The Response of Sugar Beet (*Beta vulgaris* L.) to Different Irrigation Methods and Different Nitrogen Fertilization Levels in Summer Time

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Abstract

The study 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 yield and quality 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% and increases the number of plants by 5%, and does not negatively affect the qualitative traits (Brix, sucrose and purity), while reducing the yield of roots by about 17% and 8% of the top yield, and 16% of sugar yield, compared to furrow irrigation. The statistical analysis exhibited that there was no significant effect on the quality traits; brix, sucrose, and purity percentages (20.92, 14.57 and 69.61%) respectively, while the nitrogen levels affected significantly the yield traits and plant density, which were the highest at the addition of 250 kg N/hectare (102.8, 50.4, 153.3 and 3.79 ton/hectare, respectively). The highest value of plant number per hectare was (80.74 thousand plant/hectare) at a level of 250 kg N/hectare of nitrogen fertilization. These results assure the importance of the nitrogen fertilizer to enhance the plant's photosynthesis efficiency and dry matter accumulation.

Keyword: Sugar beet, Irrigation methods, Nitrogen fertilizer, Quality traits, Production traits.

Introduction:

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 (Al Jbawi *et al*., 2015).

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 (Ministry of Agriculture and Agrarian Reform (2002-2013).

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 (Al Jbawi and Al Zubi, 2016).
- Summer: it starts from July 15 to August 15 (Al-Jbawi *et al*., 2015).

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.

Water is a valuable natural resource, both renewable and non-renewable, while maintaining its sustainability (Sarkera *et al*., 2019). 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 (Jha *et al*., 2017; Eba and Seyoum, 2018; Islam *et al*., 2019). Agriculture is the largest freshwater user on the planet (Gan *et al*., 2013).

The use of water in irrigation must be rationalized and methods should be adopted that increase yields and improve the quality of production (Kassam *et al*., 2007). 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 (Levidow *et al*., 2014).

Davidoff and Hanks, (1989) indicated that the water requirement of sugar beet ranges between 550-750 mm. 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 (Dunham, 1993), so soil moisture is a determining factor for the productivity of this plant (Abd El-Tawwab *et al*., 2007), 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 (Badawy *et al*., 2001).

The nitrogen element is one of the major elements needed by the plant and determined for production in sugar beet (Hergert, 2010). 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 (Marinkovic *et al*., 2010).

El-Geddawy and Makhlouf (2015) 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. 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 (Hassanin and Alayan, 2000; Moustafa and Darwish, 2001; Abo El-Wafa, 2002; Hilal, 2005).

The study of Pytlarz-Kozicka, (2005) 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.

Sharaf (2012) and Masri *et al*. (2015) 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.

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 (percentage of Brix, sucrose and purity %) and productivity characteristics (number of plants, root shoot, and biological yields and actual sugar yield) 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 m^3. $dunums^{-1}$, 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 m^2), 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).

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 $CaCo_3$	Electrical conductivity ($ds.m^{-1}$)	pH						Clay	Salt	Sand
13.5	0.66	6.8	320	17.3	6.5	1.56	Clay	64	18	18

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 m^3/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 m^2.

The total area of the experiment: (9 * 12) * 3 + the distances between the factors and the replicates = 1291 m^2.

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).

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, and after topping (removal of the foliage), the roots were taken to the Beet Lab at Al-Ghab Research Center to estimate each of:

1-Quality traits:

1-1-Brix percentage (Total Soluble Solids - T.S.S%):

This is done by using the Refractometer, which is a device used to measure the specific density of liquids and thus the percentage of total soluble solids (T.S.S) by measuring the refraction index of the material.

1-2- Sucrose percentage (%): It was calculated using a Polarimeter according to (Le Docte, 1927).

1-3- Purity percentage (%):

Purity (%): It was calculated from the following equation according to (Carruthers and Oldfield, 1961):

Purity (%) = (Brix (%) / Sucrose (%)) X 100

2- Productive traits:

The roots of the plants were manually lifted for the middle rows (the two inner rows) from each experimental plot. After topping the plants, the shoots and roots were weighed in kilograms/m^2. Then the following indicators were calculated per unit area as follows:

2-1-Number of plants per hectare (thousand plants/ha).

2-2-Root yield (tons/ha).

2-3- Top yield (tons/hectares).

