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EGYPTIAN ACADEMIC JOURNAL OF BIOLOGICAL SCIENCES BOTANY

ISSN 2090-3812

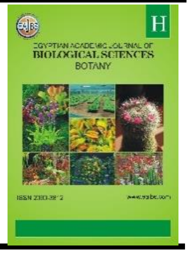
www.eajbs.com

Vol. 13 No.2 (2022)

Citation: Egypt. *Acad. J. Biolog. Sci.* (H. Botany) *Vol.13(2) pp31-42(2022)*
DOI: 10.21608/EAJBSH.2022.252621

Egypt. Acad. Journal Biolog. Sci., 13(2):31-42 (2022)

Egyptian Academic Journal of Biological Sciences
H. Botany
ISSN 2090-3812
www.eajbsh.journals.ekb.eg.



Productivity and Quality of Sugar Beet in Relation to Sowing Methods and Plant Density Under Center Pivot Irrigation System

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ARTICLE INFO
Article History
Received:17/6/2022
Accepted:30/7/2022
Available:2/8/2022

***Keywords*:**
Sugar beet, planting methods, densities, pivot irrigation, yield and quality.

ABSTRACT

The importance of the sugar beet crop to agriculture is not confined only to sugar production, but also it is adapted to saline, sodic and calcareous soils, therefore it can be planted in new reclaiming lands in Egypt, in this respect two field experiments were conducted at Nubaria Region, to study the effect of three sowing methods and planting density on yield and quality of sugar beet (*Beta vulgaris* L.) cultivar monogerm (cv. Salama) during 2020/2021 and 2021/2022 seasons. Treatments were organized in a split-plot design in three replicates. The three methods of sowing i.e., mechanical planting by a planter in rows (M1), hand sowing on ridges at the two sides of the ridge (M2) and hand sowing on ridges at one side of the ridge(M3) randomly allocated to the main plots, while, the three-planting density (60000, 64000, and 68000 plant/fed) were assigned randomly within the subplots. Generally, the results showed that planting methods such as the mechanical method in rows (flat) (M1) or on the two sides of ridges(M2) in addition to the plant density (60000 or 64000 plants/fed) and their interaction increased productivity parameters of sugar beet as well as increased root and sugar yield and sugar quality under the conditions of Nubaria Region.

INTRODUCTION

After sugarcane, sugar beet (*Beta vulgaris L.*) is regarded as the second most significant sugar crop. It is an edible plant of the *Amaranthaceae* family. It is an essential crop for humans as a source of high energy and as a source of feed for livestock. The significance of this crop stems from its ability to grow on the recently reclaimed ground and provide a high sugar recovery rate, as well as its lower water need when compared to sugarcane.

Furthermore, sugar beet is specialized as a short-duration crop, with a growth time around half that of sugarcane. Furthermore, being the most significant cash crop in the cycle, sugar beet leaves the land in good condition for the next summer grain harvest. As a result, it became the first source of sugar production in Egypt. (Amr and Ghaffar, 2010).

Sugar beet production accounted for 67.7 % (1.8 million tons) of total sugar production in Egypt. The total sugar beet cultivated area in Egypt reached 617000 feddans. However, the total sugar beet cultivated area in the world is estimated to be 12.5 million feddans (FAOStat, 2020). The quantity and productivity of sugar beet are highly dependent on the effectiveness of the environmental and agronomic factors, from these factors; sowing methods and planting spacing (plant density). In this regard, many studies, such as (Zahoor *et al.*, 2007), revealed that ridge sowing yielded the highest leaf weight and the number of beets, followed by bed sowing. (El-Sarag, 2009) exposed that ridge sown sugar beet had increased root production and sugar content. on the other hand, the sowing technique in sugar beet impacted the root diameter, root weight, leaf area, brix (TSS %), sugar %, sugar yield, and purity % (Ahmad *et al.*, 2010). Bed-planted sugar beets had the greatest mean root diameter, sugar content, and purity %. Sugar output was comparable for sugar beets cultivated on beds or ridges. Also, (Topak *et al.*, 2014) observed that 50 cm apart ridges increased root production and sugar content by 1% and 4%, respectively, compared to 60 cm apart ridges. Other research has found that ridge and bed seeding produce greater growth, root, and sugar yields in sugar beet. On the other hand, (Saini and Brar, 2018) observed that sowing sugar beet in two rows on beds or two rows on both sides of a ridge on sandy loamy soil under subtropical circumstances was a viable choice for increasing beet production. Different planting methods have a significant impact on sugar beet growth, yield, and quality metrics. Ridge planting produced the largest number of leaves per plant, chlorophyll content index, root length, root diameter, root yield, and sugar yield. Ridge seeding also resulted in the best sugar recovery, purity percentage, pol, and brix percentages. Ridge sowing of sugar beets outperforms other methods in terms of sugar beet output and quality (Sher *et al.*, 2019).

