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European Journal of Experimental Biology, 2012, 2 (6):2113-2119

ISSN: 2248 –9215
CODEN (USA): EJEBAU

Sugar beet (*Beta vulgaris* L.) response to potassium application under full and deficit irrigation

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ABSTRACT

To investigate the effect of potassium application on quantitative and qualitative characteristics of sugar beet under full and deficit irrigation, a split plot experiment in a randomized complete block design with three replications was conducted. Experimental factors included two irrigation regimes (full and deficit irrigation) and three potassium application levels (0, 50 and 100 kg K_2O ha^{-1}). Potassium sulphate was used as potassium source in this experiment. Results showed that deficit irrigation significantly decreased root yield, shoot yield and sugar yield. However, irrigation treatments had no effect on impure sugar percent, pure sugar percent and root dry matter. Potassium application rates had significant effect on all investigated characteristics, except root dry matter. Potassium application increased root yield, shoot yield, impure sugar percent, pure sugar percent and sugar yield. Maximum and minimum root yield, impure sugar percent, pure sugar percent and sugar yield were observed in 100 kg K_2O ha^{-1} and control treatments, respectively. According to experiment results, application of 100 kg K_2O ha^{-1} improved quantitative and qualitative characteristics of sugar beet under full and deficit irrigation.

Key words: Sugar beet, *Beta vulgaris* L., Deficit irrigation, Full irrigation, Potassium

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INTRODUCTION

In arid and semi arid climate ,water shortage is the main barrier in agriculture development. Without optimized use of water resources , agriculture will be impossible (Kheirabi et al., 1996). Deficit irrigation is one optimized solution to bring products under water shortage conditions , with product reduced in unite level and its increase with develop (Sepaskhah et al., 2006). Deficit irrigation allows to the plants receive water lower than request(English et al 1990). Sharify et al(2001) studied the effect of various levels of irrigation on sugar beet. They considered white sugar yield by reducing the water consumption from 1000 to 725 and to 655 mm decreased 16.6 and 39.7 percent, respectively . It showed reducing in high stress condition is high. Vazifedoust et al (2008) reported , we can get to economic yield in deficit irrigation by restrictions in water resources .They reported 1.1 kg dry material for consumption of one cubic meter for sugar beet . Jahad Akbar and Ebrahimian (2003) reported reduction in sugar yield is with 20 percent deficit irrigation at the beginning of sugar beet growing season. Results of researches by Jahad Akbar et al(2001) indicated deficit irrigation causes significant decrease in root yield , impure sugar and root sodium , But harmful nitrogen increased significantly by deficit irrigation actions.

Fabiro et al (2003) studied effect of deficit irrigation on sugar beet compared to 8 levels of irrigation than complete irrigation. They reported there is considerable difference on water use efficiency in different levels of irrigation. In the research , water use efficiency 130 – 170 $kg.mm^{-1}$ of water was reported . In the care of complete irrigation , by use of 6898 m^3 water in hectare, got the most yield of root (117.6 tone in hectare) . According to statements of Monreala et al (2007) , deficit irrigation is the main factor to accumulate Proline in sugar beets 'root . Their results represent positive and significant correlation between Proline and amount of sugar in sugar beet's root. It illustrates

relation between response to drought stress and loss of carbohydrates and glucose and proline concentration . Tavakoli (1996) studied the effect of deficit irrigation on sugar beet . He reported we can get the most pure profit by 30 percent deficit irrigation. In this study , sugar beet yield 13.8 percent reduced by 34 percent decrease in water consumption. Rahimian and Asad (2000) studied the effect of deficit irrigation on quality and quantity of sugar beet .They pointed that deficit irrigation increases efficiency of sugar beet and showed that deficient irrigation increased water use efficiency, and increasing on rate of water consumption of irrigation reduce pure sugar toward impure sugar.

Potassium plays a main role against deficit water , plant disease and loading in farm plats ,too. Potassium has great effect on keeping down Osmotic potential of root cells. Its existence is critical for duration preservation and create the pressure on poke and adjustment water balance on plants . (Ahmad et al., 1992). According to assessments of Malakotty (2000) potassium in plant has the role of catalyst and its shortage reduces plants' resistance against pests ad plant disease . Existence of potassium has special importance in keeping water plant's tissue. It has reported a lot about its accumulation. (shabala et al, 2000) .

