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Productivity and quality of sugar beet as affecting by sowing and irrigation methods and hill spacings

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Key words: Sugar beet, Sowing methods, Mechanical sowing, Manual sowing, Irrigation methods, Hill spacings, Plant populations, Plant densities, Yield, Quality

Abstract

Two field experiments were carried out at Kalabsho Experimental Farm, Dakahlia Governorate, Sugar Crops Research Institute, Agricultural Research Center, Egypt, during 2014/2015 and 2015/2016 seasons to study the effect of sowing methods (mechanical and manual methods), irrigation methods (surface and drip irrigation system) and hill spacings (10, 15 and 20cm between hills) on yield and its components, as well as quality of sugar beet cv. Hossam as a multigerm variety under sandy soil conditions. The obtained results could be summarized as follows; the optimum sowing method that produced the highest values of yield and its components as well as root quality parameters was mechanical sowing method (planter machine) in both seasons. Irrigation sugar beet plants by using drip irrigation system yielded the highest values of yield and its components as well as root quality parameters and followed by using surface flooding irrigation system in both seasons. Planting sugar beet seeds on one side of the ridge, 60cm width, and 20cm between hills, resulting plant population density 35000 plants/fed produced, the highest values of yield and its components and root quality parameters and followed by planting on 15cm between hills, resulting plant population density 46666 plants/fed and finally planting on 10cm between hills, resulting plant population density 70000 plants/fed in the two seasons. From the obtained data in this study, it can be concluded that sowing sugar beet using mechanical sowing method (planter machine), irrigation by using drip irrigation system and planting on one side of the ridge, 60cm width, and 20cm between hills, resulting plant population density 35000 plants/fed in order to maximizing its productivity and quality under the environmental conditions of sandy soil in Kalabsho region, Dakahlia Governorate, Egypt.

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Introduction

Sugar beet is a specially type of *Beta vulgaris* L. grown for sugar production and is considered the most important sugar crop in Egypt and in many countries all over the world besides sugar cane. Recently, sugar beet crop has an important position in Egyptian crop rotation as winter crop not only in the fertile soils, but also in poor, saline alkaline and calcareous soils. Sugar beet being, often, the most important cash crop in the rotation, it leaves the soil in good conditions for the benefit of the following cereal crops. By-products of sugar production, such as pulp, molasses and lime, flow bath into agriculture to increase livestock production and improve soil fertility as well as provide various middle products as alcohol, forage and other many products. Developing high yielding varieties and its high demand for agricultural practices and other production input is necessary. Thereby, sowing method, irrigation method, plant densities resulting from hill spacings are among factors that enhance sugar beet productivity.

Producers must try to use an optimum sowing methods, which is considered to be one of the most important elements of sugar beet production. There are a few investigations with respect to the effect of sowing methods on sugar beet productivity. In this concern; Awad (2000) found that maximum root weight, sugar percentage, root yield and sugar yields were obtained by rows machines planting. Morad *et al.* (2007) concluded that the minimum total cost for harvesting sugar beet crop was obtained under mechanical planting and sugar beet harvester, compared with manual method. Zahoor *et al.* (2007) showed that sowing methods significantly affected the root and foliage weights, root and top yields/ha of sugar beet crop. El-Geddawy *et al.* (2008) found that sowing sugar beet mechanically attained 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 planter technique for sowing sugar beet seeds. Sarauskis *et al.* (2010) showed that the best results in terms of root yield up to 79.1t/ha were achieved by using the rotary harrow or rotovator as compared with sowing was conventional drilling. Seadh *et al.* (2013) revealed that 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 in the two seasons. Sowing methods showed significant effect on sucrose and purity percentages and the highest values of these parameters were achieved with manual sowing.