2-4-Biological yield (tons/ha).

2-5-Sugar yield (tons/ha):

Which is calculated from the following equation:

Sugar yield (tons/ha) = root yield (tons/ha) X sugar percentage % X purity %

Experiment design and statistical analysis:

The 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 (Gomez and Gomez, 1984), 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.

Results and Discussion:

1-Effect of irrigation methods and nitrogen fertilization rates on the qualitative characteristics:

1-1-Brix (total soluble solids - TSS%):

Table (3) shows that there is no significant effect of the irrigation method on this trait, which means that it is possible to save irrigation water by following one of the irrigation methods that save water resources without affecting the qualitative characteristics of sugar beet roots (Badawy *et al.*, 2007). Also, Table (3) exhibits an existence of non-significant effect of irrigation methods on this trait, also, the results of the statistical analysis shows that there are significant differences ($p \geq 0.05$) on Brix percentage, between nitrogen fertilization levels (Table 3). 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. Nitrogen is the imbalance in the distribution of photosynthetic products between the leaves and the root system, which leads to a decrease in sugar content and an increase in the percentage of soluble solids, and consequently, a decrease in purity. Zalat and Youssif, (2001) and El-Kholy *et al*., (2006) and Manlou *et al*., (2008) showed that increasing nitrogen fertilization increases the percentage of soluble solids that hinder sugar extraction.

Table 3. Effect of irrigation methods and nitrogen fertilization rates on TSS (%) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	20.92	22.62	23.27	21.65	22.12^{a}
Drip	22.03	22.89	23.32	21.54	22.45^{a}
Foggy	22.72	20.92	22.46	22.23	22.08^{a}
Sprinkle	20.37	20.87	23.10	23.33	21.92^{a}
Mean	21.51^{b}	21.83^{b}	23.04^{a}	22.19^{ab}	22.14
LSD0.05	M=1.0ns, N=1.0*, M*N=1.95ns				
CV%	5.5				

*** 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.**

1-2-Sucrose (%):

Table (4) shows that there is no significant effect of the irrigation method on this trait, which means that it is possible to save irrigation water by following one of the irrigation methods that save water resources without affecting the qualitative characteristics of sugar beet roots (Badawy *et al.*, 2007). The results of the statistical analysis showed that there were significant differences ($p \geq 0.05$) on sucrose percentage between nitrogen fertilization levels (Table 4). 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.

Table 4. Effect of irrigation methods and nitrogen fertilization rates on sucrose (%) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	14.57	15.30	15.57	13.467	14.73[a]
Drip	15.33	15.47	14.63	13.467	14.73[a]
Foggy	15.70	14.23	14.07	14.167	14.54[a]
Sprinkle	15.40	15.23	14.87	14.300	14.95[a]
Mean	15.25[a]	15.06[a]	14.78[a]	13.85[b]	14.74
LSD0.05	M=0.54ns, N=0.45**, M*N=0.89**				
CV%	3.6				

*** , ** 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.**

1-3-Purity (%):

Table (5) shows that there is no significant effect of the irrigation method on this trait, which means that it is possible to save irrigation water by following one of the irrigation methods that save water resources without affecting the qualitative characteristics of sugar beet roots (Badawy *et al*., 2007). The results of the statistical analysis showed that there were significant differences ($p \geq 0.05$) on purity percentage 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. Nitrogen is the imbalance in the distribution of photosynthetic products between the leaves and the root system, which leads to a decrease in sugar content and an increase in the percentage of soluble solids, and consequently, a decrease in purity. Zalat and Youssif, (2001) and El-Kholy *et al*., (2006) and Manlou *et al*., (2008) showed that increasing nitrogen fertilization increases the percentage of soluble solids that hinder sugar extraction.

Table 5. Effect of irrigation methods and nitrogen fertilization rates on purity (%) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	69.61	67.68	66.87	65.02	67.30[ab]
Drip	69.74	67.68	62.75	62.71	65.72[b]
Foggy	69.24	68.05	62.66	63.72	65.92[b]
Sprinkle	75.64	73.06	64.39	61.28	68.59[a]
Mean	71.06[a]	69.12[a]	64.17[b]	63.18[b]	66.88
LSD0.05	M=2.31ns, N=2.27**, M*N=4.34ns				
CV%	4.0				

**** 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.**

2-Effect of irrigation methods and nitrogen fertilization rates on the Productive characteristics:

2-1-No. of plants per hectare (plant/ha):

Table (6) shows that there is a significant effect of irrigation methods factor on the number of plants, and it reached the highest value significantly (78148 plant/ha) with the application of drip irrigation compared with other irrigation methods, it may be due to the preservation of soil moisture with drip irrigation method (Abd El-Tawwab *et al.*, 2007) and most importantly that this method reduces water waste and increases the efficiency of its consumption (Badawy *et al*., 2001).