Fathy (2009) studied effect of various amounts of nitrogen and potassium on yield , quality and nutrients contents of sugar beet . Results showed that increasing of consumption values of nitrogen and potassium increase weight of wet and dry root and biomass and also , yield of sugar . Adding highest level of potassium (1114 kg k20/h) cause significant increase on contents of sugar , yield of recoverable sugar and some quality features. During the research , Mohammadian and his associates (2004) review effect of various levels of potassium (not using of potassium , utilization in order to reach to the exchange of soil cation to 5% capacity of exchange soil cation and use of potassium in order to reach to the exchange potassium of soil to 5 % capacity of exchange soil cation + plant requirement) four levels of away irrigation (9,12,15,18 days) on yield of sugar beet' s root in 2 years . Regard to the results , interval irrigation on root yield has significant effects. In the first year , the most yield of root gained in irrigation periods 9 and 12 days and in the second year , in irrigation periods 9 days. Upper periods of irrigation cause significant decrease of root yield. Various values of potassium consumption has just significant effect on root's yield in various periods of irrigation. Increase on consumption of potassium , also causes reduce on root's yield. Egilla and his associates (2005) showed that enough use of sufficient Potassium improved the contents of leaf moisture and water relations of plant compared to shortage conditions of potassium by reducing osmotic potential in gumbo . So that cause to stability of net photosynthetic rate , transpiration , stomatal conductance in dry tension condition and free of tension conditions. They also said in this plant , enough use of Potassium in conditions that plant water potential is low , cause to keep the rate of pour photosynthesis, increase pour photosynthesis to transpiration.

Now , there is no accurate and comprehensive information regard to effect of recourse to security of potassium and consumption value of it on quality and quantity features of sugar beet under complete irrigation and deficit irrigation. In order to improve quality and quantity of products and optimized use of reachable water resources, there is necessity to have more conditions of potassium management ,. This research reviews the effect of resource and use of potassium on root's yield and other quality and quantity features of sugar beet in complete and deficit irrigation.

MATERIALS AND METHODS

This experiment was done in 2010-2011 on personal farm in Jovein town,Malek Abad village , longitude 57 and 25 minutes East and latitude 36 and 42 minutes North and average height 1100 meters of sea level. Treatments was arranged in split plot factorial design based completely randomize block design with 3 replications. factors were two levels of irrigation(complete irrigation(irrigation periods 10 days(region custom) and deficit irrigation with irrigation periods of 20 days) as main plot , potassium resource in two levels (potassium sulfate and potassium chloride) and consumption value of potassium in three levels of(0, 50 and 100 kg/h k_2o) as factorial arrangement in subplot.

Each subplot involves 5 rows in 6 length , by distance between 50 rows and distance on row was 20 cm. In this research Aras cultivar has used.

It started to plow deep land to provide planting bed in the autumn of 2010 , final activities to proper the land done which include light plowing , disk and clearing before the acting or testing , samples were taken 0f 0-30 cm deep of farm soil . physical and chemical properties of soil was determined.(table 1)

Based on results of soil analysis , recommended value of phosphorus was added and combined to soil as triple super phosphate fertilizer(200 $kg.ha^{-1}$. Recommended nitrogen , also used as urea (250 $kg.ha^{-1}$) in 3 stages, 1/3 simultaneously by planting and the rest 2/3 during the growing of product.

After implementation of test , potassium treatments in distribution plots with soil. Yields of planting the seeds was done by using of sugar beet planting machine by distance between rows 50 cm in 13th May and at once , the farm was irrigated . After geminate , in the stage of four levels , they began to sparse the farm to access density and distance on row 20 cm. After of sparse , care of deficit irrigation done in plots and continued until the time of harvest. Other activities in the farm were done like weeding weeds and struggle with pests and illness according to the custom of region .

Table 1 physical and chemical features of soil in 30 cm deep in the place of test

Ph	Electrical Conductivity ds/m	Tissue	Organic carbon	Nitrogen	Phosphorus	Potassium	Manganese	Iron	zinc	copper
			percent		Mg/kg					
8/3	2/82		0/62	0/086	6	379	8/36	4/72	0/42	1/2

At the time of dealing and harvest of sugar beet in region (25 October) after removing of the marginal effect , one cubic mater was harvested completely. After separating of crown and air organic. It took to shoot and root and calculate of root yield and shoot . To review the quality features of root , samples of root transferred to laboratory of quality analysis of researches and crop services of sugar beet of Khorasan . After collection of all information , analysis of information used by SAS, and drawn tables and charts by Excel. The comparison of informs mean done by method of Duncan.