Recent studies indicated that by year 2030 one-third of the population in the developing countries will be exposed to absolute water scarcity, in the sense that they will not have sufficient water resources to meet their agricultural demands, industrial and environmental needs. With the reduction of water resources, in agriculture, the application of suitable irrigation methods has become a necessity for the protection of water resources and the reduction in contamination of chemicals into groundwater. The most difficult point, in agriculture, is to obtain more yield with less water, which may be possible to increase the water use efficiency of the plant (Masri *et al.*, 2015). One of the ways of alleviating water scarcity, especially in the newly reclaimed areas, is by using benefit irrigation system such as drip and sprinkler irrigation, where water is a limiting factor for producing sugar beet strategically. In addition, growing sugar beet in newly reclaimed sandy soil needs different cultural practices than from those used in old lands, especially irrigation system. In this respect, Cassel-Sharmasarkar *et al.* (2001) evaluated the effect of surface drip and flood irrigation on water and fertilizer use efficiency for sugar beet. They concluded that applying irrigation water with drip systems used less water and fertilizer than when using flood irrigation. Sharmasarkar *et al.* (2001) reported that drip irrigation system had an advantage and produced 3-28% higher root yield and sugar content as compared with surface irrigation method. Sakellariou-Makrantonaki *et al.* (2002) concluded that subsurface drip irrigation led to a greater sugar beet yield and higher sugar content and also significant water savings compared with surface drip irrigation. Yonts (2006) stated that furrow irrigation significantly produced greater sucrose yield, when compared to sprinkler irrigation treatment.

Hassanli *et al.* (2010) indicated that the irrigation methods (drip, surface drip and furrow irrigation) had a significant effect on sugar beet root yield, sugar yield, and irrigation water use efficiency. The highest root yield was obtained using surface drip irrigation and the lowest root yield was obtained using furrow irrigation. El-Darder *et al.* (2017) revealed that drip irrigation system with 80% of irrigation water requirement (IWR) recorded the highest significant sucrose percentage, purity percentage and extractable sugar percentage in both seasons of sugar beet crop. While application of sprinkler irrigation at 100% (IWR) gave the heaviest root weight, purity percentage and root yield. Ozbay and Yildirm (2018) showed that the irrigation methods has significant effects on root and sugar yields of sugar beet. In drip irrigation system, the amount of irrigation water and evapotranspiration were almost 11% lower than the sprinkler irrigation.

There is a general agreement that plant population play important roles for sugar beet not only on productivity, but also on quality. For the effects of plant population, Nassar (2001) found that sucrose content and recoverable sugar percentages were linearly decreased with the reduction in plant density. Root yield and sugar yields were maximized with plant density of 42000 plants/fed. Abd El-Kader (2005) found that plant density of 56000 plant/fed gave the highest root and sugar yields compared to the low density 33600 plant/fed. El-Bakary (2006) found that hill spacings significantly affected root fresh weight, root length and diameter, sucrose%, root and sugar yields/fed. Neamet - Alla *et al.* (2007) mentioned that planting sugar beet seeds in ridges of 50cm and hill space of 20cm caused significant increases in sucrose percentage and root diameter, but there were no significance effects on root length and juice purity percentage. Bhullar *et al.* (2010) found that plant population of 100 000 plants/ha (rows spaced at 50cm and plants at 20cm) produced the lowest beet root diameter and highest root length, root and sugar yields. Nafei *et al.* (2010) found that increasing plant spacing from 20 to 30cm caused significant response in root length, diameter, fresh weight/plants, sucrose%, top, root and sugar yields. Shalaby *et al.* (2011) found that significant increases in root fresh weight, sucrose%, root and sugar yields/fed with increasing distance between hills from 15 to 25cm. Yousef and Heidri (2011) demonstrated that the highest root and sugar yields were resulted from spacing of 15 or 20cm between hills and 60cm between rows. Abdou *et al.* (2014) showed that sowing sugar beet seeds in both sides of terraces 80cm width at 25cm distance between hills led to significant increase in yields of roots, gross sugar and white sugar. Ragab and Rashed (2016) reported that planting sugar beet seeds at 20cm between hills progressive than other distance (15 and 25cm) for most important characters, root, top fresh weight, sucrose and purity%. On the other hand. space 15cm between hills gave the highest values of top fresh weight, root yield, sugar yield and sucrose%. Leilah *et al.* (2017) showed that cultivating sugar beet seeds in both sides of mastaba 80cm width at 35cm distance between hills (30000 plants/fad) resulting significant increase in foliage fresh weight/plant, plant weight, root weight, sucrose and purity percentages.

Therefore, this study aimed to study the effect of sowing and irrigation methods and hill spacings on productivity and quality of sugar beet under the environmental conditions of sandy soil in Kalabsho region, Dakahlia Governorate, Egypt.

Materials and methods

The present investigation was carried out at Kalabsho Experimental Farm, Dakahlia Governorate, Sugar Crops Research Institute, Agricultural Research Center (ARC), Egypt during 2014/2015 and 2015/2016 seasons to study the effect of sowing and irrigation methods and hill spacings on yields and its components as well as quality of sugar beet cv. Hossam as a multigerm variety under sandy soil conditions

Each sowing method (mechanical and manual) was performed in separate experiment. Mechanical sowing method was done by using planter machine in ridges 60cm in width. However, manual sowing method was undertaken workers in ridges 60cm in width.

