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Research Article

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The Response of Morphological Traits of Sugar Beet (*Beta vulgaris L*) To Different Irrigation Methods and Nitrogen Fertilization Ratios

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Abstract

A field experiment was conducted at Taizin Research Station for irrigation, Hama Agricultural Research Center, General Commission for Scientific Agricultural Research (GCSAR), during summer time, the growing season of 2020/2021, to study the effect of four irrigation methods (sprinkle, foggy, drip and furrow) and four levels of nitrogen fertilizer (0, 200, (+25%) 250 and (-25%) 150 kg N/hectare) on some morphological traits of sugar beet monogerm variety (Dita). The experiment was laid according to the randomized complete block design (RCBD) arranged in split plot, where the main plots occupied by irrigation methods, while the sub plots allocated with fertilization levels, with three replications. The results showed that the use of drip irrigation saves water consumed by 34.4% didn't differ significantly in its effect on root length and diameter compared to furrow irrigation, but furrow irrigation gave significantly higher values of root and shoot and plant weight, where the percentages of increase attained to values of 22, 14 and 20% respectively. Also, the nitrogen fertilization level of 250 kg N/ha significantly increased the morphological traits, which indicated the importance of nitrogen fertilization in increasing the efficiency of plant in the photosynthesis process and increasing the percentage of dry matter accumulation, and this reflected positively on the morphological characteristics of the plant.

Key Words: Sugar Beet, Irrigation Methods, Nitrogen Fertilizer, Morphological Traits.

Introduction

Water is a valuable natural resource, both renewable and non-renewable, while maintaining its sustainability [1]. Also, water supply, in almost all regions of the world, is the main limiting factor that is most important for crop production, due to the demand of water for the rapid industrial sector and high population growth. Water is the main element in economic growth and poverty reduction [2-4]. Agriculture is the largest freshwater user on the planet [5].

Beta vulgaris L. belongs to the family Chenopodiaceae and is a biennial herbaceous plant that completes its life cycle in two years. It grows vegetatively in the first year, where the root is formed at the maximum size, and sugar and other nutrients are stored in it, and the stem is a disc. In the second year, if the roots are left in the field, the plant completes its life cycle, so the stems will elongate and bear a large number of flowers, which turn to fruits [6].

The cultivated area and production of sugar beet crop ranged between 2002 and 2013 at about 32.562 hectares, with a production of 1437.921 tons in 2006, and 26014 hectares and a production of 1805184 tons, for the year 2011, respectively [7].

Sugar beet is grown in the Syrian Arab Republic in several dates: Autumn time: it starts from October 15 to November 15, and is planted in the governorates of Hama, Idlib, Aleppo, Raqqa, and Deir Ezzor.

Winter: starts from January 15 to February 15, and is grown in the governorates of Hama, Idlib, Aleppo, and Raqqa [8].
Summer: it starts from July 15 to August 15 [6].

It is a new planting date that avoids high temperatures that deteriorate the sucrose stored in the roots and allows the application of a crop rotation that contributes to a better investment of agricultural lands and extends the operating period of the sugar factory for a longer period in the governorates of Raqqa and Deir Ezzor.

The use of water in irrigation must be rationalized and methods should be adopted that increase yields and improve the quality of production [9]. The development of irrigation methods and techniques and rationalization of water use has become an urgent necessity that must be taken as one of the main priorities in developing irrigated agriculture and improving its production [10].

Davidoff and Hanks, indicated that the water requirement of sugar beet ranges between 550-750 mm [11]. They added that irrigation increases root yield but reduces sucrose.
Furrow irrigation of sugar beet crop causes many problems because of water gatherings such as the spread of diseases and available nitrogen leaching, so soil moisture is a determining factor for the productivity of this plant, especially since surface irrigation does not provide a homogeneous distribution of water to a large extent, and from here it is necessary to control and manage the available water to control this problem, reduce irrigation water losses and raise the efficiency of its consumption [12-14].