RESULTS AND DISCUSSION

Results of variance analysis exert that effect of irrigation value on sugar beet yield, Biomass and sugar yield was significant, but percent of dry material didn't take influence of irrigation value. Different amount of potassium had significant effect on all quantity features in statistic level of 5% . (table 2)

The most of root yield in sugar beet , biomass and sugar yield gained on complete irrigation. Increase of irrigation interval to 20 days cause 20.96 % decrease in root yield and 24 % biomass, while percent of dry material of root increases 5 % (table 3).It seems in drought conditions, closing the stomata cause decrease value of photosynthesis and finally decrease in building construction leaves. Therefore, this action will cause decreasing in root yield and biomass of sugar beet .

The most yield of sugar gained in complete conditions of irrigation and the least value of it gained in deficit irrigation(table 3). Because sugar yield was Multiplying root yield and sugar percent, It's said that increase of root yield in complete care of irrigation is the main factor of increase in sugar yield. Maybe the sugar content in root of sugar beet increases, because of moisture tension actions , but should be careful about this ; maybe whole of product sugar decreases, because of decrease in root yield. According to the report of Zahedi and Alahrnadi (2007) decrease in relative water content and close the stomata, it was the first effect of dry stress that through disturbance in system to build photosynthetic materials cause decrease of yield . Shabala et al.(2000) studied response of 4 sugar beet cultivar to water in different levels, they show that growing and yield of shoot yield like root influence by shortage of water . in the case of dry material of root , Hills and his associates (1990) reported drought stress didn't have any effect in dry material of root. In studying the effects of deficit irrigation on sugar beet , Mahmoodi and et al. (2008) exerted the care of irrigation has significant effect on sugar yield and conditions of deficit irrigation cause decrease on sugar yield in effect of dry tension.

Table 3 : Effect of irrigation , resource of potassium and different values of potassium on root yield , Biomass and root dry matter of root

Irrigation	Root yield (tone at hectare)	Shoot yield (tone at hectare)	Dry material of root (Percent)	Sugar yield (tone at hectare)
complete irrigation	59/28a	20/04a	27/34a	10/60a
Deficit irrigation	43/89b	15/23	27/49a	7/17b
Potassium resource				
Potassium sulfate	50/72a	18/07a	27/19b	8/89a
Potassium chloride	52/44a	17/19a	27/63a	9/22a
Value of potassium Kg/hectare				
0	45/17b	14/84b	27/19a	7/63c
50	49/17b	19/24a	27/94a	8/65b
100	57/83a	19/17a	27/85a	10/38a

Average in each column at the least have one common letter . according to the Donkon multiple range test don't have significant difference.(p ≤0.05%)

Based on results of data variance analysis, the effect potassium fertilizer type wasn't significant on root yield of sugar beet, shoot yield and sugar yield statistically, but percent of dry material of root influenced by kind of potassium fertilizer (table 2) . Yield of sugar beet's root with using of potassium chloride (52.44 ton.ha^{-1}) was more than the time use of potassium sulfate as resource of potassium (table 3). In the case of sugar yield , in spite of lack meaningful difference in use of potassium chloride , sugar yield 9.22 ton.ha^{-1} was more than , when potassium sulfate 8.89 ton.ha^{-1} used as potassium resource (table 3)

Using of potassium chloride fertilizer cause an increase on percent of dry material of sugar beet's root compared to potassium sulfate. (table 3). It seems chloride plays a role in loading and depletion of sugars in Phloem. Therefore , using of fertilizer containing chlorine , especially under non-saline condition through increasing in transmission of sugar to root cause increase in quality and quantity of products on sugar beet.(Chen et al 2010).

Consume value of potassium influenced root yield ,shoot yield and sugar yield in sugar beet ($p\leq0.05\%$) but statistically didn't have any effect n percent of root's dry material(table 1). As consumption rate of potassium increase , root's yield increase ,too. The most and the least yield of root gained in order care 100 kg.ha^{-1} k_2o and control(table 1) .use of 50 kg.ha^{-1} k_2o cause a considerable increase on shoot yield compared to control. The difference between consume levels of potassium 50 and 100 kg.ha^{-1} k_2o isn't important. The role of potassium in making active enzymes cells division and growing, opening and closing of stomata and loading carbohydrates on phloem are the main case of increase of root yield, by increasing on consume values of potassium. (Taiz and Zeiger,2006).