Each experiment of sowing method was performed in strip-plot design with three replicates in both seasons. The vertical-plots were occupied with two irrigation methods (surface and drip irrigation system). The plots were irrigated immediately after sowing by surface flooding method in both irrigation methods. After that, in surface flooding irrigation method, plants were irrigated after sowing regularly every 15-18 days. In the drip irrigation system, polyethylene drip lines of 16mm in diameter had in-line type emitters. The distance between emitters along the drip line was 0.20m and the discharge of one emitter was 4L/h under the running pressure of 1.5 atm.

The horizontal-plots were devoted at random with three hill spacings (10, 15 and 20cm between hills) on one side of the ridge. Plants were thinned at the age of 45 days from sowing to obtain one plant/hill, resulting three plant population densities of 70000, 46666 and 35000 plants/fed, respectively.

Each experimental basic unit included ten ridges, each 60cm apart and 3.5 m length, which resulted an area of 21 m2 (1/200 fed).

Soil samples were taken at random from the experimental field area at a depth of 0-30cm from soil surface and prepared for both mechanical and chemical analyses. The results of both mechanical and chemical analyses are presented in Table 1.

The experimental field well prepared by two ploughing, leveling, compaction, division and then divided to the experimental units. Calcium super phosphate (15.5% P2O5) was applied during soil preparation at the rate of 200kg/fed.

Sugar beet balls (seeds) were sown using mechanical and manual methods as previously mentioned at the first week of November in both growing seasons. Nitrogen fertilizer (100kg N/fed) in form of urea (46.5%) was applied in three equal doses, the first portion was applied after thinning (45 days from sowing), the second portion was applied after 60 days from sowing, and the third portion was applied after 75 days from sowing. Potassium sulphate (48% K2O) at the rate of 24kg/fed was applied after 30 days from sowing.

Other agricultural practices for growing sugar beet were performed as recommendations by Ministry of Agriculture, except the factors under study.

Table 1. Mechanical and chemical properties of soil at the investigational site in 2014/2015 and 2015/2016 seasons.

Variables		2014/2015	2015/2016
A: Mechanical analysis			
Sand (%)		91.40	91.80
Silt (%)		4.95	5.05
Clay (%)		3.65	3.15
Soil texture class		Sandy	Sandy
B: Chemical analysis			
Soil reaction pH		8.07	7.91
EC (dS m^{-2}) in soil water extraction (1:5) at 25°C		2.89	2.81
Organic matter (%)		0.166	0.195
CaCo^{3} (%)		0.78	0.71
Macronutrients (ppm)	Total N	18.50	20.50
	Available P	2.85	2.97
	Available K	78.00	83.00
Soluble cations (meq L-1)	Ca^{++}	1.19	1.12
	Mg^{++}	0.46	0.53
	Na^{+}	5.53	5.27
	K^{+}	0.19	0.21
Soluble anions (meq L-1)	CO^{3--}	0.00	0.00
	HCO^{3-}	1.15	1.11
	SO4^{--}	0.76	0.88
	Cl^{-}	4.85	4.70

Studied characters

At maturity (after approximately 195 days from sowing) five plants were chosen at random from the outer ridges of each plot to determine yield components and quality characters, as follows:

A-Yield components

1. Root fresh weight (g/plant).
2. Root dry weight (g/plant).
3. Foliage fresh weight (g/plant).
4. Foliage dry weight (g/plant).

To determine root and foliage dry weights, all plant fractions were air-dried, then oven dried at 70°C till constant weight obtained.

5. Root length (cm).
6. Root diameter (cm).

B- Yield quality

1. Sucrose percentage (%). It was determined Polarimetrically on lead acetate extract of fresh macerated roots, according to the method of Carruthers and OldField (1960).

2. Apparent purity percentage (%). It was determined as a ratio between sucrose% and TSS% of roots, as the method outlined by Carruthers and Oldfield (1960).

C-Yields

At harvest, plants that produced from the two inner ridges of each plot were collected and cleaned. Roots and tops were separated and weighted in kilograms, then converted to estimate:

1. Root yield (t/fed).
2. Top yield (t/fed).
3. Sugar yield (t/fed). It was calculated by multiplying root yield by sucrose percentage.