Plant density is one of the major factors, determining the total yield of roots in terms of quality and quantity per unit area. Crop sown at optimum plant density can utilize a sufficient quantity of water and light, which results in an increase in efficiency of photosynthesis, an increase in dry matter accumulation in the roots and higher productivity (Freckleton *et al.*, 1999). The highest root and sugar yield at Plant density was 56000 plants fed-1 as compared to 33600 plants/fed (Abd El-Kader, 2005). Plant densities were raised from 28000 to 42000, which resulted in higher root length, diameter, fresh weight/plants, sucrose percent, total soluble solids (TSS %), phosphorus percent, and top, root, and sugar yields. Plant density of 42000 plants/fed was the best treatment, yielding the highest values on the majority of the attributes studied (Nafei and Osman, 2010). The highest plant density of 56000 plant/fed gave the highest values of sucrose %, purity %, top yield /fed, root yield /fed and sugar yield/fed, but it gave the lowest root fresh weight (El-Ghareib *et al.*, 2012). The interaction (sowing date x plant density x varieties) had a highly significant influence on yield, yield components, and quality (Refay, 2010). The plant densities of 48000, 46666, 42000, 56000 and 62000 plants/fed., respectively gave the highest root, top and sugar yields/fed., root length and diameter, fresh weight/plant, sucrose (%) and purity (%) (El-Hity *et al.*, 2014). The technique of sowing, plant density, and depth of sowing are all likely to have a significant impact on crop performance. Better growth and yields can be obtained by using a two-row-bed planting strategy, a plant density of 12 plants/m^2, and planting depths of 1.25 and 2.5 cm (Brar *et al.*, 2015).

Sowing sugar beet mechanically attained an additional increment in root yield over those under the traditional method (sowing manually). There are general tendencies toward increasing the sugar yield/fed by using the planter technique for sowing sugar beet seeds (El-Geddawy *et al*., 2008). The mechanical sowing method of sugar beet significantly surpassed the traditional sowing method (manual) in root and foliage fresh weights/plant, root length and diameter, root, top and sugar yields/fed (Seadh *et al.*, 2013). Plants sown at wider intra–row spacings (17 and 19 cm) had on average higher root weight compared to average root weight in narrower intra–row spacings (13 and 15 cm) (Varga *et al.*, 2015). In 10 plants/m^2, the maximum sugar content and acceptable root production were obtained.

Although 12 plants/m^2 generated the greatest maximum solar radiation absorption at the time of maximum light interception and the highest solar radiation absorption at the time of final harvesting, the differences were not significant when compared to 10 plants/m^2. With 10 plants/m^2, enough LAI and total dry matter were also attained. Planting at 50 cm between rows and 10 plants/m^2 resulted in the highest yield and yield components. Planting sugar beet plants at the highest plant density of 56000 plants/fed (15 cm between hills) yielded the highest values of sucrose percent, to yield /fed, root yield /feddan, and sugar yield/fed, while the lowest plant density 33600 plants/fed yielded the longest root, widest root, and heaviest root when compared to other plant densities (El-Hawary *et al.*, 2019). The highest plant density (46666 plants/fed) produced higher sucrose, extractable sugar percentages, sugar and recoverable sugar yields/fed., than at low or medium densities (Hanafy *et al.*, 2019).In the other study, planting two rows on the bed with a Plant density of 123000 plants/ha recorded maximum production efficiency, monetary efficiency and sugar productivity (9.65 and 8.62 t/ha), which was on par with planting two rows on both sides of the ridge with a plant density of 123000 plants/ha and significantly higher than rest of the treatment (Saini *et al.*, 2020). In relation to plant density, higher plant densities had on average the highest root yield, sucrose content, and white sugar yield (Varga *et al.*, 2021).

The aim of this investigation is to study the effect of sowing methods and plant density (plant spacing) and their interaction on sugar beet production as grown under a center pivot irrigation system in Nubaria conditions.