Fathy and et al.(2009) studied the effect of various values of nitrogen and potassium on yield , quality and contents of mineral on sugar beets and reported meaningful increase on dry and wet weight of shoot by increasing on consume value of potassium. Increase of potassium cause an increase on sugar yield. So that the most yield of sugar in 100 kg.ha^{-1} k_20 and the least of it observed in control (table 3). Role of potassium on increasing of root yield and percent of pure sugar is the main factor on increasing of irrigation by potassium consumption.

Interaction of irrigation and potassium levels was significant on yield of sugar beet's root(table 1), there is no meaningful difference between levels of potassium amount 50 , kg.ha^{-1} k_20, in full irrigation treatment , but in deficit irrigation using 50 kg.ha^{-1} k_20 increased significantly root yield than control and 50 kg.ha^{-1} k_20 (figuare1) . Reaction dry material of root to consume value of potassium was different in various levels of irrigation . (table 1) . in condition of complete irrigation , use of kg.ha^{-1} k_20 increase dry material of root compare to control and kg.ha^{-1} k_20 however , difference isn't important between control levels and 100 kg.ha^{-1} k_20 statistically it isn't observed meaning difference between various levels of potassium . (figure 1)

Result of variance analysis showed impure sugar , pour sugar molasses sugar and sugar purity don't influence by the values of irrigation and the kind of potassium fertilizer while various values of potassium had significant effect on these features . By increasing in consume rate of potassium , percent of impure sugar increase, too . so that , the least and the most percent of pour sugar observed in order in control care and care 100 kg.ha^{-1} k_20 (table 4) . Role of potassium in photosynthesis , is through effect on process of opening and closing of stomata and also consolidation Co2 by setting the activity of Enzymes and its participation in transition and store of sugar in root are the main reason for increasing of sugar yield by increasing of potassium (Draycott, 2006) . Increasing in use of potassium until 100 kg.ha^{-1} k_20 , increase percent of pour sugar of root , too however , the difference between 50 and 100 kg.ha^{-1} k_20 wasn't important statistically . (table 4). Role of potassium in photosynthesis and activity of Enzymes related to sucrose synthesis and also it's participation in loading the sucrose to phloem are from the most important reasons of increase in sugar's rate and increasing in potassium consumption (draycott 2006) .potassium consumption cause a considerable decrease in percent of molasses sugar in sugar beet . However, difference isn't meaningful between levels of 50 and 100 kg.ha^{-1} k_20 statistically . (table 4) . increase in quality of sugar beet's product is the main factor on decrease percent of molasses sugar in effect of potassium's consumption through raise percent of recoverable sugar and reduce of un sugar material specially nitrogen and sodium . because , increase in this impure cause to prevent crystallization by sources ad decrease capability extraction of sugar and causes increase the rate of manufacture molasses. (Jooleini et al.,2007)