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for strip-plot design of each experiment (sowing method), then the combined analysis was carried out as outlined by Gomez and Gomez (1984) by using means of "MSTAT-C" computer software package. Least significant difference (LSD) method was used to compare the differences among treatment means at 5% level of probability, as described by Snedecor and Cochran (1980).

Results and discussion

1- Sowing methods effect

From obtained results in Tables 2 and 3, all yield components (root and foliage fresh and dry weights/plant and root length and diameter) and root quality parameters (sucrose and apparent juice purity percentages in roots) had a significant effect owing to different sowing method (mechanical and manual methods). It can be statement that mechanical sowing method recorded the highest values of yield components and root quality parameters in the two seasons. In the other side, the lowest values of yield components and root quality parameters of sugar beet were resulted from manual sowing method in both seasons.

Table 2. Root and foliage fresh and dry weights/plant of sugar beet as affected by sowing and irrigation methods and hill spacings as well as their interactions during 2014/2015 and 2015/2016 seasons.

Characters / Treatments / Seasons	Root fresh weight (g/plant)		Root dry weight (g/plant)		Foliage fresh weight (g/plant)		Foliage dry weight (g/plant)	
	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016
A- Sowing methods:								
Mechanical	950.1	982.6	218.5	226.0	428.1	442.1	92.90	102.93
Manual	568.1	587.5	130.6	134.5	256.1	264.4	59.49	60.59
F. test	*	*	*	*	*	*	*	*
B- Irrigation methods:								
Surface	672.7	696.1	154.7	160.1	302.7	313.2	70.19	72.02
Drip	845.5	874.0	194.4	200.3	381.5	393.3	82.20	91.51
F. test	*	*	*	*	*	*	*	*
C- Hill spacings:								
10cm	738.7	764.0	169.9	174.7	333.1	343.7	69.15	79.00
15cm	759.3	785.8	174.6	180.7	342.5	353.6	78.79	81.96
20cm	779.3	805.4	179.2	185.2	350.7	362.5	80.64	84.32
F. test	*	*	*	*	*	*	*	*
LSD at 5%	13.6	14.3	3.1	3.4	5.0	6.1	3.22	2.26
D- Interactions (F. text):								
A × B	*	*	*	*	*	*	NS	*
A × C	NS	NS	NS	NS	*	NS	NS	NS
B × C	NS	NS	NS	NS	NS	NS	NS	NS
A × B × C	*	*	*	NS	*	*	NS	NS

Table 3. Root length and diameter, sucrose and apparent juice purity percentages in sugar beet roots as affected by sowing and irrigation methods and hill spacings as well as their interactions during 2014/2015 and 2015/2016 seasons.

Characters / Treatments / Seasons	Root length (cm)		Root diameter (cm)		Sucrose (%)		Apparent purity (%)	
	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016
A- Sowing methods:								
Mechanical	25.88	25.19	14.87	14.00	19.57	19.42	76.46	82.09
Manual	17.16	16.86	10.91	10.41	17.47	17.48	76.90	76.79
F. test	*	*	*	*	*	*	*	*
B- Irrigation methods:								
Surface	18.61	8.19	11.27	10.64	17.10	17.05	65.85	70.96
Drip	24.43	3.86	14.51	13.78	19.94	19.85	87.51	87.92
F. test	*	*	*	*	*	*	*	*
C- Hill spacings:								
10cm	21.10	20.57	12.59	11.84	18.17	18.13	69.43	79.10
15cm	21.57	20.92	12.89	12.26	18.35	18.34	79.31	79.28
20cm	21.89	21.59	13.19	12.53	19.05	18.89	81.30	79.94
F. test	*	*	*	*	*	*	*	*
LSD at 5%	0.30	0.25	0.20	0.22	0.22	0.26	0.17	0.19
D- Interactions (F. text):								
A × B	*	*	*	*	*	*	*	*
A × C	NS	NS	NS	*	NS	NS	*	*
B × C	NS	NS	*	NS	*	NS	*	*
A × B × C	*	NS	NS	NS	*	*	*	*

All yield characters (root, top and sugar yields/fed) significantly affected by sowing method *i.e.* mechanical and manual methods, this comment was mostly true in the two seasons of study (Table 4). The optimum sowing method that yielded the highest values of root, top and sugar yields/fed was mechanical sowing method (planter machine) in both seasons. The corresponding data were 21.093 and 21.107 ton roots/fed, 9.075 and 8.896 ton top/fed and 4.223 and 4.201 ton sugar/fed in the first and second seasons, respectively. On the other hand, the lowest values of these traits were recorded under manual sowing condition in the two growing seasons.

