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Effect of Nitrogen Fertilizer and Plant Spacing on Vegetative Growth of Sugar Beet (*Beta vulgaris*)

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Abstract

Despite the existing several Sugar manufacturing companies in Sudan, there is an acute shortage in sugar supply, therefore the government imports Sugar to bridge the gap. One of the strategies to be followed is the introduction of Sugar beet (*Beta vulgaris*) crop, mainly for sugar production. This crop has several advantages over Sugarcane such as short duration, less water requirement, in addition to other uses like animal feed. Therefore it became necessary to have good understanding of agricultural operations, cultural practices and adaptation. However, the main objective of this study was to assess the effect of Nitrogen fertilizer and plant spacing on vegetative growth of Sugar beet. This study was conducted at the farm of the College of Agriculture, University of Bahri, Alkadro, Khartoum State-Sudan; during the season 2016/2017. The experiment was arranged in Split plot in Randomized Complete Block Design with six treatments and four replications. Two plant spacing (15 and 20 cm.) were used as main plot, referred as (S_1, S_2) along with three levels of Nitrogen fertilizer (40, 80 and 120 kg/ha.), as subplot; referred as (N_1, N_2 and N_3) and the control (0). Data regarding leaf number, leaf area index (LAI), leaf dry weight (g) (LDW), root diameter (mm.) and root fresh weight were recorded and statistically analyzed. The results showed S_2 (20 cm) increased all the studied plant characters, namely the leaf number (29.139), leaf area index by (7.54), leaf dry weight (g) to (89.870), root diameter (mm) (94,992), root fresh weight (g) (695.80) compared to S_1(1015 cm). On the other hand; the application of N_3 (120 kg/ha.) increased

the lead number (30.956), leaf Area Index (8.841), Leaf dry weight (102.47), root diameter (97.955) and root fresh weight (851.77) compared to S_2 and S_1 as presented in tables (4,5 and 6).

Introduction

Sugar beet is a biennial crop. Its roots have high reserves of sucrose, especially during the first growing season. Usually, the harvested roots are processed into sugar. It is preferable to have plant populations a round 30,000 -40,000 plants/acre, which produce very good yields of easily harvested of high quality Sugar beet (Cattanach, *et. al.*; 1991) [1]. Maximum yields per unit area of small beet were achieved at high plant densities, whereas maximum yields of large beet were achieved at low plant densities (Benjamin, *et. al.*; 2009) [2].

Fertilization is considered as a limiting factor for Sugar beet production. Therefore, it is important to choose the optimum rate and times of application of macro and micro nutrients to attain the maximum yield and high quality of Sugar beet crop However, Nitrogen is the most important nutrient that to be considered when planning a fertilizer program for Sugar beet production. This is because Nitrogen status of the plant affects the early growth and the quality of the Sugar beet at harvest (Nemeat alla et. al.; 2008 .[3] (Several studies demonstrated that early canopy closure allows Sugar beet to be more efficient in utilizing the sunlight to produce more sugar. However, an excess Nitrogen at or near the end of the growing season reduces Sugar beet quality by reducing sucrose concentration (Daniel. 2018) [4]. Nevertheless, John, *et. al.*; 2011 [5], reported that, better Nitrogen management promotes early vigorous plant growth and reduces the number of days to canopy closure which enables sugar beet to utilize the sunlight's energy more efficiently to produce more sucrose. Excess Nitrogen at or near the end of the growing season reduces Sugar beet quality by reducing sucrose concentration and increasing impurity concentration (John, *et. al*. 2011) [5].

The main objective of this study was to assess the efficiency of Nitrogen fertilizer and plant spacing on sugar beet growth and yield at Alkodro area.