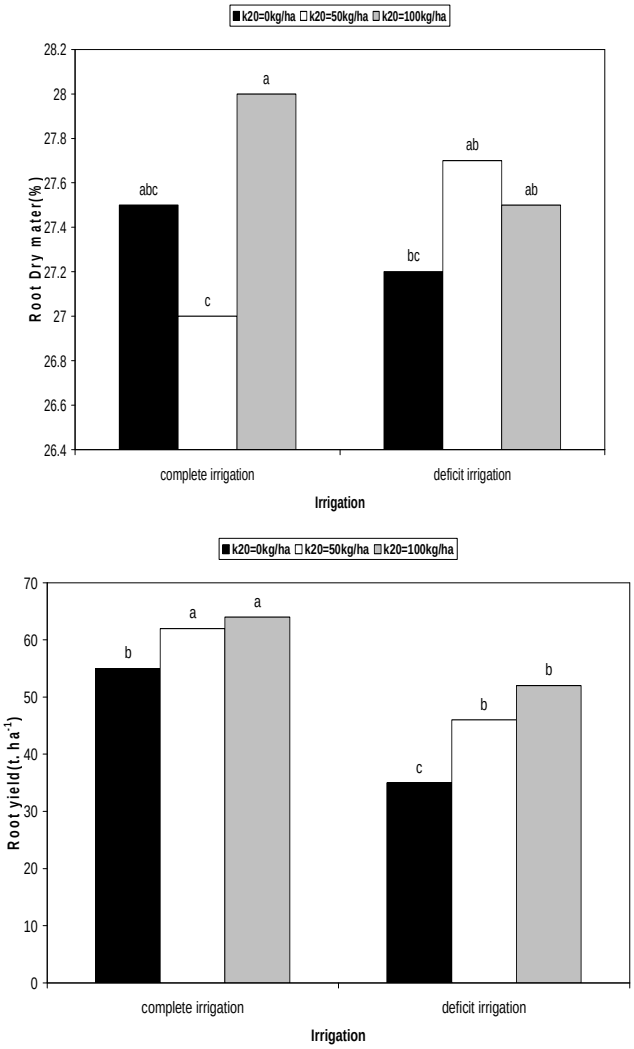

Figure 1: interaction of irrigation and amount of potassium on root yield and dry mater of root

Table 4 effect of irrigation, potassium resource and various values of potassium on the rate of impure sugar , pour sugar, molasses sugar, sugar purity

Irrigation	Impure sugar (Percent)	Pure sugar (Percent)	Molasses sugar (Percent)	Sugar purity (Percent)
complete irrigation	19/83a	17/57a	1/89a	90/21a
Deficit irrigation	19/31a	17/38a	1/93a	90/01a
Potassium resource				
Potassium sulfate	19/39a	17/44a	1/95a	89/90a
Potassium chloride	19/44a	17/51a	1/87a	90/32a
Value of potassium Kg. ha^{-1}				
0	19/05b	16/84b	2/08a	90/7a
50	19/83a	17/63ab	1/8b	90/3a
100	19/83a	17/86a	1/76b	89/32b

Average in each column at the least have one common letter . according to the Donkon multiple range test don't have significant difference.(p ≤0.05%)

Based on results of compare on data's mean , interaction of irrigation and potassium resource is significant on rate dry material of sugar beet's root (table 1). Incomplete irrigation , use of potassium chloride increased the dry material of root compare to potassium sulfate , but in deficit irrigation , there is no difference between various levels of potassium resource regard to dry material of root. (figure 2)

Reaction of dry material to use value of potassium was different in various levels of irrigation (table 1 appendix) . under complete irrigation , use of 100 kg/h k2o , increased dry material of root compare to witness care and care 50 kg/h k2o . however , the difference between levels of control and 100 kg/h k2o isn't important. While in deficit irrigation , there is no significant difference between various levels of potassium (figure 3)

