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The Response of Sugar Beet Productivity to Irrigation Intervals in Semi-Arid Zone

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Abstract: *Optimum irrigation management is one of the most important factors in sugar beet production, one of the main reasons, limiting the sugar beet production in Sudan there is limited information regarding the interactive effects of irrigation in the farmer's field. This experiment was aimed to study the growth and yield response of sugar beet to the different Irrigation Intervals at farmer's field at the Guneid Sugar Cane Research Center, Gezira state-Sudan during October 2013 – April 2014 and repeated in October 2014- April 2015. Randomize complete block design with three treatments and three replications were used in the study. The treatments I1: 7 days irrigation interval; I2: 10 irrigation intervals; I3: 14 irrigation intervals were applied. Results indicated that irrigation intervals significantly affected germination rate; root thickness; plant population; crop yield and total sugar production, maximum germination percentage (67.3%) was obtained when I1 was used, while minimum germination rate (62.4%) was recorded when I 3 was used. Maximum Plant population, crop yield and Total Sugar production from sugar beet (58772, 26.7 ton/fedd and 4.3 ton/fedd. respectively) were recorded in I1 (7 days interval).*

Keywords: Sugar beet, Irrigation interval, Root yield, Sucrose percent and Sugar production

INTRODUCTION

Low crop productivity is one of the major problems that are facing agricultural production in the Sudan. Low crop productivity in addition to high production costs, low prices and high taxes had all resulted in a general deterioration of the agricultural sector. This has contributed in converting agriculture from an attractive business to a repellent activity and caused many farmers to abandon agriculture and migrate to cities. The agricultural sector in the Sudan contributes to about 48% of the Gross Domestic Production (GDP) and to about 93% of the foreign currency earnings (Ministry of Finance and National Economy, 1996). It also employs about 65% of the labor force.

Optimum irrigation management is one of the most important factors in sugar beet production, as it can increase yield and reduce water costs, fertilizer leaching and soil erosion (Reddy et al. 2007). Sugar beet can grow in a wide range of water conditions and irrigation treatments (Davidoff, Hanks 1989). This crop is compatible with soil water deficit. With increasing irrigation interval, the root to shoot ratio is increased and water uptake from the lower layers of soil through the deep roots can be remarkably increased (Camposeo, Rubino 2003). Several studies have been conducted on the effects of irrigation regime changes on various traits of sugar beet (Hang, Miller 1986; Groves, Bailey 1997; Choluj et al. 2004; Monti et al. 2006; Mahmoodi et al. 2008; Morillo-Vellarde 2010; Kiymaz, Ertek 2015; Malik et al. 2018; Zare Abyaneh et al. 2017).

Sugar beet (*Beta vulgaris*) is one of the most important sugar production crops (Abdel-Motagally and Attia, 2009). It is a hardy biennial plant whose root contains a high concentration of sucrose (15-20 %). It is grown commercially for sugar production in a wide variety of temperate climates. Sugar beet accounts for 30% of the world's sugar production. During its first growing season, it produces a large (1-2 kg) storage root whose dry mass is 15-20 % sucrose by weight. In commercial sugar beet production, the root is harvested after the first growing season. In most temperate climates, sugar beet is planted in the spring and harvested in autumn (Draycott 2006). Sugar beet can be cultivated under any irrigation system. Worldwide, the most prevalent irrigation system is gravity-fed furrow irrigation. However, others showed an improvement in yield and efficiency with the smaller amounts of water that can be applied using drip irrigation (Sharmasarkar *et al*. 2001; Tognetti *et al*. 2003). The first trials of sugar beet in Sudan were conducted in nineteen thirties at Gezira Research Station. Some work was carried out by EL-Karouri and EL- Rayh (2006) at Um Dom during 1994/95-1996/97 seasons, sponsored by Arab Authority for Agricultural Investment and Development (AAAID), to investigate the production of some sugar beet genotypes.

Thus, this study was conducted to determine sugar beet response to changes in the irrigation intervals practices on growth and yield at the central clay plain of Gezira State. The specific objectives, is to be achieved, are the following: some crop performance parameters such as root thickness, crop root yield, and sucrose percent (pol %), and sugar production.