Materials And Methods

A field experiment was conducted during the winter season of 2016 - 2017 at the demonstration farm of College of Agriculture, University of Bahri, Khartoum State-Alkadaro (Latitude 15^0-44^0N; Longitude 32^0-35^0E, and altitudes 398m above the sea level). The soil of the study area is moderate to strong alkaline; with pH 7.5-8; and EC 1.1-8.3 dSm^{-1} (Hatim *et. al.,* 2017) [6]. The area is located within the semi-arid zone with mean daily maximum temperature of 45°C - 30°C during summer and 25°C-10°C during winter. The annual average rainfall ranges between (0 -100) mm and relative humidity about 16% – 50%. The area is characterized by having long dry hot summer period and cool in winter. The adopted experiment was split-plot in randomized Complete Plot Design with four replications, where Nitrogen was considered as sub plot and plant spacing as main plot. The soil was well prepared by a tractor 75HP using disk plough, harrow, leveler, and moldboard implements. The land was divided into plots; each one was $5x4m^2$ with four rows and plant space kept at 15 and 20 cm which were referred as S_1 and S_2 respectively; and 70cm between rows. Seed were sown in 13/12/2016 by planting two seeds/hole and later on thinned to one plant/hole. Irrigation was carried out every 7-10 days. As far the fertilizer concern, Nitrogen as urea was applied 4 weeks after sowing (WAS) as one dose (1N), at three levels; namely 40, 80, and 120 kg/ha which were referred as N_1, N_2, and N_3 respectively. In this study, the following plant parameters were studied, the Leaf number, Leaf dry weight (g), Root diameter (cm), Root fresh weight (g) and Leaf Area Index. Sampling was done by taking three random plants from the each plot after 7, 10, 13, and 16 weeks after sowing. The said data were subjected to statistical analysis using Statistic 8 Software Program. The results were arranged in tables.

Results And Discussions

All the results of statistically analyzed data of this study were presented in the following 6 tables.

The results table (1) showed the different plant spacing had significantly affected the leaf number of Sugar beet crop. However S_2 (20 cm) has increased the leaf number per plant compared to S_1 (15 cm). This may be due to the wide spacing which allows penetration of more sun light which increases the process photosynthesis efficiency and eliminates the competition for nutrients. Similar result was obtained by Yuji. et. al.; 1979 [7], who reported that the increase in hill space from 30 to 35 cm has increased the crown and decreased the petioles.

The leaf area index was significantly increased with the increase of spacing between plants However, S_2 treatment revealed the highest value of leaf area index (7.514) compared to S_1 (7.280) 16 WAS. This result indicated that leaf area index increased due to the increase of spacing between the plants as well as the surface area. A similar trend was observed by (Varga, et. al., 2021) [8], who concluded that differences in the size of leaf area of Sugar beet plant affect the leaf growth and canopy development.

The results in table (2) showed plant spacing had significantly increased the leaf dry weight (g), where S_2 (20 cm) produced the highest value compared to S_1. Similar results were obtained by a researcher (1978)[9]; who obtained the maximum distribution of root dry matter with 30 cm hill space. The effects of hill spacing on dry matter production are understood on the basis of growth analysis of sugar beet. Furthermore, the results displayed the different plant spacing had significant effect on root diameter of Sugar beet. Where the S_2 produced the highest root diameter (94.99 mm), whereas the lowest was obtained by S_1 (88.83 mm.) 16 WAS. Moreover, the root fresh weight was also significantly increased due to application of different plant spacing.

Table (3), revealed the highest root fresh weight was recorded by S_2 (695.80 g), whereas the lowest was obtained by S_1 (613.87g). These results are similar to those obtained by (Izumiyama, 1978) [9], who got the maximum distribution of dry matter to roots with 30 cm hill space

Considering table (4), the results showed the different levels of Nitrogen fertilizer had significant influenced on leaf number of Sugar beet, where N_3 recorded the higher leaf number (31) 16 WAS, whereas the lowest was recorded by N_1 (25). This result indicated the leaf number of Sugar beet crop increased with the increased level of Nitrogen fertilizer. These results agreed with that obtained by Mustafa, 2007 [10], who showed that; application of Nitrogen fertilizer tends to increase the leaf number. It is known that Nitrogen fertilizer has the most profound effect on plant growth and efficient utilization of light interception in the plant canopy. Therefore, an adequate Nitrogen fertilizer is needed at the earlier seedling stage for vigorous and competitive seedling growth and for subsequent canopy development. (Amber, et. al., 2009) [11]