The nitrogen element is one of the major elements needed by the plant and determined for production in sugar beet [15]. It is very important in the mineral nutrition of the plant, because of its importance in the formation and composition of proteins, and in the synthesis of nucleic acids. It is also included in the synthesis of photosynthetic chlorophyll pigments, so it is an important and necessary component of photosynthesis and respiration [16].

El-Geddawy and Makhlouf confirmed that increasing the nitrogen fertilization of sugar beet increases root dimensions (length and diameter), the percentage of impurities (Brix), the production of the shoot and the actual sugar yield, and in return it reduces the percentage of sucrose [17]. Several studies in Egypt showed that adding nitrogen fertilizer between 214 and 262 kg N/ha in clay or sandy soils gives the best productivity indicators of roots, actual sugar yield and qualitative traits [18-21].

The study of Pytlarz-Kozicka, showed that the increase in nitrogen fertilization rate from 90 to 180 kg N/ha increased insignificantly the root production, while it decreased the sucrose percentage in the roots [22].

Sharaf and Masri et al. exhibited that the positive effect of increasing nitrogen fertilization rate is on leaf area index, root weight of the plant, the percentage of impurities, root production and actual sugar yield, while the percentages of sucrose and purity were negatively affected [23,24].

In the absence of previous studies, on the recommendations for cultivating sugar beet in Syria in summer time, in Hama governorate, and where studies were limited to determining the dates of planting and harvesting, it was necessary to implement this research to find out the best agricultural treatments that contribute to improving the properties of soil and increasing yields regarding maintaining a high percentage of sugar for this crop in Syria, taking into consideration irrigation method and nitrogen fertilization.

The research aims to study the effect of irrigation method and nitrogen fertilization rate on some qualitative characteristics (root length and diameter, root and shoot fresh weight and plant fresh weight) of genetically monogerm sugar beet.

Materials and Methods

Site of Experiment

The experiment was carried out at Taizin Irrigation Research Station, Hama Research Center, General omission for Scientific Agricultural Research, Syria. The center is located within the first stability zone, at longitude of 35.9º and latitude of 36.52º and its height above sea level is 270 m, with an average rainfall of 400 mm/year.

Variety

The study was carried out on a variety of genetically monogerm hybrid of sugar beet, this variety is called Dita, which is recommended for cultivation in autumn, winter and summer dates, and its source is the General Commission for Scientific Agricultural Research GCSAR. Table (1) shows its most important productive and technological characteristics.

Table 1: Productive and technological characteristics of the studied variety.

Characteristics	Dita (monogerm)
Seeds source	Belgium
Type of variety	N
Sucrose %	16.74
Root yield (ton/ha)	74.23
Ploidy	Triploid

Planting Method

The land was prepared for cultivation, with a first plowing at a depth of 30 cm and a second plowing at a depth of 20 cm. Then, organic fertilizers were added at a rate of 5 m3. dunums-1, at a rate of 13.33 tons/ha. Then the land was plowed with a cultivator, and it was leveled, and the soil was planned, taking into account the following:

Experimental plot length (row length): (6 m), width: (3 m), and area: (18 m2), while the distance between rows: (50 cm), between plants: (20 cm), and between replicates: (1.5 m).

The planting was done manually during summer time (beginning of September) at a depth of 2-3 cm and at a rate of 2 seeds in each hole, in order to allow the process of thinning and replanting to obtain the required plant density. The number of irrigation times throughout the agricultural season (6 times). Thinning and replanting were also done before the plant reached the stage of the second pair of true leaves, with manual hoeing of for weeding, at a rate of 3 times during the growing season. The nitrogen fertilizer was

added according to the studied rates for two times, in each time half the studied amount of the three fertilizer rates, the first before planting, specifically between the second and third plowing according to the soil analysis, and the second was added during the period of emergence of the second pair of true leaves (the fourth true leave).
The following studied quantities of fertilizers were added according to the soil analysis:
Phosphorous fertilizer: Triple super phosphate (46% P_2O_5) was not added, because the soil has a good content of this element.

