Impact of sowing dates and planting densities on yield and quality of sugar beet

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Abstract

Sugar beet (*Beta vulgaris* L.) is the second source of sugar all over the world. A field experiment was carried out during the 2019/2020 and 2020/2021 growing seasons to study the performance of two sugar beet varieties under three planting densities and three planting dates. Planting densities, planting dates and varieties as well as their interactions exhibited significant effects on all studied traits including, root length and diameter, root and top yields, sucrose content, impurities%, quality index (Qz), recoverable sugar (RS)%, and recoverable sugar yield (RSY). The highest root length and diameter from planting sugar beet at a density of 28,000 plants/feddan (Feddan = 4200 m2) in both growing seasons. Meanwhile, the highest values of the remaining studied traits were produced from cultivating sugar beet at 42,000 plants/ feddan Superiority in all studied traits was scored to the September 25th planting date. The variety Hercules surpassed the Husam variety in all the measured desirable traits in both growing seasons. Moreover, the variety Hercules produced the highest values of root and top yields, sucrose content, impurities%, quality index (Qz), recoverable sugar (RS)% and recoverable sugar yield (RSY) when planted at a planting density of 42,000 plants/ feddan on September 25th in both growing seasons.

Keywords: Sugar beet; Planting densities; Sowing date; Sugar beet varieties; Sugar yield**.**

Introduction

Sugar beet (Beta vulgaris L.) is the most important sugar crop that can be grown commercially in a wide variety of temperate regions. Beet sugar production in the tropical and subtropical regions, including Egypt, is growing as an important component of sugar industry (Abou-Elwafa et al. 2020; Alotaibi et al. 2021). Sugar beet, producing annually about 40% of the global sugar production, ranked the second important sugar crop after sugar cane, and have readily adaptable to different environmental conditions (Abo-Elwafa et al. 2013). In Egypt, there is a gap between sugar production and consumption due to steady increases in the population (2.5% annually) as well as the increase in sugar consumption. Increasing sugar beet cultivated area and sugar production per unit area is considered the important national target to minimize the gap between sugar production and consumption. Moreover, cultivation of sugar beet in developing countries could be a profitable for farmers by diversification of their incomes by enabling them to grow an additional cash crop, supply sugar factories with additional raw material to the sugar cane that will extend the crashing period (Abou-Elwafa et al. 2020; Balakrishnan and Selvakumar 2009; Mandere et al. 2010 .(

The importance of this crop is not only from its ability to grow in a wide range of soils (saline, alkaline, and calcareous soils) but also sugar beet plants could be successfully cultivated in the newly reclaimed soils without competition with other traditional winter crops due to its tolerance to salinity and the ability to produce high root and sugar yields under stressed conditions and its low water requirement compared to sugarcane (Aljabri et al. 2021; Abofard et al. 2021; Abdel-Motagally and Attia 2009; Nadali et al. 2010). It is known that a sugar beet variety is valuable for sugar production when it is well adapted to the prevailing environmental conditions and reacts properly to agronomical practices (Fabeiro et al. 2003; Romaneckas et al. 2009). In Egypt, the total cultivated area of sugar beet reached about 651.23 feddan with a total sugar beet roots production of 13.04ton. Most of these areas are cultivated at Dakahlia and Kafer El-Sheikh Governorates (FAO 2020). The composition of sugar beet is mainly affected by agronomical practices such as fertilizers application, varieties, sowing dates, and plant population (Sogut and Arioglu 2004). Sowing date, planting density, and harvest date are important factors affecting root yield and quality of sugar beet (ÇAKMAKÇI et al. 2002; Gobarah et al. 2019; Kumar et al. 2019).

Therefore, the current study was conducted to study the effect of planting dates and planting density on the performance of two sugar beet varieties in terms of growth, yield and quality .

Materials and Methods

Plant material and experiments

A field experiment was carried out during the 2019/2020 and 2020/2021 growing seasons at El Damaird, Bilqas, El Dakahlia Governorate to study the effect of three planting densities, i.e., 42,000 (sowing at 60 cm between rows and 15 cm between plants in the row), 34,000 (sowing at 60 cm between rows and 20 cm between plants in the row), and 28,000 plants /fed (sowing at 60 cm between rows and 25 cm between plants in the row) and three planting dates on August 25th , September 25th and October 25th on the yield and quality of two sugar beet varieties designated as Husam and Hercules. The experimental design was a split-split plot design with three replications. Planting densities were allocated to the main plots, planting dates ro the sub-plots and sugar beet varieties to the sub sub-plots. Recommended rates of N, P and K and all other cultural practices were performed according to locally recommended practices for sugar beet production. In brief, single super phosphate (15.5% P_2O_5) at a rate of 200 kg/fed. was applied during soil bed preparation. Nitrogen was applied in the form of urea (46.5% N) at a rate of 90 kg/fed. in two equal doses, i.e., the first one after thinning with the second irrigation, and the second one applied with the third irrigation. Potassium sulfate (50% K_2O) at a rate of 50 kg K_2O/fed. was added with the first irrigation. Furrow irrigation was applied. The same treatments were applied to the same plots in both growing seasons.