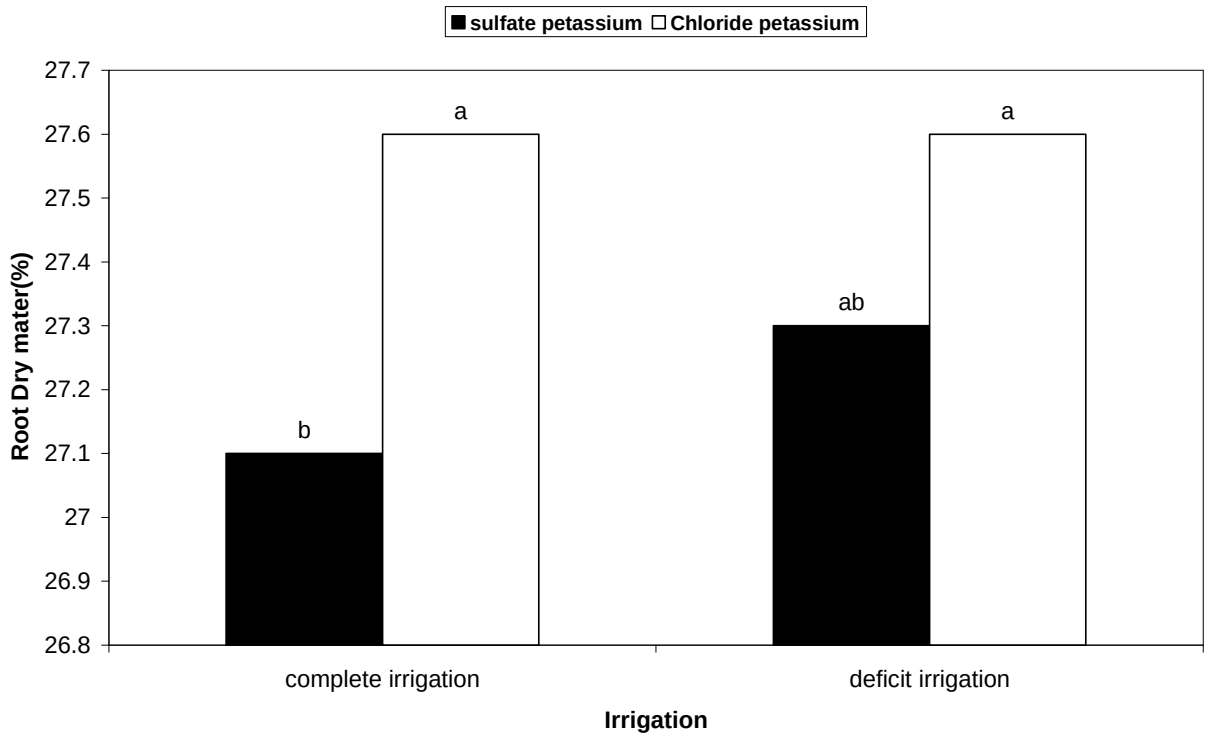

Figure 2: Interaction of irrigation and sources of potassium on root dry matter

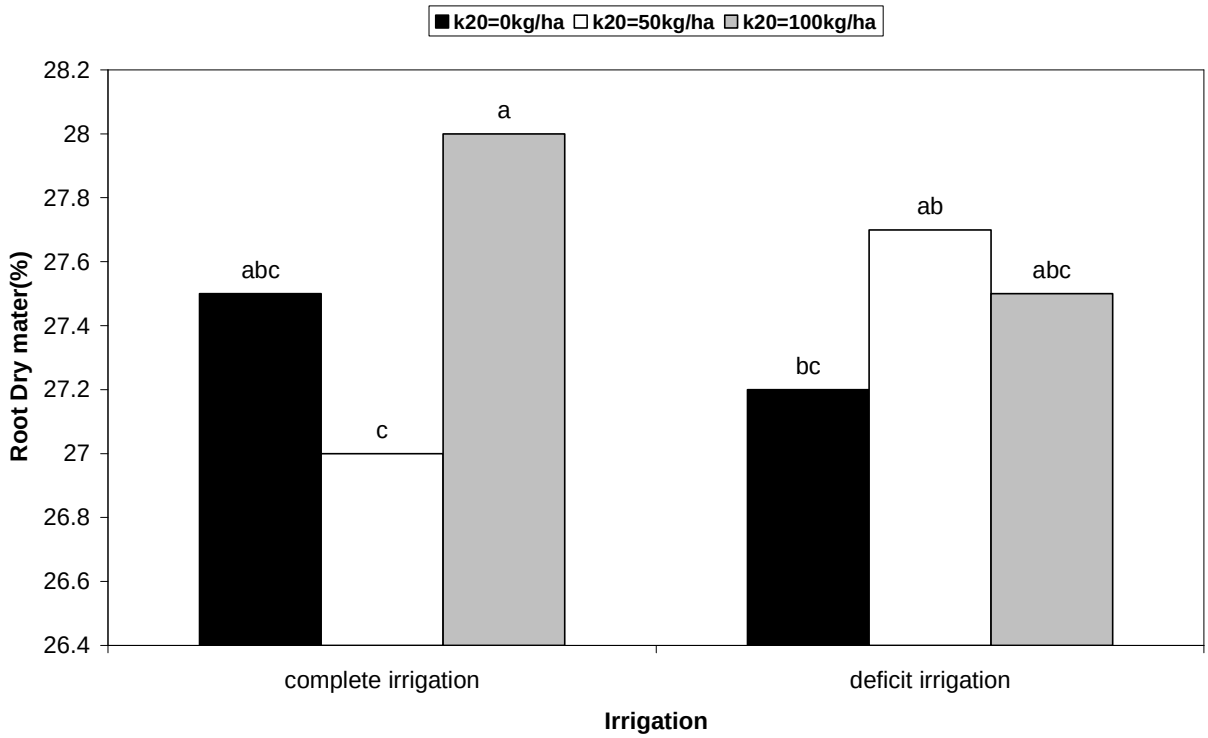

Figure 3: interaction of irrigation and using value of potassium on dry material of root

CONCLUSION

Results of test point deficit irrigation care decrease root yield , Virgo yield and sugar yield I sugar beet , but didn't have any effect on percent of upper sugar , percent of pour sugar and dry material of root . Use of 100 kg/h k20 increased toward to witness care sulfate , root yield ,Virgo yield , percent of impure sugar , percent of pour sugar and yield of extraction able sugar in complete irrigation and deficit irrigation.

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