MATERIALS AND METHODS

Experimental Site, Design and Treatment Applications

This study was conducted at farmer's field in at the Guneid Sugar Cane Research Center which located 117 km south of Khartoum, on 14o30′N Latitude, 33o15′E Longitude at the eastern bank of the Blue Nile. The experiment was carried out for two successive growing seasons 2013/14 and 2014/15 to evaluate the Irrigation Intervals on the growth and yield of sugar beet. The mechanical analysis of the soil showed clay 45 %, sand 28% and silt 27 %. The average bulk density 1.75 % and the average moisture content 15 %. Some chemical properties measured at three depths are shown in Table 1. Guneid Sugarcane Scheme is characterized by relatively cool winters, hot summers, low rainfall, low relative humidity and a potential evapotranspiration exceeding precipitation throughout the year. The water requirement of the crop during the research was fulfilled by canal water from the main canals of the scheme. A randomize complete block design (RCBD) with four treatments and three replications was used in this study resulting in a total of 12 plots. The treatments were designed as follows:

(I 1) = 7days irrigation interval;
(I 2) = 10 days irrigation interval;
(I 3) = 14 days irrigation interval;

The net plot size was 350 m^2 (7 × 50) for each treatment. The plots were separated by a distance of 5m and seven meters between replications and by distance of 10 m at the end of two sub plots for the tractor turning. Each plot had buffer areas at two ends for tractor acceleration and deceleration to ensure the tractor travelled at a specified constant speed within the plot. The speeds of ploughing were determined using the tractor hand throttle and constant gear ratio (monitored on the tractor's dash board). The land was prepared by the disk plow three weeks from planting for every replication, and then the land was harrowed by the disc harrow before one week from planting and also furrowed by ridger at the same time of planting. After the soil was prepared the crop was sown in rows on October in both years using a pneumatic planter with four units which was calibrated and used for planting the other 12 sub subplots to plant the seed 75 cm between rows and 15 cm between plants. Lenard, monogerm seed type was used for cultivating the experiment field.

The quantity and variety of seed, fertilizer, measures for the protection of plants, quantity of irrigation water, harvesting and threshing methods were same for all treatments.

Measurements

Plant germination percentage

The plant germination ratio was determined for the tillage treatments by the following equation:

$$ermination\ ratio\% = \frac{Number\ of\ \ germinated\ seeds}{Number\ of\ actual\ seeds\ per\ row} \times 100$$

Root thickness

The tab meter was used to measure the thickness of the tuber at harvest. It was measured by putting the measuring tab around the middle of the tuber and measuring the root thickness. Five plants per sub subplot were selected randomly and measured from harvested rows and then the average was taken.

Plant population

At harvest, the number of tubers was counted for an area of 7.5 m^2 (area of one row). The number of tubers per hectare was determined by the following equation:

$$\text{Number of tubers per hectare} = \frac{10000\ \times\ \text{number of tubers counted per area}}{7.5\ \text{m}^2}$$

Where:

7.5 = Area of one row (m^2).

10000 = Area of hectare (m^2).

Crop yield (tuber and leaf)

A spring balance was used to determine the weight of the sugar beet tuber and the weight of the leaves at the end of the season by harvesting one row 7.5 m^2 from each treatment. The leaves were separated from tuber and weighted. The weight of the sugar beet tubers and the weight of the leaves were determined by the following equations:

$$\text{Sugar beet ton per hectare} = \frac{10000\ \times\ \text{yield of one row kg}}{7.5\ \times 1000}$$

$$\text{Leaves weight in ton per hectare} = \frac{10000 \times \text{ yield of one row kg}}{7.5 \times 1000}$$

Where:

7.5 = Area of one row (m^2).

10000 = Area of hectare (m^2).

Sugar Beet chemicals analysis

Before beet was harvested, 5 tubers were selected randomly from each sub subplot and then topped, cleaned from soil, crushed and sliced fine enough and samples were taken to determine the sugar beet chemical components.

Sucrose percent in beet (Pol%) analysis

The polarization or sugar content was determined by taking twenty six mg of sliced beet + reagents (174 cm3 lead acetate), mixed in a blender and filtered. 200 ml of the extract was read in a Saccharimeter following (ICUMSA, 1994).

Estimated recovery sugar (ERS%) analysis

The sugar beet estimated recovery sugar (ERS%) was determined by following equation:

$$\text{ERS \%} = \text{Pol\%} - 2.5$$

Where:

2.5 = Expected losses of sugar content through production.