These results may be attributed to the regularity spacing and numbers of plants between hills in mechanical sowing method, which minimizing the intra competition between plants and led to high light use efficiency of solar radiation utilized by beet plants, in turn high in the conversion of light energy to chemical energy and consequently high accumulation of dry matter and improvement of yields and its components as well as root quality parameters. These findings are in harmony with those reported by Awad (2000), Morad *et al.* (2007), El-Geddawy *et al.* (2008) and Seadh *et al.* (2013).

Irrigation methods effect

Yield components (root and foliage fresh and dry weights/plant and root length and diameter) and root quality parameters (sucrose and apparent juice purity percentages in roots) were significantly affected by studied irrigation methods (surface and drip methods) in both growing seasons as shown in Tables 2 and 3. The highest values for yield components and root quality parameters were achieved when irrigation sugar beet plants by using drip irrigation system in both season. On the other hand, the lowest values for whole these yield components and root quality parameters were resulted from using surface flooding irrigation system in both seasons.

All yield characters under study *i.e.* root, top and sugar yields/fed were significantly responded due to studied irrigation methods in both seasons (Table 4). Noteworthy, irrigation sugar beet plants by using drip irrigation system yielded the highest values of root (23.694 and 23.478t/fed), top (10.235 and 9.956t/fed) and sugar (4.759 and 4.701t/fed) yields/fed in the first and second seasons, respectively. On the other hand, irrigation sugar beet plants by using surface flooding irrigation system resulted in the lowest means of yield characters in both seasons.

Such enhancement in sugar beet yields due to favourable available soil moisture in sugar beet root zone by drip irrigation system may be ascribed to alleviating water scarcity, especially in the newly reclaimed areas, is by using benefit irrigation system such as drip irrigation, reduction in contamination of chemicals into groundwater and enhancing vegetative growth attributes and resulting in highest yields and quality. In this connection Cassel-Sharmasarkar *et al.* (2001), Sharmasarkar *et al.* (2001), Sakellariou-Makrantonaki *et al.* (2002), Hassanli *et al.* (2010), El-Darder *et al.* (2017) and Ozbay and Yildirm (2018) reported comparable results.

Table 4. Root, top and sugar yields/fed of sugar beet as affected by sowing and irrigation methods and hill spacings as well as their interactions during 2014/2015 and 2015/2016 seasons.

Characters / Treatments / Seasons	Root yield (t/fed)		Top yield (t/fed)		Sugar yield (t/fed)	
	2014/ 2015	2015/ 2016	2014/ 2015	2015/ 2016	2014/ 2015	2015/ 2016
A- Sowing methods:						
Mechanical	21.093	21.107	9.075	8.896	4.223	4.201
Manual	18.864	18.327	8.011	7.789	3.321	3.225
F. test	*	*	*	*	*	*
B- Irrigation methods:						
Surface	16.263	15.957	6.851	6.729	2.785	2.726
Drip	23.694	23.478	10.235	9.956	4.759	4.701
F. test	*	*	*	*	*	*
C- Hill spacings:						
10cm	18.759	18.697	7.896	7.953	3.472	3.446
15cm	19.607	19.705	8.589	8.378	3.647	3.691
20cm	21.569	20.750	9.143	8.697	4.197	4.002
F. test	*	*	*	*	*	*
LSD at 5%	0.914	0.875	0.238	0.269	0.204	0.180
D- Interactions (F. text):						
A × B	*	*	*	*	*	*
A × C	NS	NS	NS	NS	NS	NS
B × C	*	*	*	*	*	*
A × B × C	*	*	NS	NS	*	*

Hill spacings effect

The obtained results in Tables 2 and 3 show that studied hill spacings (10, 15 and 20cm between hills) that resulting three plant population densities of 70000, 46666 and 35000 plants/fed, respectively significantly affected yield components (root and foliage fresh and dry weights/plant and root length and diameter) and root quality parameters (sucrose and apparent juice purity percentages in roots) in both seasons. It can be easily consider that planting sugar beet seeds on one side of the ridge, 60cm width, and 20cm between hills, resulting plant population density 35000 plants/fed markedly accompanied with obvious increases and the highest values of all studied yield components and root quality parameters in both seasons. In addition, planting sugar beet seeds on one side of the ridge, 60cm width, and 15cm between hills, resulting plant population density 46666 plants/fed produced the best results after aforementioned hill spacing in both seasons. Nevertheless, the lowest values of all studied yield components and root quality parameters were resulted from planting sugar beet seeds on one side of the ridge, 60cm width, and 10cm between hills, resulting plant population density 70000 plants/fed in the two seasons. These results may be due to the facts that hill spacings allow to high amounts of sun light to pass to plants which reflect on photosynthesis process consequently root weight. It also increase the soil volume which feed plants (it decrease the competition among beet roots).