MATERIALS AND METHODS

Two field experiments were carried out at Nubaria, Egypt during 2020/2021 and 2021/2022 seasons, to study the effect of sowing methods and plant density on sugar beet (*Beta vulgaris L*. var Salama) under Nubaria region. Each experiment had 27 units total, made up of three planting methods, three plant densities, and their combinations spread among three replications.

The preceding summer crop was maize (*Zea mays* L.) in both seasons. Before planting, soil samples were randomly taken from the experimental site at a depth of 0 to 60 cm below the soil surface and prepared for chemical analysis according to the method described by (Chapman and Pratt, 1978). Which is presented in (Table 1).

The experimental design was a split-plot design in three replications, the sub-plot area was 10.8m2, including 6ridges of 4m in length and 2.7m in width. The main plots were occupied by planting methods (mechanical planting by a planter in rows(M1), hand sowing on ridges on two sides of the ridge (M2), and hand sowing on ridges on one side of the ridge (M3), while the sub-plots were occupied randomly by plant densities (68.000, 64.000, and 60.000 plants/fed), referred to as space between hills (13.5, 14.5, and 15.5 cm), respectively, and 45 cm between rows)), in both seasons.

The soil of field experiments was prepared through two ploughings and leveling. Plants were kept free from weeds, by spraying pre-emergency herbicide and one time manually controlled by hand hoeing.

Sugar beet variety Salama (mono germ variety) was recorded from Alexandria Sugar Company. Seeds were sown on the 4th and 1st of December, respectively and harvested after 200 days during the two seasons.

Table 1. Some physical and chemical properties of the experimental soil sites in both seasons.

Soil properties	Season	
	2020/2021	2021/2022
A- Mechanical analysis (%)		
Sand	87.00	88.23
Clay	4.10	4.80
Silt	8.90	6.97
Texture soil	Sandy	
B- Chemical analysis		
PH	7.92	8.0
Ec (ds/m)	4.80	4.80
Anions (meq/l)		
HCo_3^-	3.00	2.93
Cl^-	12.01	12.60
So_4^{--}	32.00	32.90
Cations (meq/l)		
Cu^{++}	5.00	5.4
Mg^{++}	6.20	6.5
Na^{++}	35.40	35.20
K^+	0.71	0.90
Available nitrogen (meq/l)	33.00	28.5
Organic matter (%)	0.15	0.10

All required nutrients (macronutrients and micronutrients) were applied by the Center Pivot application, which is shown in Table (2).

The sugar beet Salama variety was planted under irrigation by a pivot that had a Pump flow (220 m^3/h). Common agricultural practices for growing sugar beet plants according to the recommendations of the Ministry of Agriculture and land Reclamation were followed, except for the factors under study.

Studied Characteristics:

At the maturity stage, (200 days from sowing) plants were harvested from the four middle ridges of each sub-plot, and the following parameters were estimated:

1. Root length and root diameter (cm) were calculated on roots from 20 plants collected from inside ridges to avoid the border ridges.
2. Top yield (t/ha).
3. Root yield (t/ha).
4. Biological yield (t/ha).
5. Extracted sugar yield (S.Y)/feddan was calculated according to the following equation.

S.Y = root yield (t/fed) x extractable white sugar (%) /100.

6. Sucrose percentage (%): Sucrose content in the juice of beet was determined in sugar Alexandria Company by mean of automatic sugar Polarimetric according (McGinnis, 1971).
7. Recoverable sugar percentage (RS %) sometimes referred to as (Corrected sugar %) or white extractable sugar %) was determined by using the following equation:
   R.S.% = Sucrose % - SLM (D%) according to the method described by (Akyar *et al.*, 2013; Hoffmann, 2010).
8. Total soluble solids (TSS %): were recorded in the juice of fresh roots using a hand refractometer, and sucrose% was measured polarimetrically on a lead acetate extract of fresh macerated root (Carruthers and Oldfield, 1961).

9. Purity percentage (QZ), sometimes referred to as Quality index (QI%) was calculated using the equation as follows:
   Purity % = Sucrose % / TSS % × 100.
10. Impurity (%) = K + Na + α-amino N
11. Sugars lost to molasses percentage (SLM%) was calculated according to the following equation as demonstrated by (Devillers, 1988; Hoffmann, 2010):
   SLM % (D %) = $[(K^+ + Na^+ * 0.343 + (\alpha - \text{amino N x } 0.094)] \text{ x } 0.29$.
12. Potassium (K^+), sodium (Na^+), and α-amino N in roots were estimated as meq/100 g sugar beet root, were determined in Alexandria Sugar Company Laboratories, El-Behira Governorate, by an Automated Analyzer as described by (Carruthers and Oldfield, 1961; Hoffmann, 2010).