Potassium fertilizer: Potassium sulfate fertilizer (50% K_2O) was added at a rate of 80 kg. ha^{-1}, which is equivalent to 40 kg K_2O/ha.

Boron fertilizer: (10% effective boron) was added at a rate of 2 kg/ha.

Studied Variables

Irrigation Methods (sprinkle, foggy, drip and furrow):

A- Furrow irrigation: Six rows were planted for each treatment in each replicate, where the distance between lines is 50 cm, and 20 cm between plants on the same row.
B- Sprinkler Irrigation: It consists of 8 sprinklers for three repetitions, the distance between the sprinklers is 12 x 6 m, with a discharge of 1.25 m3/h at a pressure of 3 bar, the sprinkler radius is 6 m on a stand with a height of 75 cm.
C- Surface drip irrigation: the irrigation rows are spaced 50 cm apart, and the experimental plot consists of six rows.
D- Foggy irrigation: drain sprinklers of 50 l/h, where the spacing of sprinklers (mine sprinklers) is 3 m, the pressure is 1 bar, and the sprinkler radius is 3 m on a stand of 30 cm.

Irrigation was carried out every 5 days according to the amount of evaporation from the glass basin.
The area of the experimental plot is 9 m2.

The total area of the experiment: (9 * 12) * 3 + the distances between the factors and the replicates = 1291 m2.

Nitrogen Fertilizer

It was noticed from the soil analysis (Table 2) that the soil content of available nitrogen is low, and urea fertilizer (effective N 46%) was used at four rates: (no addition, 200, +25% (250) and -25% (150) kg/ha) as a pure unit of nitrogen, which is equivalent to (0, 434, 445, 326 kg urea/ha).

Table 2: Soil analysis of the experiment site at Taizin Research Station in Hama

Chemical analysis			Available K ppm	Available P ppm	Available N ppm	Organic matter (%)	Soil texture	Mechanical analysis		
Calcium carbonate CaCo3	Electrical conductivity (ds.m-1)	pH						Clay	Salt	Sand
18	18	64	Clay	1.56	6.5	17.3	320	6.8	0.66	13.5

Studied Traits

Experiment plants were lifted at the harvest time (middle of March) after about 195 days, and samples of the crop (3 plants) at the stage of full maturity of the roots were taken from each experimental plot from each of the replicates of the experiment to estimate each of:

1- Root Length (cm)

After topping, which was done by a horizontal cut just below the thick disc stem and the vegetative system was excluded, and the thin wedge root was cut (the taper end of the root) after leaving a distance of 1 cm from the root end, a longitudinal section was made from the middle of the root tip, then the distance was measured by means of a graduated ruler, located vertically from the top of the root to its end.

2- Root Diameter (cm):

the measurement was taken horizontally with a ruler for the longest distance between the two ends of the root (after cutting it vertically from the middle to calculate the length).

3- Fresh root weight per plant (g).

4- Fresh shoot weight per plant (g).

5- Plant weight (g).

Experiment Design and Statistical Analysis:

Field experiment was carried out according to a randomized complete block design with three replications. The sources of variance (ANOVA) were analyzed for the main factors and their interaction according to the least significant difference (L.S.D) was estimated at 5% level of significance, and coefficient of difference (C.V%) was calculated using the statistical program Genestat v.12 [25].

