.9 g and 170 mm equal 257.2 g, respectively. Irrigation after 90, 130, 170 mm evaporation did not show significant difference. Also irrigation treatment after 50 mm evaporation had significant difference with other irrigation levels in biomass.

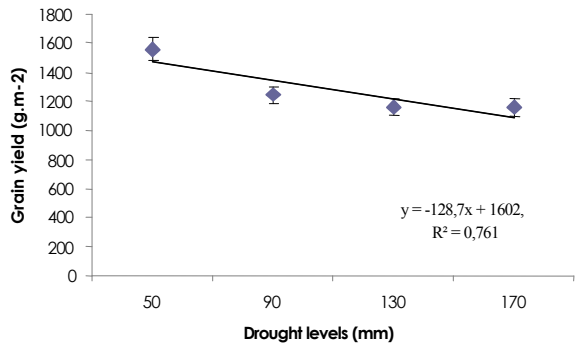

Fig. 1: Effect of drought stress on corn grain yield

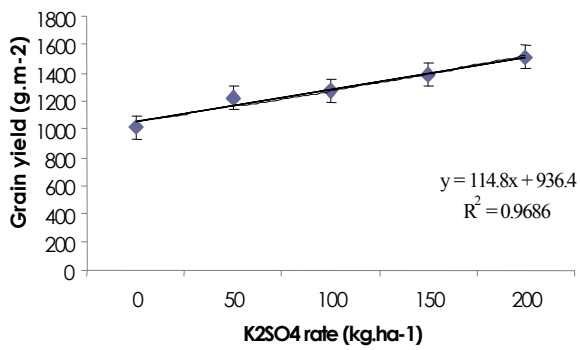

Fig. 2: Effect of potassium sulfate on corn grain yield

Irrigation after 90, 130, 170 mm evaporation in comparison with control decreased biomass as 20.46, 20.55 and 22.03%, respectively (Table 3). Smith [18] reported that water stress decreased dry weight as 28 to 32% in growth period. Stress caused reduction of cell development through incomplete edema cell and reduced photosynthesis [19]. All consumptive levels of potassium fertilizer had significant difference on biomass.The highest and lowest biomass obtained respectively at 200 kg/ha equal 330.8 g and control equal 225.3 g. Wiebold and Scharf [20] indicated that potassium increased yield of dry substance in corn. Potassium could increase the rate of CO_2 stabilizing with interference in osmosis regulation, improving stoma closure, increased CO_2 conductivity and enzyme activity as a result of photosynthesis and carbohydrate produce. Therefore potassium increased in carboxilation efficiency in water deficit condition and this increased dry weight of shoot [16].

Grain Yield: The highest grains yield was obtained in irrigation after 50 mm evaporation equal 15.6 t/ha that have significant difference with other levels stress and the lowest was in irrigation after the 110 mm evaporation equal 11.59 ton that had significant difference with irrigation levels after the 90 and 130 mm evaporation. Irrigation after 90, 130 and 170 mm evaporation relative to control evaporation increased the rate as 20.25, 64, 25, 25/7%. On other hand, increase in stress level showed a decrease in grains yield per area unit (Figure 1). Stress before flowering period affect on leaf area and stem development and severely changes the rate of gathering substance in organs. Despite stop of photosynthesis decreasing, seed growth accomplished through renewed store assimilation transfer especially stem. Therefore, the reduction in developed stem by stress affected on ultimate yield [21]. Increase drought stress not only increased ABA and hydrolyze enzyme but also Abscisic acid (ABA) transfer in high rate to endosperm tissue and prevent endosperm cell division [22]. Also reduction of yield over 50 percent as stress results in corn reported by Wydianatha and Tandon [23].The highest and lowest grains yield in consumption of 200 kg/ha equal 15.09 t/ha and in control with 10.17 t/ha. Consumptive levels as 50, 100 and 150 kg/ha had no significant difference on grains yield. Potassium fertilizer in comparison with control increased grains yield as rate 49.96, 25.27, 36.08, 48.38%, respectively (Fig. 2). Water stress increased growth hormone level for example cytokinin and decreased inhibitor hormones for example ABA, but potassium increased cell division, grains number per row, row numbers per row, 1000 grains weight and grains yield [9]. Potassium regulate stoma closure and prevent water wasting and regulating osmosis, increase water use efficiency and improved growth condition in corn [20].

Leaf Area Duration: Result showed that in all levels of water deficit stress until 128 day after the sowing leaf area duration increased. But at the end of growth period, means 142 days after the sowing showed decrease. In irrigation after 50 mm evaporation leaf area duration showed significant difference with other stress levels. Levels of stress after 90 mm evaporation had highest leaf area duration in 121 days after the sowing. But after that until growth period end, showed highest leaf area duration in irrigation after 50 mm evaporation. 170 mm evaporation in all growth period had lowest leaf area duration.The highest leaf area duration was obtained with irrigation after the 50 mm evaporation and 128 days after the sowing equal 6159.5 cm^2.day and the lowest with 107 day after sowing and stress level of 170 mm evaporation equal with 3292.1 cm^2.day (Fig. 3). All levels of potassium until 128 day after sowing increased leaf area duration significantly but after that it showed the least LAD.