Analysis of physical and chemical properties of the experimental soil

For analysis of the physical and chemical properties of the soil after harvest, composite represented soil samples were collected from the surface layer (0 - 30 cm) of the experimental soil before sowing. Soil samples were air-dried, ground and sieved using 2 mm sieves. The soil pH was measured in a 1:2.5 of soil to deionized water suspension using a glass electrode (Jackson 1973). The electrical conductivity (EC) of the soil was determined in a 1:2.5 of soil to water extract using the EC meter (Hesse 1998). Available soil nitrogen was extracted using 2 M potassium chloride and then nitrogen in the extract was measured using micro-kjeldahl method (Burt 2004). Available phosphorus in the soil was extracted using 0.5 M sodium bicarbonate solution at pH 8.5 (Olsen 1954) and phosphorus was determined using the spectrophotometer set at a wavelength of 550 nm. The ammonium acetate procedure at pH 7.0

was implemented to extract the extractable potassium. Potassium was then measured using flame photometry (Jackson 1973). The organic matter (OM) in the soil was measured using the Walkley–Black method (Jackson 1973). The physical and chemical properties in Central Laboratory, Faculty of Agriculture, Assiut University, Egypt of the experimental field soil in the two growing seasons are presented in Table 1.

Table 1. Physical and chemical properties of the experimental soil at the depth of 30 cm in 2019/2020 and 2020/2021 growing seasons.

	2019/2020	2020/2021
Texture analysis		
Sand (%)	22.20	22.00
Silt (%)	39.30	40.10
Clay (%)	38.50	37.90
Texture grade	Clay loam	Clay loam
Chemical properties		
Soil (pH)	7.95	7.75
EC (ds/m)	1.33	1.30
Organic Matter (%)	1.40	1.44
N (mg/kg)	167.0	171.0
P(mg/kg)	0.34	0.35
K(mg/kg)	292.0	303.0
Fe(mg/kg)	6.38	6.10
Zn(mg/kg)	1.00	1.20
Mn(mg/kg)	7.69	7.15
Cu (mg/kg)	4.10	4.80
Soluble cations concentration (meq/L)		
CL	7.22	6.82
HCO3-	0.50	0.50
SO4-	5.20	4.70
Co3	0.00	0.00
Soluble cations concentration (meq/L)		
Na+	4.40	4.35
K+	1.10	0.80
Ca2+	4.00	3.60
Mg2+	3.50	3.30

valuation of studied traits

Harvest was carried out 180 days after sowing. A sample of ten plants were randomly selected from the inner ridges of each sub-plot to estimate yield components traits, i.e., Root length and diameter (cm). Root and top yields were determined from the central area of each plot (the central 3 rows). A representative root sample from each plot was collected for quality analysis by measuring sucrose% Na%, K%, α-amino-N and quality index (Qz)% using the venma, Automation BV AnalyzerIIG-16-12-99, 9716JP/ Groningen/Holland according to the procedure used by Dakahlia Sugar Company, as described by le-Docte (1927) and Brown and Lilliland (1964). The results were calculated as mmol /100 g beet. Impurities% and recoverable sugar (RS) % were calculated using the following equations according to Reinefeld et al. (1975):

Impurities% =0.29-0.343(K+Na)-0.094(α-amino N)

Recoverable sugar% =Pol-0.29-0.343(k +Na)-0.094(α-amino N)

Statistical analysis

Data obtained from each growing season of the study were statistically analyzed according to the procedures outlined by Gomez and Gomez (1984) using the M-STAT-C computer program (Freed et al. 1989; MSTAT-C 1991). The differences among statistically different means were compared using the least significant difference (LSD) at 0.05 level of probability.

Effect of planting densities, planting dates and varieties on plant growth parameters
Results and Discussion