Results and Discussion

Effect of Irrigation Methods and Nitrogen Fertilization Rates on the Morphological Traits:

1- Root length (cm)

Table (3) shows that there is a significant effect of irrigation method on this trait, where the sprinkler irrigation method gave the lowest value root length (24.39 cm), but foggy irrigation method gave the highest (27.06 cm), this may be attributed to the homogeneous distribution of irrigation water to the plants [26]. Also, Table (3) exhibits an existence of a significant effect of nitrogen fertilization on this trait, between nitrogen fertilization levels (Table 3), where the treatment (N1=200 kg N/ha) gave the highest value (27.11 cm), but the treatment (N0) gave the lowest value (24.87 cm), this may be due to the role of nitrogen in improving the meristematic activity which contribute to the increase in number of cells in addition to cell enlargement. Also, enhancing net assimilation rate and dry matter accumulation which in turn incrementing root length and diameter as well as root fresh weight [27].

The beet plant gave the highest root length (28.11 cm) when following furrow irrigation and adding 200 kg nitrogen/ha.

Table 3: Effect of irrigation methods and nitrogen fertilization rates on root length (cm) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	24.67	28.11	27.22	25.56	26.39[a]
Drip	24.78	25.56	27.22	27.78	26.33[a]
Foggy	25.89	28.22	26.33	27.78	27.06[a]
Sprinkle	23.78	26.56	23.56	23.67	24.39[b]
Mean	24.78c	27.11a	26.08b	26.19b	26.04
LSD0.05	M= 1.35**, N= 0.73**, M*N= 21.64**				
CV%	3.3				

* Means that there are significant differences at 0.05 level of probability, ns means that there are no significant differences at 0.05 level of probability.

2-Root diameter (cm)

Table (4) shows that there is a significant effect of the irrigation method on this trait. The sprinkle irrigation method gave the lowest value of root diameter (8.89 cm), while the other irrigation methods did not differ significantly in the effect on this characteristic. The results of the statistical analysis showed that there were significant differences ($p \geq 0.05$) on root diameter between nitrogen fertilization levels (Table 4). The highest value of root diameter (10.19 cm) was achieved when using the furrow irrigation method and adding 250 kg of nitrogen/ha.

Table 4: Effect of irrigation methods and nitrogen fertilization rates on root diameter (cm) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	9.18	9.52	10.19	10.19	9.77[a]
Drip	8.83	9.15	10.05	9.15	9.29a[b]
Foggy	9.24	9.94	9.80	10.18	9.79[a]
Sprinkle	8.47	8.94	9.31	8.84	8.89[b]
Mean	8.93b	9.39a	9.84a	9.59a	9.44
LSD0.05	M= 0.74**, N= 0.45** , M*N= 0.99**				
CV%	5.6				

*, ** Means that there are significant differences at 0.05 and 0.01 levels of probability, ns means that there are no significant differences at 0.05 level of probability.

3-Root fresh weight/plant (g)

Table (5) shows that there is a significant effect of the irrigation method on this trait. The furrow irrigation method had a significant effect on increasing the root weight of the plant, as it gave the highest value (1139.5 g). The results of the statistical analysis showed that there were significant differences ($p \geq 0.05$) on root weight between nitrogen fertilization levels (Table 5). In general, it was observed that this trait increased with the increase of nitrogen fertilization up to the rate of N2, then this trait began to decrease with the increase of nitrogen fertilization. The highest value of root weight (1463 g) was achieved when using the furrow irrigation method and adding 250 kg of nitrogen/ha.

Table 5: Effect of irrigation methods and nitrogen fertilization rates on root fresh weight/plant (g) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	1013	1006	1463	1077	1139.5[a]
Drip	832	800	1137	779	886.9[b]
Foggy	558	1050	943	924	868.8[b]
Sprinkle	652	797	890	579	729.4[b]
Mean	763.7c	913.1b	1108.2a	839.7bc	906.2
LSD0.05	M= 157.7**, N= 95.4**, M*N= 211.9**				
CV%	12.5				

** Means that there are significant differences at 0.01 level of probability, ns means that there are no significant differences at 0.05 level of probability.

4-Shoot fresh weight/plant (g)

Table (6) shows that there is no significant effect of irrigation methods factor on the shoot weight/plant.