All yield characters under study *i.e.* root, top and sugar yields/fed were significantly affected due to studied hill spacings (10, 15 and 20cm between hills) in both seasons (Table 4). Planting sugar beet seeds on one side of the ridge, 60cm width, and 20cm between hills, resulting plant population density 35000 plants/fed produced the highest values of root (21.569 and 20.750t/fed), top (9.143 and 8.697t/fed) and sugar (4.197 and 4.002t/fed) yields/fed in the first and second seasons, respectively. Additionally, planting sugar beet seeds on one side of the ridge, 60cm width, and 15cm between hills, resulting plant population density 46666 plants/fed produced the best results of yields after planting on 20cm between in both seasons. On the other hand, the lowest values of yields were resulted from planting sugar beet seeds on one side of the ridge, 60cm width, and 10cm between hills, resulting plant population density 70000 plants/fed in the two seasons.

This improvement in sugar beet yields that obtained with increasing hill spacing up to 20cm may be due to increasing the amounts of light coming to individual plants. The aforementioned results generally are in good agreement with those stated by Nassar (2001), El-Bakary (2006), Bhullar *et al.* (2010), Nafei *et al.* (2010), Shalaby *et al.* (2011), Yousef and Gholamrez (2011), Abdou *et al.* (2014) and Leilah *et al.* (2017).

Interactions effect

Regarding the effect of interactions, there are many significant effect of the interactions among studied factors (sowing and irrigation methods and hill spacings) on studied characters as shown in Tables 2, 3 and 4. We reported enough the significant interactions on root and sugar yields only.

A significant effects on root and sugar yields/fed in both seasons resulted from the interaction between sowing methods and irrigation methods are presented in Table 5. Root and sugar yields/fed reached its maximum values with combination between mechanical sowing method and irrigation sugar beet plants by using drip irrigation system in both seasons. It was followed by manual sowing method and irrigation sugar beet plants by using drip irrigation system in both seasons. Meanwhile, the minimum root and sugar yields/fed values were obtained from manual sowing and irrigation sugar beet plants by using surface flooding irrigation system in both seasons.

Table 5. Root and sugar yields/fed of sugar beet as affected by the interaction between sowing and irrigation methods during 2014/2015 and 2015/2016 seasons.

Characters		Root yield (t/fed)		Sugar yield (t/fed)	
Sowing methods	Irrigation methods	2014/ 2015	2015/ 2016	2014/ 2015	2015/ 2016
Mechanical	Surface	17.019	16.770	2.950	2.889
	Drip	25.167	25.444	5.495	5.513
Manual	Surface	15.507	15.143	2.619	2.562
	Drip	22.222	21.511	4.024	3.888
F. test		*	*	*	*
LSD at 5%		1.056	0.926	0.191	0.123

Effect of the interaction between irrigation methods and hill spacings on root and sugar yields/fed was significant in both seasons, as shown in Table 6. Maximum means of root and sugar yields/fed were produced from irrigation sugar beet plants by using drip irrigation system and planting on one side of the ridge, 60cm width, and 20cm between hills, resulting plant population density 35000 plants/fed in both seasons. On the other hand, minimum ones were induced from irrigation sugar beet plants by using surface flooding irrigation system and planting on one side of the ridge, 60cm width, and 10cm between hills, resulting plant population density 70000 plants/fed in both seasons.

Table 6. Root and sugar yields/fed of sugar beet as affected by the interaction between irrigation methods and hill spacings during 2014/2015 and 2015/2016 seasons.