Sugar production from sugar beet

The sugar production from sugar beet ton sugar per feddan was determined by the following equation:

$$\text{Sugar ton per Feddan} = \frac{\text{ERS\%} \times \text{ Yield of sugar beet per Feddan kg}}{1000}$$

Statistical analysis

Statistical analysis was accomplished by Statstix 8. Analysis of variance (ANOVA) was used to evaluate the significance of each treatment on all parameter under this study in a randomized complete block design with 4replications.Comparison of means was performed with Duncan's multiple range tests

RESULTS AND DISCUSSION

In order to determine the effect of different irrigation interval on Plant germination percentage, Root thickness, Leaf weight, Plant population or number of Tubers, Sugar beet Crop yield, Sucrose percent in beet (Pol), Sugar production from sugar beet, the variance analysis are given in Table 1.

Table 1: Statistical description of variation for all observed parameters affected by different irrigation interval (average of two seasons):

Observed Parameters	M. S	P. value	Std. Error	CV %
Plant germination percentage	21.0700	0.0000	0.18	0.18
Root thickness (cm)	12.0900	0.0031	0.3456	1.72
Leaf weight (ton/fed.)	0.39130	0.4087	0.3400	5.67
Plant population (No. of Tubers)	846409	0.0000	1.3333	0.10
Sugar beet Crop yield (Ton/fed.)	26.1300	0.0000	0.0667	0.47
Sucrose percent in beet (Pol%)	1.57000	0.0926	0.3383	3.06
Sugar production from sugar beet (Ton/fed.)	0.27000	0.0048	0.0577	2.5

Effect of Different tillage practices on germination ratio (%):

The variance analyses of the average values of the two seasons for the (GR %) were presented in table 1. Average GR% values and LSD test estimates are shown in fig. 1. The effect of irrigation interval on the GR% was statistically highly significant

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(P≤0.05). The highest GR was obtained from I 1 (7 days) (67.3%), I 3 (14 days) gave the lowest GR (62.4%). The Sugar beet Crop GR value with 7 days interval was greater compared to 10 days (I 1) by 1.05% and 14 days (I 3) by7.3%, which may be due the saving water after irrigation depend to short period led to save optimum moisture content that helped in proper root growth and germination.

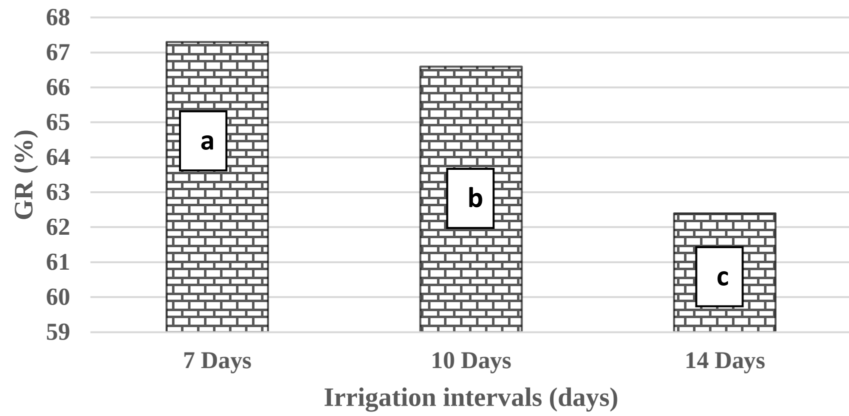

Fig. 1: Two seasons Mean germination rate (%) affected by Different Irrigation Intervals.(mean followed by the different letter differ significantly according to LSD test

Effect of Different tillage practices on Root thickness (cm)

In order to determine the effect of different irrigation interval on root thickness (cm) the variance analysis are given in Table 1. A statistically highly significant difference (P<0.05) was observed in root thickness between different irrigation interval (Table 1). Figure 2 indicates the effect of different irrigation interval on root thickness (when averaged over two seasons) at experiment site. It is clear that the (I 2) recorded maximum root thickness (37 cm) which is significant effect with the other two irrigation interval (I 1 and I 3) based on the LSD test. In general the root thickness in I 2 was found to be higher than I 1 and I 3 by 8.1%, 10.8% respectively, which may be due the high moisture content after irrigation that helped in proper root growth and distribution.