The analysis of variance (Table 6) shows a significant effect of the rate of nitrogen fertilizer addition on the number of plants per hectare, where the highest value in the treatment (N1 = 250 kg N/ha) was (80.74 thousand plants per hectare), and in contrast the lowest value was (68.89 thousand plants/ha) (Table 6). These results did not agree with what was found by Pytlarz-Kozicka, (2005), which is that there was no significant effect of nitrogen fertilization rate on the number of plants per hectare.

Table 6. Effect of irrigation methods and nitrogen fertilization rates on plant densities (plant/ha) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	68889	80741	70370	76296	74074^{b}
Drip	71111	77037	82963	81481	78148^{a}
Foggy	62222	81481	79259	78518	75370^{b}
Sprinkle	67407	70370	73333	72593	70926^{c}
Mean	67407^{b}	77407^{a}	76481^{a}	77222^{a}	74629.5
LSD0.05	M= 1432.9** , N= 2993.2** , M*N= 5298.3**				
CV%	4.8				

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

2-2-Root yield (ton/ha):

Table (7) shows that there is a significant effect of irrigation factor methods on yield of roots, and it reached the highest value (83.89 tons/hectare) significantly when following surface irrigation compared with other irrigation methods. Davidoff and Hanks, (1989) showed that surface irrigation increases root yield. But it was also not recommended (Abd El-Tawwab *et al*., 2007), to follow this method in irrigating sugar beet crop, as it does not achieve a homogeneous distribution of water in the field to the plants.

It is noted from Table (7) that there are highly significant differences between nitrogen fertilization rates for root yield, where the treatment (N2 = 250 kg/hectare) gave the highest value for root weight (102.8 tons/hectare) significantly than the other treatments, and the lowest value was when no addition of nitrogen fertilizer (69.7 tons/ha). It could be concluded that high nitrogen fertilization to a certain extent leads to a significant increase in root yield. These results are in agreement with those of Ismail, (2002) and El-Sayed, (2005).

Zalat and Youssif, (2001) and El-Kholy *et al*., (2006) Manlou *et al*., (2008) explained that the reason for the increase in root yield as a result of the increase in nitrogen fertilization is because of the increase in the size and number of leaves, and thus the increase in leaf area, which increases the rate of photosynthesis and positively reflects on plant growth.

Table 7. Effect of irrigation methods and nitrogen fertilization rates on root yield (ton/ha) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	69.7	81.0	102.8	82.1	83.89[a]
Drip	59.1	61.0	95.5	63.3	69.74[b]
Foggy	34.6	85.6	75.0	72.7	66.97[b]
Sprinkle	44.3	56.0	65.3	42.0	51.92[c]
Mean	51.93[c]	70.90[b]	84.66[a]	65.03[b]	68.13
LSD0.05	M= 12.71**, N= 9.47**, M*N= 19.44**				
CV%	16.5				

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

2-3-Top yield (ton/ha):

Table (8) shows that there is no significant effect of the irrigation factor methods on top yield, so it could used the method that save water with no native effect on top yield.

The analysis of variance table (Table 8) 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) (22 tons/hectare), where the highest value of the treatment was (N2 = 250 tons). N/ha) (50.4 t/ha) but with apparent differences from treatments N1 and N3 (43 and 40.4 t/ha) respectively (Table 8). This was confirmed by both Ouda, (2002) and Osman, (2005) that the increase in nitrogen fertilization leads to an increase in the production of the vegetative growth.