Characters		Root yield (t/fed)		Sugar yield (t/fed)	
Irrigation methods	Hill spacings	2014/ 2015	2015/ 2016	2014/ 2015	2015/ 2016
	10cm	15.11	15.652	2.547	2.648
Surface	15cm	16.56	15.798	2.807	2.678
	20cm	17.11	16.420	3.001	2.851
	10cm	22.40	21.742	4.397	4.244
Drip	15cm	22.65	23.612	4.487	4.704
	20cm	26.02	25.080	5.394	5.154
F. test		*	*	*	*
LSD at 5%		1.341	1.238	0.308	0.255

Data presented in Table 7 indicate that the triple interaction among sowing and irrigation methods and hill spacings had a significant effect on root and sugar yields/fed during the first and second seasons. The highest means of root and sugar yields/fed were produced under mechanical sowing, irrigation sugar beet plants by using drip irrigation system and planting on one side of the ridge, 60cm width, and 20cm between hills, resulting plant population density 35000 plants/fed in both seasons. On the other wise, the lowest ones were obtained with manual sowing, irrigation sugar beet plants by using surface flooding irrigation system and planting on one side of the ridge, 60cm width, and 10cm between hills, resulting plant population density 70000 plants/fed in both seasons.

Table 7. Root and sugar yields/fed of sugar beet as affected by the interaction among sowing and irrigation methods and hill spacings during 2014/2015 and 2015/2016 seasons.

Characters			Root yield (t/fed)		Sugar yield (t/fed)	
Sowing methods	Irrigation methods	Hill spacings	2014/ 2015	2015/ 2016	2014/ 2015	2015/ 2016
Mechanical	Surface	10cm	15.51	16.303	2.628	2.772
		15cm	17.32	16.490	2.969	2.824
		20cm	18.21	17.517	3.254	3.071
	Drip	10cm	23.81	23.150	5.130	4.946
		15cm	23.30	25.900	5.073	5.637
		20cm	28.38	27.283	6.282	5.957
Manual	Surface	10cm	14.71	15.000	2.466	2.524
		15cm	15.80	15.107	2.645	2.533
		20cm	16.00	15.323	2.747	2.630
	Drip	10cm	20.99	20.333	3.664	3.543
		15cm	22.00	21.323	3.901	3.771
		20cm	23.67	22.877	4.506	4.351
F. test			*	*	*	*
LSD at 5%			2.027	1.750	0.448	0.361

Conclusion

From the obtained data in this study, it can be concluded that sowing sugar beet using mechanical sowing method (planter machine), irrigation by using drip irrigation system and planting on one side of the ridge, 60cm width, and 20cm between hills, resulting plant population density 35000 plants/fed in order to maximizing its productivity and quality under the environmental conditions of sandy soil in Kalabsho region, Dakahlia Governorate, Egypt.

References

Abd-El-Kader EMAM. 2005. Effect of some Agricultural practices on sugar beet tolerance to salinity. M.Sc. Thesis in Agron Fac. of Agric. Al-Azhar Univ.

Abdou MA, Dalia IH, El-Geddawy, Elwan AM. 2014. Productivity and quality of sugar beet as affected by plant distribution pattern and nitrogen fertilizer level. J. Plant Production, Mansoura Univ **5(12),** 2155- 2167.

Awad NMM. 2000. Effect of mechanical planting on production of sugar beet yield. Ph. D. thesis, Fac. of Agric Kafr EI- Sheikh Tanta Univ.

Bhullar MS, Uppal SK, Kapur ML. 2010. Influence of planting density and nitrogen does on root and sugar yield of beet (*Beta vulgaris* L.) under sub-tropical semiarid conditions of Punjab. J. of Res., Punjab Agric. Univ **47 (1/2),** 14-17.

Carruthers A, OldField JFT. 1960. Methods for the assessment of beet quality. Int. Sugar J **63,** 72-74.

Cassel-Sharmasarkar F, Sharmasarkar S, Miller SD, Vance GF, Zhang R. 2001. Assessment of drip and flood irrigation on water and fertilizer use efficiencies for sugar beets. Agric. Water Man **46(3),** 241-251.

El-Bakary HMY. 2006. Studies on yield and quality parameters of some sugar beet varieties. M. Sc. Thesis, Fac. of Agric., Al-Azhar Univ.

El-Darder AMA, Gamaa MA, Sayed MA, Kamel MZ. 2017. Water stress effects on yield and quality of sugar beet crop in sandy soils. Alexandria Sci. Exch. J **38(4),** 828-836.

El-Geddawy IH, Kheiralla KA, Darweish YYI, Sharaf EA. 2008. Agricultural practices in relation to yield and quality of sugar beet: Yield and yield components. Special Issue: Sugar Crops & Integrated Industries in Egypt, Sugar Tech **10(3),** 227-233.

El-Maghraby, Samia S, Gomaa MA, Rehab IF, Hala Hassan MS. 2008. Response of sugar beet to some mechanical management practices, irrigation and plant densities. Sugar Tech **10(3),** 219-226.