The analysis of variance (Table 6) shows a significant effect of the rate of nitrogen fertilizer addition on the shoot weight per plant, where the highest value in the treatment (N2 = 250 kg N/ha) was (585.0 g), and in contrast the lowest value was (313.1 g) (Table 6).

Table 6: Effect of irrigation methods and nitrogen fertilization rates on shoot fresh weight/plant(g) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	320	535	719	529	525.6[a]
Drip	287	518	583	426	453.3[a]
Foggy	240	677	504	454	468.9[a]
Sprinkle	406	486	533	401	456.4[a]
Mean	313.1c	553.6a	585.0a	452.5b	476.5
LSD0.05	I= 101.9, N= 94.8**, I*N= 183.4				
CV%	23.6				

**Means that there are significant differences at 0.01 level of probability.

5-Plant Weight (g)

Table (7) shows that there is a significant effect of the irrigation factor methods on plant weight, where the highest value of the plant weight (1665 g) was reached when the furrow irrigation method was followed.

The analysis of variance table (Table 7) shows that there is a significant effect of increasing the nitrogen fertilization rate in increasing the value of this trait compared with the no-addiction treatment (N0 =no addition) (1077 g), where the highest value of the treatment was (N2 = 250 kg N/ha) (1693 g) (Table 7). This was confirmed by both that the increase in nitrogen fertilization leads to an increase in plant weight [28,29].

Table 7: Effect of irrigation methods and nitrogen fertilization rates on plant weight (g) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	1333	1540	2182	1606	1665[a]
Drip	1119	1318	1720	1204	1340[b]
Foggy	798	1727	1447	1379	1338[b]
Sprinkle	1058	1282	1423	980	1186[b]
Mean	1077d	1467b	1693a	1292c	1382.25
LSD0.05	M=227.6**, N=131.8**, M*N= 298.8**				
CV%	11.3				

** Means that there are significant differences at 0.01 level of probability.

6-Water Consumption (m3/ha) Provided to Sugar Beet in Summer Time Using Four Irrigation Methods:

Table (8) shows that the water consumption of beet planted in summer time was high when following surface irrigation with a value of (5350 m3/ha), while it decreased by 28% in sprinkle irrigation, 32% when following foggy irrigation, and by 34.5% in drip irrigation, this means that the percentage of savings water provided to the crop was the highest when using drip irrigating, followed by foggy method and finally the sprinkle irrigation method. reported that drip irrigation system resulted in higher water saving than sprinkler and furrow systems in sugar beet fields [30].

Table 8: Water consumption (m3/ha) of sugar beet under four irrigation methods

Date	Irrigation method			
	Sprinkle	Foggy	Drip	Furrow
3/9	180	171	164	500
6/9	326	310	297	400
10/9	350	332	319	400
13/9	298	243	272	450
16/9	349	331	318	450
22/9	450	428	411	500
29/9	562	534	513	500
4/10	369	351	337	400
8/10	267	253	243	400
12/10	281	267	257	450
15/10	160	152	147	400
20/10	251	238	229	500
Total	**3843**	**3610**	**3507**	**5350**

Conclusions

The use of drip irrigation saves water consumed by 34.4% didn't differ significantly in its effect on root length and diameter compared to furrow irrigation, but furrow irrigation gave significantly higher values of root and shoot and plant weight, where the percentages of increase attained to values of 22, 14 and 20% respectively.

The nitrogen fertilization level of 250 kg N/ha significantly increased the morphological traits, which indicated the importance of nitrogen fertilization in increasing the efficiency of plant in the photosynthesis process and increasing the percentage of dry matter accumulation, and this reflected positively on the morphological characteristics of the plant [31-37].

Recommendations

The experiment recommends continuing the implementation of this experiment for another season to confirm the results before generalizing them due to the importance of these factors on the morphological traits of sugar beet.

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