Statistical Analysis:

All recorded data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split-plot design as published by (Gomez and Gomez, 1984). The Least Significant Difference (LSD) method was used to test the differences between treatment means at a 5% level of probability. All the statistical analyses were performed application of (CoStat, 2005) for Windows.

Table 2. Requirements of sugar beet from all the macros and micronutrients during both seasons.

Crop Age	Application method	Super calcium phosphate (granules) (15 % P_2O_5)	Ammonium Sulfate (20.5 % N)	Ammonium Nitrate (33.5 % N)	Urea (46.5 % N)	MAP (Mono ammonium phosphate (N-P-K) (12-61-0)	Magnesium sulphate (16 %)	Phosphoric acid (80 %)	Potassium sluphate (50 % K_2O)	Nitric acid (52 %)	Sulfuric Acid (98 %)
		kg	kg	kg	kg	kg	kg	kg	kg	Litter	Litter
0 (with preparation)	Broad casting (soil application)	100	-	-	-	-	-	-	-	2	-
10	fertigation	-	10	-	-	-	-	-	-	2	-
15	fertigation	-	15	-	-	5	-	-	-	2	-
20	fertigation	-	-	15	-	5	-	-	-	2	-
27	fertigation	-	-	15	-	-	-	5	-	2	
34	fertigation	-	-	20	-	-	-		-	3	
41	Broad casting (soil application)	-	-	-	25	-	5	5	-	-	3
48	Broad casting (soil application)	-	-	-	25	-	5	5	-	-	3
55	fertigation	-	-	20	-	-	5	-	-	-	3
62	fertigation	-	-	20	-	-	5	-	-	-	3
69	fertigation	-	-	20	-	-	5	-	-	-	3
76	fertigation	-	-	20	-	-	5	-	7	-	-
83	fertigation	-	-	20	-	-	-	-	7	-	-
90	fertigation	-	-	20	-	-	-	-	7	-	-
97	fertigation	-	-	25	-	-	-	-	7	-	-
104	fertigation	-	-	25	-	-	-	-	7	-	-
110	fertigation	-	-	15	-	-	-	-		-	-
120	fertigation	-	-	15	-	-	-	-		-	-
Total rate (kg/fed)		100	-	250	50	10	30	15	35	13	15
Total Units		N= 115 kg	P2O5= 30 kg	K=18	Ca=15	Mg= 5 kg	S= 20 kg				
Foliar application		Br Compound (14 %) at the three times 70-, 90- and 130-days after sowing at the rate of 250,250,350 cm3 respectively									
Foliar application		Micronutrients at the two times 95 and 130 days after sowing at the rate of 350,400 gm respectively									

RESULTS AND DISCUSSION

The obtained results in Table (3) showed the significant effect of planting methods, plant density and their interaction on root length, root diameter, root yield, top yield, and biological yield of sugar beet Salama during 2020/2021 and 2021/2022 seasons. Concerning the effect of planting methods on the previous characters, results in Table (3) revealed that planting sugar beet using a planter in rows=flat (M1) recorded the highest values of root length and diameter (cm), root yield, top yield, and biological yield followed by M2= hand sowing on ridges at two sides of the ridge while sowing on one side of the ridge gave the minimum mean values of the previously mentioned characters in both seasons. The results in the same Table (3) showed that planting sugar beet at density (60000 plants/fed) gave the maximum mean values of root length and diameter (cm), root yield, top yield, and biological yield followed by plant density at 64000 plants/fed but plant density at 68000 plants/fed gave the lowest ones in both seasons. Also, the interaction between planting methods (M1= planting by a planter in rows=flat) and plant density at 60000 plants/fed achieved the highest mean values of root length and diameter (cm), root yield, top yield, and biological yield followed by M2= hand sowing on ridges at two sides of the ridge in both seasons. This showed that planting methods and plant densities under this study act dependently on the previous characters as shown in Table (3).

Table 3. Sugar beet cv. Salama root length, root diameter, root yield, top yield, and biological yield as affected by planting methods, plant density and their interaction during 2020/2021 and 2021/2022 seasons.