Planting densities and planting dates exhibited significant differences in root length and diameter in both growing seasons (Table 2). Planting sugar beet at a density of 28,000 plants/fed. resulted in the highest root length (18.17 and 18.57 cm) and diameter (11.58 and 11.03 cm) in the first and second growing seasons, respectively (Table 2). This could be attributed to the larger sowing distances which was in favor of enhancing plant growth and development. Meanwhile, the highest planting density of 42,000 plants/fed. produced the lowest root length (23.52 and 24.50 cm) and diameter (7.05 and 7.23 cm) in the first and second growing seasons, respectively. Planting sugar beet on September 25th produced the highest root length (22.94 and 23.91 cm) and diameter (10.43 and10.90 cm) in the first and second growing seasons, respectively. In contrary to that, the latest planting date on October 25th resulted in the lowest values of root length (18.04 and 18.78 cm) and diameter (6.89 and 7.16 cm) in the first and second growing seasons, respectively. These findings could be ascribed to that the favorable environmental conditions during September that promoted plant growth. Significant differences between the two varieties were observed in root length and diameter in the two growing seasons, with superiority was scored to the Hercules variety in both traits. These varietal differences could be due to the genetic makeup of the two different varieties. The interactions between planting densities, planting dates and varieties showed significant differences in root length and diameter in the two growing seasons. The highest root length (24.16 and 27.36, and 25.76 and 25.86 cm) and diameter (11.96 and 13.51, and 12.74 and 12.80 cm) values, in the first and second growing seasons respectively, were produced from planting sugar beet on September 25th at a planting density of 28,000 plants/fed (Table 2). The variety Hercules was superior in root length and diameter when planted on September 25th at a planting density of 28,000 plants/fed. in both growing seasons.

Table 2. Root length and diameter of two sugar beet varieties as affected by planting densities and planting dates in the 2019/2020 and 2020/2021 growing seasons. Plant densities,

Plant densities	Sowing date	Root length (cm)						Root diameter (cm)					
		2019/2020			2020/2021			2019/2020			2020/2021		
		Husam	Hercules	Mean	Husam	Hercules	Mean	Husam	Herculs	Mean	Husam	Hercules	Mean
42000	25 Aug.	18.29	19.48	18.89	18.65	19.92	19.29	6.40	7.50	6.95	6.53	7.66	7.10
	25 Sept.	18.75	21.22	19.99	19.03	21.56	20.30	7.87	9.33	8.60	7.99	9.54	8.77
	25 Oct.	14.89	16.38	15.64	15.23	17.03	16.13	5.08	6.09	5.58	5.19	6.34	5.76
Mean		17.31	19.03	18.17	17.64	19.50	18.57	6.45	7.64	7.05	6.57	7.85	7.21
34000	25 Aug.	21.27	22.32	21.80	22.11	23.65	22.88	7.55	8.89	8.22	7.84	9.42	8.63
	25 Sept.	21.81	24.31	23.06	22.34	25.96	24.15	9.16	10.71	9.93	9.38	11.46	10.42
	25 Oct.	17.31	18.77	18.04	18.63	19.65	19.14	5.99	7.23	6.61	6.42	7.54	6.98
Mean		20.13	21.80	20.97	21.03	23.09	22.06	7.56	8.94	8.25	7.88	9.47	8.68
28000	25 Aug.	23.56	25.12	24.34	24.08	26.31	25.20	9.86	11.22	10.54	10.08	11.65	10.87
	25 Sept.	24.16	27.36	25.76	25.86	28.67	27.27	11.96	13.51	12.74	12.80	14.18	13.49
	25 Oct.	19.76	21.13	20.45	20.35	21.75	21.05	7.82	9.13	8.47	8.06	9.38	8.72
Mean		22.49	24.54	23.52	23.43	25.58	24.50	9.88	11.29	10.58	10.31	11.74	11.03
Overall mean of densities	25 Aug.	21.04	22.31	21.68	21.61	23.29	22.45	7.93	9.20	8.57	8.15	9.58	8.86
	25 Sept.	21.58	24.30	22.94	22.41	25.40	23.91	9.66	11.19	10.43	10.06	11.73	10.90
	25 Oct.	17.32	18.76	18.04	18.07	19.48	18.87	6.29	7.48	6.89	6.56	7.75	7.16
Mean all varieties		19.98	21.79		20.70	22.72		7.96	9.29		8.25	9.69	
L.S.D 0.05	A=0.95	B=1.35	AB= 1.75	C=**	A=1.12 B=1.46 C=** AB=1.75			A=0.76 B=1.12 C=** AB=1.37			A=0.82 B=1.24 C=* AB=1.41		
	AC=1.62	BC= 1.62	ABC=1. 76		AC=1.35 BC=1.35 ABC=1.82			1.08 1.08 1.43			1.23 1.23 1.50		

*** significant and highly significant, respectively. NS = Not significant**

A= Plant densities, B= Sowing date, C= varieties.

Effect of planting densities, planting dates and varieties on root and top yields.