Gomez KN, Gomez AA. 1984. Statistical procedures for agricultural research. John Wiley and Sons, New York, 2nd ed 68 P.

Hassanli AM, Ahmadirad S, Beecham S. 2010. Evaluation of the influence of irrigation methods and water quality on sugar beet yield and water use efficiency. Agric. Water Man **97,** 357-362.

Leilah AA, Abdel-Moneam MA, Shalaby GA, Abdou MAE, Heba M, AbdEl-Salam. 2017. Effect of plant population and distribution and nitrogen levels on yield and quality of sugar beet. J. Plant Production, Mansoura Univ **8(5),** 591-597.

Masri MI, Ramadan BSB, El-Shafai AMA, El-Kady MS. 2015. Effect of water stress and fertilization on yield and quality of sugar beet under drip and sprinkler irrigation systems in sandy soil. Intern. J. of Agric. Sci **5(3),** 414-425.

Morad MM, Elsaid GH, El-Sharabasy MMA, Abd-Elgawad FA. 2007. Comparative study between manual and mechanical methods of harvesting sugar beet crop. Misr J. Ag. Eng **24(4),** 793-813.

Nafei AI, Osman AMH, Maha El-Zeny M. 2010. Effect of plant densities and potassium fertilization rates on yield and quality of sugar beet crop in sandy reclaimed soils. J. of plant production. Mansoura Univ **1(2),** 229- 237.

Nassar AM. 2001. Effect of plant density on the productivity of some sugar beet varieties. J Agric Sci. Mansoura Univ., **26(12),** 7533-7546.

Nemeat-Alla EAE, Abou Shady KA, Youssef NO. 2007. Sugar beet yield and quality as affected by cultivating patterns and nitrogen levels. J. Agric. Sci. Mansoura Univ **32(10),** 8069-8078.

Ozbay S, Yildirm M. 2018. Root yield and quality of sugar beet under drip and sprinkler irrigation with foliar application of micronutrients. Comu. Zir. Fak. Derg. (Comu. J. Agric. Fac.) **6(1),** 105-114.

Ragab AY, Sahar Rashed H. 2016. Sugar beet yield and quality as affected by water regime before harvest, density and some cultivars in new reclaimed soils. J. of Adv. in Agric **6(1),** 853-862.

Sakellariou-Makrantonaki M, Kalfountzos D, Vyrlas P. 2002. Water saving and yield increase of sugar beet with subsurface drip irrigation. Global Nest: Int. J **4(2-3),** 85-91.

Sarauskis E, Godlinski F, Sakalauskas A, Schlegel M, Kanswohl N, Romaneckas K, Jasinskas A, Pilipavicius V. 2010. Effects of soil tillage and sowing systems on sugar beet production under the climatic conditions of Lithuania. Landbauforschung lkenrode **60(2),** 101-110.

Seadh SE, Attia AN, Said EM, Samia S El-Maghraby, Ibrahim MEM. 2013. Productivity and quality of sugar beet as affecting by sowing methods, weed control treatments and nitrogen fertilizer levels. Pakistan. J. of Biol. Sci **16(15),** 711-719.

Shalaby NME, Osman AMH, El-Labbody AHSA. 2011. Relative performance of some sugar beet varieties under three plant densities in newly reclaimed soil. Egypt, J. Agric., Res **89(1),** 2011-2019.

Sharmasarkar C, Sharmasarkar S, Miller SD, Vance GF, Zhang R. 2001. Assessment of drip and flood irrigation on water and fertilizer use efficiencies for sugar beets. Agric. Water Man **46,** 241-251.

Snedecor GW, Cochran WG. 1980. Statistical Methods. 7th ed. Iowa State Univ. Press, Iowa, USA.

Yonts CD. 2006. Sugar beet response to irrigation method and polymer placed in the seed furrow. J. of Sugar Beet Res **43(4),** 155-166.

Yousef S, Heidri G. 2011. Influence of withholding irrigation and harvest time on yield and quality of sugar beet (*Beta vulgaris* L.). Intern. J. of Agric., Bio **12,** 1814- 9596.

Zahoor A, Paigham S, Kakar KM, Sanaullah B, El-Sharkawi H, Honna T, Yamamoto S. 2007. Sugar beet (*Beta vulgaris* L.) response to different sowing methods and row geometries. I- Effect on plant growth and yield. Archives of Agron. and Soil Sci **53(1),** 49-61.