However, significant differences were registered in leaf area index of Sugar beet due to the application of Nitrogen fertilizer 16 WAS (table 4). Application of 120 kg N/ha (N_3) showed significant increase in leaf area index compared to 80kg N/ha (N_2) and 40 kg N/ha (N_1) respectively. These results indicated that, leaf area index increased with the increasing rate of Nitrogen fertilizer. These results agreed with the results found by Mustafa, 2007 [10], who showed that; application of Nitrogen tends to increase leaf area index of sugar beet. Also, Hosseinpour, et. Al.; (2013) [12] obtained similar results. Regarding table (5), the results indicated the different treatments of Nitrogen fertilizer had significantly increased the leaf dry weight of Sugar beet. However, the application of N_3 had significantly increased leaf dry weight (102.47 g) compared to N_2 (87.50 g) and N_1 (72.24 g) respectively. Where N_2 had significantly increased the leaf dry weight compared to N_1. This result agreed with the results obtained by (Pytlarz, et. Al.; 2005) [13], who reported that, an increase of Nitrogen rate from

Table 1. Effect of plant spacing on leaf No. leaf area index, of Sugar beet (Alkadaro-Sudan-2016/2017)

Times / Treatments	7 WAS	10 WAS	13 WAS	16 WAS
Effect of plant spacing on leaf number				
S1	11.582 B	14.388 B	24.416 A	26.748 B
S2	12.166 A	16.083 A	24.722 A	29.139 A
SE±	00.2283	00.8392	00.4335	01.2315
C.V.	04.710	13.490	04.3200	10.8000
Effect of plant spacing on leaf area index (LAI)				
S1	1.328 B	02.106 B	5.350 B	7.280 B
S2	1.669 A	03.601 A	6.005 A	7.514 A
SE±	0.041	00.058	0.335	0.193
C.V.	6.610	15.43	9.69	8.12

WAS: Week after sowing, Means followed by the same latter(s) within a column are not significantly different at the 5% level according to (LSD).

Table 2. Effect of plant spacing on leaf dry weight (g) and root diameter (mm) of sugar beet (Alkadaro- Sudan, 1016/2017).

Times / Treatments	7 WAS	10 WAS	13 WAS	16 WAS
Effect of plant spacing on leaf dry weight (g)				
S1	2.8567 B	23.413 B	47.275 B	84.936 B
S2	8.1792 A	32.010 A	57.244 A	89.870 A
SE±	0.809	3.262	0.626	3.117
C.V.	38.58	13.20	5.64	3.65
Effect of plant spacing on root diameter (mm)				
S1	16.453 B	39.433 B	77.544 B	88.833 B
S2	23.974 A	50.441 A	79.897 A	94.992 A
SE±	0.3379	0.7872	0.9031	1.4031
C.V.	5.52	3.05	1.09	4.07

WAS: Week after sowing, Means followed by the same latter(s) within a column are not significantly different at the 5% level according to (LSD).

Table 3. Effect of plant spacing on root fresh weight (g) of Sugar beet (Alkadaro-Sudan, 2016/2017)

Times / Treatments	7 WAS	10 WAS	13 WAS	16 WAS
S1	46.512 B	121.98 B	314.47 B	613.87 B
S2	72.792 A	166.72 A	510.81 A	695.80 A
SE±	1.534	5.7437	1.7535	15.972
C.V.	6.36	8.54	6.87	4.56

WAS: Week after sowing, Means followed by the same latter(s) within a column are not significantly different at the 5% level according to (LSD).

Table 4. Effect of mineral Nitrogen fertilizer on leaf No. and leaf area index of Sugar beet (Al kadaro- Sudan-2016/2017).

Times / Treatments	7 WAS	10 WAS	13 WAS	16 WAS
Effect of Nitrogen fertilizer on leaf number.				
N1	09.790 B	13.790 B	24.000 B	25.209 C
N2	12.416 A	14.418 B	24.250 AB	27.666 B
N3	13.416 A	17.500 A	25.456 A	30.956 A
SE±	0.5474	0.5802	0.5684	0.7707
C.V.	4.71	13.49	4.32	10.80
Effect of Nitrogen fertilizer on leaf area index				
N1	0.991 C	1.865 C	4.590 B	5.979 C
N2	1.570 B	2.795 B	6.065 A	7.731 B
N3	1.935 A	3.901 A	6.378 A	8.481 A
SE±	0.050	0.220	0.275	0.301
C.V.	6.61	15.43	9.69	8.12

WAS: Week after sowing, Means followed by the same latter(s) within a column are not significantly different at the 5% level according to (LSD).