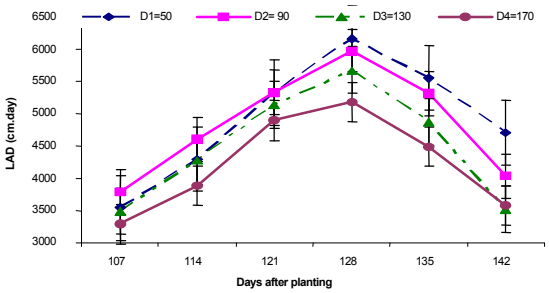

Fig. 3: Effect of drought stress on corn leaf area duration

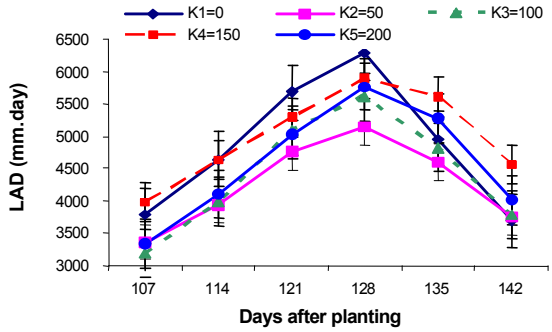

Fig. 4: Effect of drought stress on corn leaf area duration

Application of potassium fertilizer as rate 150 kg/ha in 142 day after the sowing and application of potassium fertilizer at rate 50 kg/ha in 128 day after the sowing had significant difference with other levels of application. Perfectly until 128 day after the sowing control treatment had highest leaf area index. But after 128 days to growth period end had lowest leaf area duration (Fig. 4). Nesmith and Ritchie [9] indicated that stress during grains filling period decreased leaf area and acceleration of leaf ages process. Yegappan *et al*. [24] showed on sunflower that water deficit stress accelerated leaf aging and decreased leaves number. Also leaf area duration as a result of potassium supply reported in corn [20] and mustard [12].

Grain Filling Period: The highest grain filling period was at irrigation after 50 mm evaporation as 84.83 days and the lowest with control as 65.41 days. On other hand, grains filling period increased as 29.68% in irrigation after 50 mm evaporation and 50 kg/ha of potassium fertilizer relative to control. Also application of 200 kg/ha potassium fertilizer relative to control increased the rate 10.21% in grains filling period (Fig. 5). Irrigation after 170 mm evaporation and in all potassium levels significant difference was showed in comparison with control. In irrigation treatment after 170 mm evaporation the highest grain filling period was obtained with consumption of 50 kg/ha equal 64.06 and the lowest was equal 57.35 with

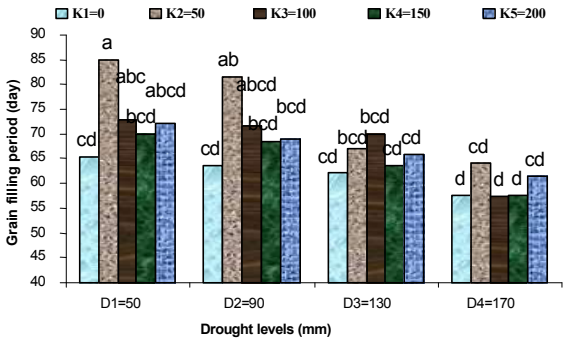

Fig. 5: Effect of drought stress and potassium sulfate on corn grain filling period

consumptive 100 kg/ha. Perfectly among all levels of water stress and in among all levels of potassium fertilizer, the highest grain filling period was obtained by irrigation after the 50 mm evaporation and consumption of potassium fertilizer as 50 kg/ha and the lowest with irrigation after 170 mm evaporation with consumption of potassium fertilizer as 100 kg/ha. This affair indicated that the highest grain filling period in relative to the lowest and irrigation after the 50 mm and control increased rate 29.68% and decreased the rate 12.32%, respectively in relative to control. Irrigation after 90, 130 and 170 mm evaporation in relative to 50 mm decreased the rate as 2.47, 4.81, 11.84%, respectively in grain filling period. Results showed that water deficit after pollination shortened grain filling period to give priority to dried endosperm and limited of embryo volume [25]. Drought stress in grain filling period shortened effective grain filling period and as a result, grains weight decreased [14]. Increase in potassium fertilizer consumption increased CO_2 stabilization and photosynthesis and attentive to important role of potassium in transfer of substances in leaf to procreative segment and filled seed as a result of grain filling period increase [16].

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