Attributes	A) Planting methods	Season 2020/2021				Season 2021/2022			
		B) Plant density (plants/fed)							
		60000	64000	68000	Average A	60000	64000	68000	Average A
Root length (cm)	M1	28.7	26.8	21.7	25.7	29.0	26.7	23.0	26.2
	M2	27.7	22.0	21.0	23.6	29.3	23.7	22.2	25.1
	M3	21.7	22.3	19.5	21.2	23.8	21.0	20.2	21.7
Average (B)		26.0	23.7	20.7		27.4	23.8	21.8	
LSD at 0.05	A		0.9				1.2		
	B		0.7				0.8		
	AB		1.1				1.3		
Root diameter (cm)	M1	15.5	11.6	10.1	12.4	17.4	16.2	14.0	15.9
	M2	14.2	12.0	11.8	12.7	16.5	15.3	12.4	14.7
	M3	12.5	10.5	9.5	10.8	14.1	13.7	11.8	13.2
Average (B)		14.1	11.4	10.5		16.0	15.1	12.7	
LSD at 0.05	A		1.1				1.2		
	B		0.7				0.8		
	AB		1.2				1.4		
Root yield (t/fed).	M1	34.4	31.9	28.1	31.5	34.4	32.1	28.9	31.8
	M2	32.4	30.3	27.9	30.2	33.2	31.3	28.7	31.1
	M3	30.4	26.2	25.4	27.3	30.9	26.5	25.3	27.6
Average (B)		32.4	29.5	27.1		32.8	30.0	27.6	
LSD at 0.05	A		1.2				1.7		
	B		0.6				1.0		
	AB		1.1				1.8		
Top yield (t/fed)	M1	13.5	11.2	10.3	11.7	13.2	12.6	11.5	12.4
	M2	11.6	10.0	9.4	10.3	12.7	12.0	11.2	12.0
	M3	11.2	9.5	8.2	9.6	12.5	10.3	9.7	10.8
Average (B)		12.1	10.2	9.3		12.8	11.6	10.8	
LSD at 0.05	A		1.2				0.3		
	B		0.5				0.8		
	AB		0.8				1.2		
Biological yield (t/fed)	M1	47.9	43.1	38.4	43.1	47.6	44.7	40.4	44.2
	M2	44.0	40.3	37.3	40.5	45.9	43.3	39.9	43.0
	M3	41.6	35.7	33.6	37.0	43.4	36.8	35.0	38.4
Average (B)		44.5	39.7	36.4		45.6	41.6	38.4	
LSD at 0.05	A		0.8				1.1		
	B		0.2				1.1		
	AB		1.4				2.0		

M1= planting by planter in rows=flat; M2= hand planting on ridges at two sides of the ridge, and M3= hand sowing on ridges at one side of the ridge.

Results in Table (4) revealed the significant response of sugar beet characters such as extracted sugar yield (t/fed), sucrose (%), recoverable sugar (RS%), total soluble solids (TSS %) to planting methods, plant density and their interaction in both seasons, while there no significant effect of planting methods and density on sugar beet purity (%). On the other hand, the interaction between these factors had a significant effect on purity. Where, M1= planting by a planter in rows=flat increased sugar yield (t/fed), sucrose (%), recoverable sugar (RS%), extracted sugar (B%), and total soluble solids (TSS %) followed by M2= hand sowing on ridges at two sides of the ridge in both seasons. On the same trend, planting at 60000 plants/fed increased these traits followed by 64000 plants/fed. In this line, the interaction of planting method (M1= planting by a planter in rows=flat) + plant density

(60000 plants/fed) yielded the highest values of extracted sugar yield (t/fed), Recoverable sugar (RS percent), and TSS (Brix percent), followed by M2= hand sowing on ridges at two sides of the ridge + 60000 plants/fed yielded the highest values of sucrose percent and RS percent. In the first and second seasons, the maximum value of purity percent was observed with M2= hand sowing on ridges on two sides of the ridge or M3 (on one side) + the greater plant density (68000).

Table 4. Extracted sugar yield (t/fed), sucrose (%), recoverable sugar (RS%), total soluble solids (TSS %) and purity (%) of sugar beet cv Salama as affected by planting methods, plant density and their interaction during 2020/2021 and 2021/2022 seasons.