Table 5. Effect of mineral Nitrogen fertilizer on leaves dry weight (g) and root diameter (mm) of Sugar beet (Alkadaro-Sudan, 2016/2017)

Times / Treatments	7 WAS	10 WAS	13 WAS	16 WAS
Effect of Nitrogen fertilizer on leaves dry weight (g)				
N1	5.1000 A	20.741 C	35.483 C	72.24 C
N2	4.8012 A	25.296 B	52.686 B	87.50 B
N3	6.6525 A	37.096 A	68.610 A	102.47 A
SE±	1.0643	1.830	1.474	1.594
C.V.	38.58	13.20	5.64	3.65
Effect of Nitrogen fertilizer on root diameter (mm)				
N1	17.203 C	39.640 C	72.926 C	85.897 C
N2	19.669 B	44.820 B	78.026 B	91.886 B
N3	23.769 A	50.351 A	85.209 A	97.955 A
SE±	0.5579	0.6863	0.4271	1.8719
C.V.	5.52	3.05	1.09	4.07

WAS: Week after sowing, Means followed by the same latter(s) within a column are not significantly different at the 5% level according to (LSD).

Table 6. Effect of mineral Nitrogen fertilizer on root fresh weight (g) of sugar beet (Alkadaro-Sudan,, 2016/2017).

Times / Treatments	7 WAS	10 WAS	13 WAS	16 WAS
N1	33.021 C	100.64 C	199.32 C	398.23 C
N2	61.870 B	128.16 B	443.11 B	714.51 B
N3	84.064 A	204.26 A	595.49 A	851.77 A
SE±	1.897	6.167	14.184	14.93
C.V.	6.36	8.54	6.87	4.56

WAS: Week after sowing, Means followed by the same latter(s) within a column are not significantly different at the 5% level according to (LSD).

90 to 180 kg N/ha caused a significant increase of the average leaf dry matter.

The study reflected that the application of different levels of Nitrogen fertilizer had positive influential effect on Sugar beet growth and development. Where the application of N_3 produced the highest root diameter (97.96 mm) 16 WAS compared to N_2 (91.89 mm) and N_1 (85.897 mm) treatments in table 5. In this respect, El-Harriri. Et. Al.; (2001) [14], and Nawar. Et. Al.; (2003) [15], found that increasing the Nitrogen significantly increased the root diameter of Sugar beet. Ismail. Et. Al.; (2005) [16] and Nemeat Alla et al. (2007) [17] reported that root diameter significantly affected by Nitrogen levels and produced maximum root diameter with the higher dose of Nitrogen.

Results in table (6) showed that, root fresh weight was significantly increased due to applications of Nitrogen fertilizer. Where, N_3 recorded the highest root fresh weight (851.77 g) compared to N_2 (714.51 g) and N_1 (398.23 g) respectively. These results indicated that, root fresh weight of Sugar beet plant increased due to increased rate of Nitrogen levels. Similar results were obtained by (Shalaby, et. al, 2003) [18] in Egypt, who reported that application of Nitrogen fertilizer at the rate of 80 and100 kgN/fad produced the highest values of the chemical constituents of fresh Sugar beet roots. They also showed that increasing Nitrogen up to 120 kg N/fad had significantly increased the roots.

Conclusion And Recommendations

The application of (20cm) plant spacing between the sugar beet plants revealed significant effect on different parameters of sugar beet growth including leaves number, leaf area index, leaves dry weight (g), root diameter (mm) and root fresh weight (g). On the other hand application of Nitrogen fertilizer as urea (120kgN/ha) was significantly increased all Sugar beet growth parameters compared to other Nitrogen levels (80kgN/ha and 40kgN/ha).

It is recommended that this experiment to be replicated at Alkadaro and other locations in Sudan.

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