Table 8. Effect of irrigation methods and nitrogen fertilization rates on top yield (ton/ha) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	22.0	43.0	50.4	40.4	38.97[a]
Drip	20.3	39.6	48.7	34.5	35.78[a]
Foggy	15.1	55.1	40.0	35.9	36.51[a]
Sprinkle	27.6	34.1	39.1	29.2	32.49[a]
Mean	21.25[c]	42.95[a]	44.55[a]	35.00[b]	35.94
LSD0.05	M= 7.66ns, N= 7.77**, M*N= 14.78**				
CV%	25.7				

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

2-4-Biological yield (ton/ha):

Table (9) shows that there is a significant effect of the irrigation factor methods on the biological yield, and it reached the highest value (122.9 tons/ha) significantly when following surface irrigation compared with other irrigation methods, and the sprinkler irrigation method gave the lowest value (84.4 tons/ha) when sprinkler irrigation was followed.

The analysis of variance (Table 9) shows that there are significant differences between the nitrogen fertilization treatments with regard to biological production, which expresses the total root and vegetable production. The highest value in the treatment was (N2 = 250 kg N/ha) (153.3 tons/ha) with significant differences with the other treatments, and the treatment without addition (N0) gave the lowest value (91.7 tons/ha).

This was demonstrated by Duval *et al*., (2003) that the increase in nitrogen fertilization rates contributes to an increase in the root growth rate, the percentage of biomass and the rate of crop growth, as they showed that the nitrogen fertilization rate of 250 kg/ha led to an increase in top yield and an increase in the efficiency of the plant in the composition of dry matter, and a greater investment in the nitrogen stored in leaves, as the percentage of nitrogen in leaf tissue decreased compared to the increase in the percentage of dry matter in it.

Table 9. Effect of irrigation methods and nitrogen fertilization rates on biological yield (ton/ha) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	91.7	123.9	153.3	122.5	122.9[a]
Drip	79.4	100.7	144.2	97.8	105.5[ab]
Foggy	49.7	140.7	114.9	108.7	103.5[b]
Sprinkle	71.9	90.1	104.5	71.1	84.4[c]
Mean	73[d]	113.9[b]	129.2[a]	100.0[c]	104.1
LSD0.05	M=18.1**, N=13.4**, M*N=27.5**				
CV%	15.2				

**** Means that there are significant differences at 0.05 level of probability.**

2-5-Sugar yield (ton/ha):

Table (10) shows that there is a significant effect of irrigation factor methods on yield of sugar, and it reached the highest value (2.78 tons/hectare) significantly when following surface irrigation compared with other irrigation methods. This might be as a result to the increase in root yield (Davidoff and Hanks, 1989). While the lowest value (1.71 tons/ha) by using sprinkle irrigation.

Based on the analysis of variance (Table 10) it is clear that there are significant differences in the different rates of nitrogen fertilizer addition in relation to sugar yield, as the highest value in the treatment was (N2 = 250 kg N /hectare) (3.73 tons /hectare), and the reason may be due to the high root yield as shown in Table (7) and the high percentage of sucrose and purity which are shown in Tables (4 and 5), given that sugar yield is the product of the three mentioned indicators.

Table 10. Effect of irrigation methods and nitrogen fertilization rates on sugar yield (ton/ha) of sugar beet.

Irrigation method (M)	Nitrogen fertilizer (N)				Mean
	N0	N1	N2	N3	
Furrow (control)	2.14	2.79	3.73	2.458	2.78[a]
Drip	1.99	2.17	3.27	1.835	2.32[b]
Foggy	1.23	2.55	2.36	2.292	2.11[b]
Sprinkle	1.39	1.80	2.25	1.400	1.71[c]
Mean	1.69[c]	2.33[b]	2.91[a]	2.00[bc]	2.23
LSD0.05	M=0.39*, N=0.37**, M*N=0.69ns				
CV%	19.0				

*** Means that there are significant differences at 0.05 level of probability.**

3-Water consumption (m^3/ha) provided to sugar beet in summer time using four irrigation methods:

Table (11) shows that the water consumption of beet planted in summer time was high when following surface irrigation with a value of (5350 m^3/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.

Table 11. Water consumption (m^3/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% and increases the number of plants by 5%, and does not negatively affect the qualitative traits (Brix, sucrose and purity), while reducing the yield of roots by about 17% and 8% of the top yield, and 16% of sugar yield, compared to furrow irrigation.
- The nitrogen fertilization level of 250 kg N/ha significantly increased root, top and biological production and sugar yield, 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, while the fertilization rates did not affect significantly the qualitative indicators.

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 qualitative and productive traits of sugar beet.

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