Attributes	A) Planting methods	Season 2020/2021				Season 2021/2022			
		B) Plant density (plants/fed)							
		60000	64000	68000	Average A	60000	64000	68000	Average A
Extracted sugar yield (t/fed)	M1	5.9	5.4	4.2	5.2	6.3	5.8	4.8	5.6
	M2	5.7	4.8	4.4	5.0	6	5.3	4.8	5.4
	M3	5.0	4.1	3.8	4.3	5.4	4.4	4.1	4.6
Average (B)		5.5	4.8	4.1		5.9	5.2	4.6	
LSD at 0.05	A		0.3				0.4		
	B		0.2				0.2		
	AB		0.3				0.3		
Sucrose (%)	M1	18.8	18.9	16.8	18.2	19.3	19.4	17.9	18.9
	M2	19.1	17.7	17.6	18.1	19.4	18.2	18.1	18.6
	M3	18.4	17.8	17.7	18.0	18.9	18.3	18.2	18.5
	Average (B)	18.8	18.1	17.4		19.2	18.6	18.1	
LSD at 0.05	A		1.1				1.0		
	B		0.4				0.5		
	AB		0.7				0.8		
Recoverable sugar (RS%)	M1	16.9	16.7	14.4	16.0	17.9	17.9	16.1	17.3
	M2	16.9	15.2	15.1	15.7	17.8	16.4	16.1	16.8
	M3	16.1	14.8	14.1	15.0	17.1	15.9	15.3	16.1
	Average (B)	16.6	15.6	14.5		17.6	16.7	15.8	
LSD at 0.05	A		1.1				0.9		
	B		0.5				0.5		
	AB		0.8				0.9		
Total soluble solids (TSS %)	M1	26.1	24.5	20.6	23.7	25.7	24.7	21.9	24.1
	M2	24.5	22.8	20.4	22.6	24.7	24.3	21.7	23.6
	M3	22.9	20.7	21.0	21.5	23.5	20.0	21.3	21.6
	Average (B)	24.5	22.7	20.7		24.6	23.0	21.6	
LSD at 0.05	A		1.0				1.8		
	B		0.7				1.1		
	AB		1.3				1.9		
Purity (%)	M1	72.0	77.1	81.6	76.9	75.1	78.5	81.7	78.4
	M2	78.0	77.6	86.3	80.6	78.5	74.9	83.4	78.9
	M3	80.3	86.0	84.3	83.5	80.4	91.5	85.4	85.8
	Average (B)	76.8	80.2	84.1		78.0	81.6	83.5	
LSD at 0.05	A		ns				ns		
	B		ns				ns		
	AB		5.7				9.5		

M1= planting by planter in rows=flat; M2= hand planting on ridges at two sides of the ridge, and M3= hand sowing on ridges at one side of the ridge.

The results in Table (5) showed that sugar lost to molasses (SLM percent), potassium (K percent), sodium (Na percent), and -amino N (percent) were reduced with M1= planting by a planter in rows=flat, followed by M2= hand sowing on ridges at two sides of the ridge, and also with planting sugar beet at plant density at 60000 plants/fed, similarity the interaction between these traits gave the lowest mean values.

The increase in root length and diameter caused by reducing plant density levels might be ascribed to increased cell elongation and cell division, resulting in increased root length and diameter. Furthermore, the rise in the top and root yield owing to higher plant/fed may be ascribed to increased vegetative growth as well as root length and diameter, which resulted in increased top and root yield / fed. Sugar yield/fed may have increased due to an increase in root yield per fed and quality. The rise in root and sugar yields/fed due to increased plant density might be ascribed to sucrose percent produced the sufficient root having the greatest sucrose percent and having the largest number of roots/fed which delivered the heaviest root yield/fed. It also produced the highest sugar yield/fed since sugar yield/fed is a function of root yield multiplied by sucrose percent, hence it was the superior plant density because it produced higher yields than the other plant densities studied. The rise in sucrose and purity percentages might be ascribed to the maximum plant density, which resulted in the smallest root size and lowest root wetness, resulting in a higher concentration of sucrose and purity percentages in roots. Sugar beet production increase owing to favorable accessible soil moisture in sugar beet root zone by spray irrigation system may be attributed to reducing water constraint, particularly in freshly planted sugar beets. These findings are consistent with those of (Abd El-Kader, 2005; Ahmad *et al.*, 2010, 2015; Al-jbawi *et al.*, 2015; El-Geddawy *et al.*, 2008; El-Hawary *et al.*, 2019; Hanafy *et al.*, 2019; Nafei and Osman, 2010; Saini and Brar, 2018; Varga *et al.*, 2021) who reported that using suitable planting method and optimum plant density increased growth, yield and quality of field crops. Bed planting not only lowers operational costs, but also improves water distribution and efficiency (Hobbs *et al.* 2000).