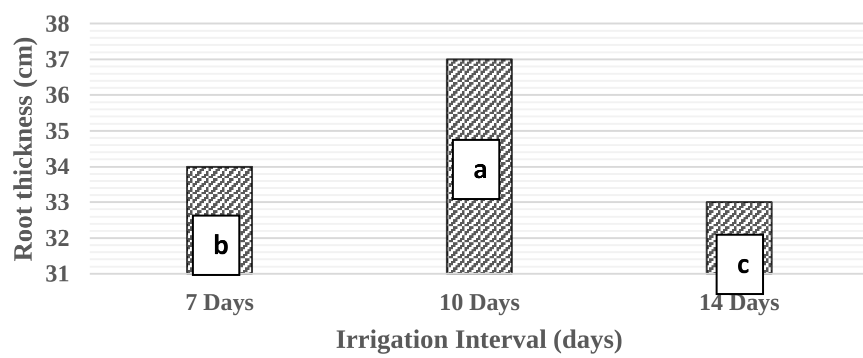

Fig.2: Two seasons Mean Root thickness (cm) affected by Different irrigation intervals.(mean followed by the different letter differ significantly according to LSD test

Effect of Different tillage practices on Plant population (No. of Tubers)

Over the course of the study the analysis of variance showed that different irrigation intervals have significant effect on Plant population (Table 1). Data of the Plant population per 4200 square meter is presented in fig. 3. Maximum plant population of 58772 tubers was obtained when irrigation interval was 7 days (I 1) which it was sig. with other practices based on the LSD test), while minimum plant population was recorded when (I 3) was used. In general the Plant population in (I 1) was found to be higher than (I 2) by 0.6%, and (I 3) by 1.7%.

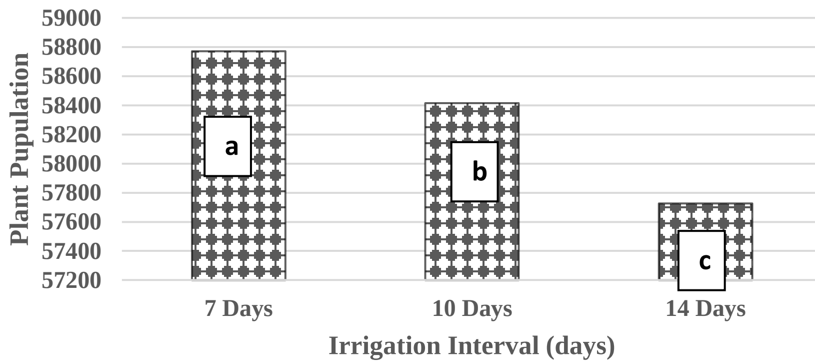

Fig. 3: Two seasons Mean Plant population (No. of Tubers) affected by Different irrigation interval.(mean followed by the different letter differ significantly according to LSD test

Effect of Different tillage practices on Sugar beet Crop yield (Ton/fed.)

Over the course of the study, irrigation interval significantly different ($P<0.05$) affect the average values of two seasons for Sugar beet Crop yield (Table 1).

As shown in Figure 3 which presented the LSD test estimates shows that the 7 days irrigation interval yielded 26.7 ton/fed which were significantly higher than the other two irrigation interval. The 14 days irrigation interval yielded significantly lowest productive 21.4 ton/fed as shown in (Fig.3). Generally, the I 1 was found to be higher than (I 2) and (I 3) by 1.5% and 19.8% respectively, which may be due the high moisture content after irrigation that helped in proper root growth.