Table 5. Sugar beet cv. Salama sugar lost to molasses (SLM %), Potassium (K%), sodium (Na %), and α-amino N (%) of sugar beet cv Salama are affected by planting methods, plant density and their interaction during 2020/2021 and 2021/2022 seasons.

Attributes	A) Planting methods	Season 2020/2021				Season 2021/2022			
		B) Plant density (plants/fed)							
		60000	64000	68000	Average A	60000	64000	68000	Average A
SLM (%)	M1	1.5	1.7	1.9	1.7	0.9	1.1	1.4	1.1
	M2	1.6	2	1.9	1.8	1.1	1.3	1.4	1.3
	M3	1.7	2.3	2.8	2.3	1.3	1.8	2.2	1.8
	Average (B)	1.6	2.0	2.2		1.1	1.4	1.7	
LSD at 0.05	A		0.2				0.1		
	B		0.2				0.1		
	AB		0.3				0.2		
K+	M1	3.6	4.3	5.0	4.3	2.9	3.1	3.9	3.3
	M2	4.0	4.9	4.8	4.6	3.2	3.7	4.0	3.6
	M3	4.5	5.3	6	5.3	3.7	4.2	4.9	4.3
	Average (B)	4.0	4.8	5.3		3.3	3.7	4.3	
LSD at 0.05	A		0.3				0.2		
	B		0.4				0.3		
	AB		0.6				0.5		
Na+	M1	1.8	1.8	1.8	1.8	1.0	1.0	1.1	1.0
	M2	1.9	1.9	2.1	2.0	1.1	1.1	1.3	1.2
	M3	1.8	2.7	3.7	2.7	1.1	2.2	3.0	2.1
	Average (B)	1.8	2.1	2.5		1.1	1.4	1.8	
LSD at 0.05	A		0.2				0.2		
	B		0.3				0.1		
	AB		0.6				0.2		
α-amino N %	M1	0.7	0.7	0.8	0.7	0.6	0.6	0.6	0.6
	M2	0.8	0.9	1.1	0.9	0.6	0.7	1.0	0.8
	M3	1.3	1.9	2.8	2.0	0.8	1.2	2.2	1.4
	Average (B)	0.9	1.2	1.6		0.7	0.8	1.3	
LSD at 0.05	A		0.2				0.3		
	B		0.1				0.2		
	AB		0.2				0.3		

- M1= planting by planter in rows=flat; M2= hand planting on ridges at two sides of the ridge, and M3= hand sowing on ridges at one side of the ridge.

CONCLUSION

Generally, planting method, sowing density and their interaction had a significant impact on root length, root diameter, root yield (t/fed), top yield (t/fed), biological yield (t/fed), extracted sugar yield (t/fed), sucrose (%), recoverable sugar (RS%), total soluble solids (TSS %), purity (%), sugar lost to molasses (SLM %), potassium (K%), sodium (Na %), and α-amino N (%) of sugar beet cv Salama. The highest average increase of root length, root diameter, root yield (t/fed), top yield (t/fed), biological yield (t/fed), extracted sugar yield (t/fed), sucrose (%), recoverable sugar (RS%) and TSS % was found out with sowing plant by planter (mechanical) or hand sowing on two sides of the ridges with plant spacing (15.5 cm between hills x 45 cm ridge width) at plant density 60000 plants/fed which increased quality of sugar beet by reducing the characters mentioned below such as impurity (%), sugar lost to molasses (SLM %), Potassium (K%), sodium (Na %), and α-amino N (%) as grown in the Nubaria Region using the Pivot irrigation system.

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ARABIC SUMMARY

إنتاجية وجودة بنجر السكر وعلاقتهما بطرق الزراعة والكثافة النباتية تحت نظام الري المحوري

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محصول بنجر السكر من المحاصيل السكرية الاقتصادية الهامة لاستخراج مادة السكروز ذات القيمة الغذائية المرتفعة والتي تستخدم في غذاء الإنسان كمصدر للطاقة العالية ويعتبر بنجر السكر من المحاصيل عديدة الاستخدامات حيث يستخرج من جذوره السكر ويستخدم المجموع الخضري كغذاء للحيوانات ، وايضاً مخلفات تصنيع واستخراج السكروز كالعسل الأسود او المولاس وغيرها كما تؤدي زراعة البنجر إلي تحسين خواص التربة كما أنه يجود في الأراضي الملحية وحديثه الاستصلاح والأراضي الجيرية وتتيح زراعة البنجر فرص عمل كثيرة سواء في الحقل أو في مصانع السكر. وطبقا لتقرير مجلس المحاصيل السكرية في 2021 تصل المساحة العالمية المنزرعة من محصول بنجر نحو 12,5 مليون فدان تنتج حوالي 325 مليون طن بمتوسط انتاج 26 طن/فدان ينتج نحو 68,4 مليون طن سكر يمثل 38% من الإنتاج الكلي للسكر العالمي. بينما في مصر يساهم سكر البنجر بحوالي 1.8 مليون طن سكر تمثل حوالي 67.7 % من إجمالي إنتاج السكر، هذا ناتج من مساحة زراعية حوالي 617.000 فدان في موسم 2021.

وعلى الرغم من زيادة الإنتاجية من محصول بنجر السكر وقصب السكر الا أن هناك عجز (فجوة) بين الإنتاج والاستهلاك تصل الى 608.000 طن ويمكن تقليل هذه الفجوة الغذائية في مصر عن طريق زيادة إنتاجية وحدة المساحة (التوسع الرأسي) وذلك عن طريق اختيار طريقة الزراعة المناسبة وزيادة الكثافة النباتية. لذا تم اجراء تجربة حقلية على موسمي 2021/2020 و2022/2021 لدراسة استجابة صنف بنجر السكر وحيد الجنين (سلامة) لطرق الزراعة ومسافات الزراعة المختلفة (كثافة نباتية) تحت نظام الري بالرش المحوري في منطقة النوبارية. واستخدم التصميم الاحصائي القطع المنشقة مره واحده (split plot) في ثلاث مكررات حيث وزعت طرق الزراعة المختلفة في القطع الرئيسية: 3 طرق لزراعه بنجر السكر (الزراعة الاليه بالبلانتر والزراعة علي مصاطب على الريشتين يدوي والزراعة يدوي في خطوط على ريشة واحده) بينما القطع تحت الرئيسية وزعت (ثلاث كثافات نباتيه بواقع 60000 / 64000 / 68000 نبات/فدان) علي الترتيب في ثلاث مكررات.

أوضحت النتائج ما يلي:

- أثرت طرق الزراعة المختلفة والكثافة النباتية تأثيرا معنوياً على الصفات التالية: طول الجذر (سم) وقطر الجذر (سم) ومحصول الجذور (طن/فدان) ومحصول العرش (طن/فدان) والمحصول البيولوجي (طن/فدان) ومحصول السكر (طن/فدان) ونسبة السكروز (%) و نسبة السكر المكرر (%) ونسبة السكر المستخلص (%) ونسبة المواد الصلبة الذائبة (%) ونسبة النقاوة (%) ونسبة عدم النقاوة ونسبة السكر المفقود في المولاس ونسبة البوتاسيوم (%) والصوديوم (%) و ألفا أمينو نيتروجين (%) لصنف بنجر السكر وحيد الجينين (سلامة) حيث وجد أن طريقة الزراعة (الاليه) في صفوف حققت أعلى قيم لصفات المحصول والجودة متبوعة بطريقه زراعة المصاطب علي

الريشتين مقارنة بالزراعة على ريشة واحدة في حين أن الكثافة النباتية 60000 نبات للفدان حققت أعلى قيم لصفات المحصول والجودة متبوعة بالكثافة النباتية 64000 نبات/فدان خلال موسمي الزراعة.

- حقق التداخل بين عاملي الدراسة (طرق الزراعة والكثافة النباتية) اختلافا معنوياً على كل من صفات المحصول والجودة لنباتات بنجر السكر حيث وجد أن الزراعة الاليه (في صفوف) مع الكثافة النباتية 60000/فدان (15.5 سم بين النباتات والمسافة بين الخطوط 45سم) حققا أعلى قيم لصفات المحصول والجودة خلال الموسمين.

التوصية: يوصي البحث بزراعة صنف بنجر السكر وحيد الجنين (سلامة) بطريقة الزراعة الاليه خاصة في المساحة الكبيرة في صفوف أو على مصاطب (ريشتين) وتحت نظام الري بالرش (البيفوت) وبكثافة نباتية 60000 نبات/فدان (15.5 سم بين الجور) للحصول على محصول مرتفع من جذور بنجر السكر وأعلى نسبة السكروز عند الزراعة في الأراضي الرملية مثل منطقة النوبارية محافظة الإسكندرية جمهورية مصر العربية والمناطق المماثلة.