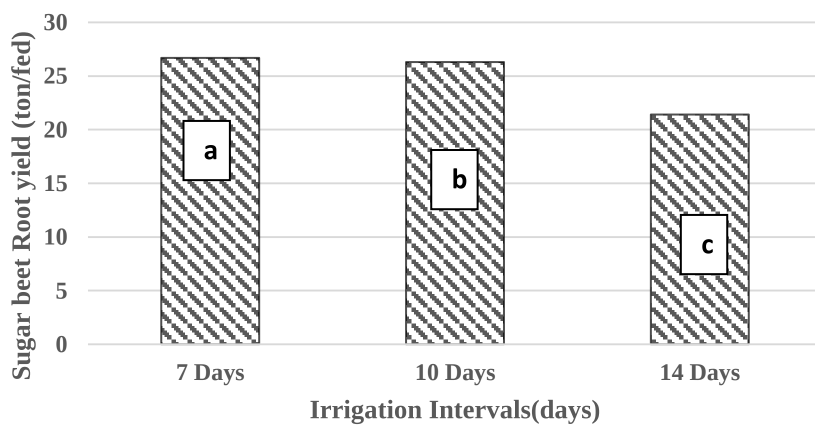

Fig. 4: Two seasons Mean Sugar beet Crop yield (Ton/fed.) affected by Different irrigation intervals.(mean followed by the different letter differ significantly according to LSD test

Effect of Different irrigation interval on Total Sugar production (TSP) (Ton/fed.)

The differences in Sucrose percent in sugar beet cop (Pol %) as well as Total Sugar production from sugar beet (Ton/fed.) between different tillage practices were statistically significant ($P<0.05$) (Table 1).

Sugar production from sugar beet produced by irrigation intervals practices were worked out, and such results are presented in Figures 5. The results indicated the highest Sugar production was recorded with (I 1). The lowest Sugar production was detected with (I 3). In general the TSP in 7 days irrigation interval was found to be greater than 10 days irrigation interval by 7.5% and 14 days irrigation interval by 15%. This result is closely related and in line with that obtained in previous parameters measured such as crop yield and number of tubers in the field of experiment. De Benito et al. (2002) reported that an increase in frequency from one to two irrigations per week significantly increased root development and yield.

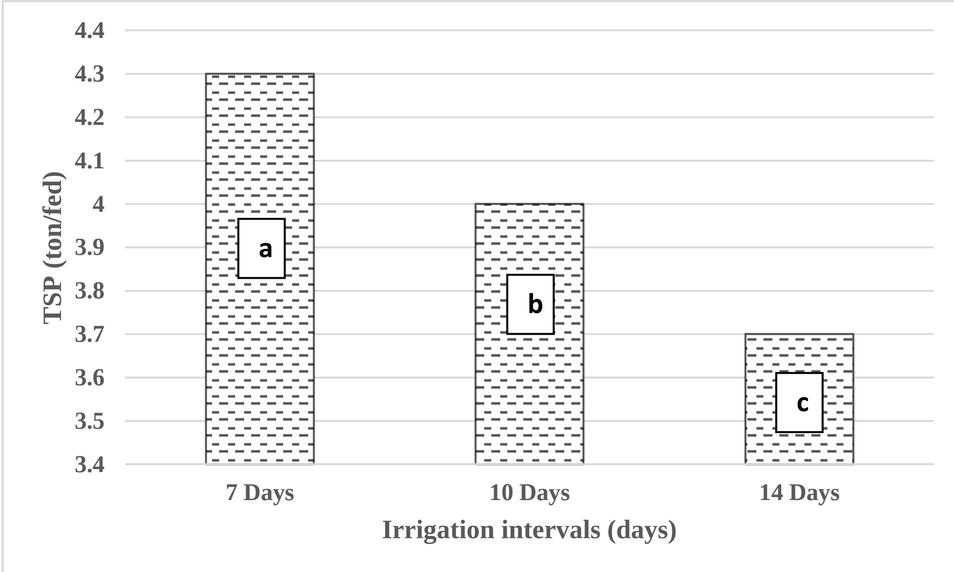

Fig. 5: Two seasons Mean Total Sugar production from sugar beet -TSP- (Ton/fed.) affected by Different irrigation intervals.(mean followed by the different letter differ significantly according to LSD test

CONCLUSIONS

From the results of this study the following conclusions can be drawn:

1. Generally, irrigation interval practices affect and improved the crop yield and quality of sugar beet.
2. 7 days irrigation interval (I1) recorded maximum GR percentage which is significant effect with the other two irrigation intervals practices
3. The root thickness in 10 days interval was found to be higher than 7 days and 14 days.
4. There were significant differences in Plant population among the irrigation intervals. Plant population under 7 days interval was greater than the other treatments.
5. Sugar beet Crop yield and Sugar production from sugar beet were significantly affected by irrigation interval; I 1 recorded highest amount in both of parameters

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