Planting densities and planting dates revealed significant effects on root length and diameter in both growing seasons (Table 3). Sowing sugar beet plants at 34,000 plants/fed. planting density produced in the highest top (7.49 and 7.54 ton/fed.) and root (33.71 and 33.97 ton/fed.) yields in the first and second growing seasons, respectively (Table 3). This could be attributed to the relatively higher root lengths and diameters in combination with high number of plants achieved from this planting density. Meanwhile, the lowest top and root yields in the two growing seasons were produced from planting sugar beet at a low planting density of 28,000 plants/fed. The highest top (8.57 and 8.62 ton/fed.) and root (33.59 and 33.79 ton/fed.) yields, in the first and second growing seasons respectively, were produced from sowing sugar beet on September 25th (Table 3). This could be due to the relatively higher root length and diameter in combination with high number of plants achieved under this planting date. Meanwhile, the latest planting date on October 25th produced the lowest top and root yields in both growing seasons. Significant differences between the two varieties were observed in top and root yields in the two growing seasons, with superiority in both traits was recorded to the Hercules variety. These varietal variations could be due to the genetic makeup of the two different varieties which was in favor of enhancing the growth and development of the Hercules variety plants.

The interactions between planting densities, planting dates and varieties revealed significant differences in top and root yields in the two growing seasons. The highest top (8.89 and 8.93 ton/fed.) and root (36.30 and 36.50 ton/fed.) yields, in the first and second growing seasons respectively, were produced from planting sugar beet on September 25th at a planting density of 34,000 plants/fed. (Table 3; Figure 1 and 2). The variety Hercules was superior in top and root yields when sown on September 25th at a planting density of 34,000 plants/fed. in both growing seasons.

Table 3. Root and top yields of two sugar beet varieties as affected by planting densities and planting dates in the 2019/2020 and 2020/2021 growing seasons.

Plant densities	Sowing date	Root yield (ton/fed.)						Top yield (ton/fed.)					
		2019/2020			2020/2021			2019/2020			2020/2021		
		Husam	Hercules	Mean	Husam	Hercules	Mean	Husam	Hercules	Mean	Husam	Hercules	Mean
42000	25 Aug.	28.63	33.81	**31.22**	28.82	33.97	**31.40**	5.93	8.36	**7.14**	5.97	8.40	**7.18**
	25 Sept.	31.59	35.75	**33.67**	31.98	35.96	**33.97**	7.03	9.91	**8.47**	7.12	9.96	**8.54**
	25 Oct.	26.50	30.16	**28.33**	26.66	30.38	**28.52**	5.43	7.51	**6.47**	5.46	7.57	**6.51**
Mean		**28.91**	**33.24**	31.07	**29.15**	**33.44**	31.30	**6.13**	**8.59**	7.36	**6.18**	**8.64**	7.41
34000	25 Aug.	32.91	35.52	**34.22**	33.10	35.81	**34.46**	6.75	7.31	**7.03**	6.79	7.37	**7.083**
	25 Sept.	34.86	37.74	**36.30**	35.12	37.87	**36.50**	8.61	9.16	**8.88**	8.67	9.19	**8.93**
	25 Oct.	29.06	32.16	**30.61**	29.58	32.32	**30.95**	6.01	7.10	**6.56**	6.07	7.13	**6.60**
Mean		**32.28**	**35.14**	33.71	**32.60**	**35.33**	33.97	**7.12**	**7.85**	7.49	**7.18**	**7.90**	7.54
28000	25 Aug.	28.65	30.14	**29.40**	28.82	30.25	**29.54**	6.83	7.63	**7.23**	6.87	7.66	**7.26**
	25 Sept.	29.43	32.16	**30.80**	29.58	32.23	**30.91**	7.41	9.28	**8.35**	7.45	9.30	**8.38**
	25 Oct.	26.76	28.86	**27.81**	26.89	29.06	**27.98**	6.09	6.54	**6.31**	6.12	6.58	**6.35**
Mean		**28.28**	**30.39**	29.33	**28.43**	**30.51**	29.47	**6.78**	**7.82**	**7.30**	**6.81**	**7.85**	7.33
Overall mean of densities	25 Aug.	**30.06**	**33.16**	**31.61**	**30.25**	**33.34**	**31.80**	**6.50**	**7.77**	**7.13**	**6.54**	**7.81**	**7.18**
	25 Sept.	**31.96**	**35.22**	**33.59**	**32.23**	**35.35**	**33.79**	**7.68**	**9.45**	**8.57**	**7.74**	**9.48**	**8.61**
	25 Oct.	**27.44**	**30.39**	**28.92**	**27.63**	**30.59**	**29.11**	**5.84**	**7.05**	**6.45**	**5.88**	**7.09**	**6.49**
Mean all varieties		**6.68**	**8.09**		**6.72**	**8.13**		**29.82**	**8.09**		**6.72**	**8.13**	
L.S.D 0.05	A=0.11	B=0.06	AB=0.09	C=**	A=**0.07** B= **0.07** C=** AB=**0.11**			A=**1.12** B=**1.28** C=** AB=**0.96**			A= **1.37** B=**1.43** C=** AB=**1.12**		
	AC=**0.08** BC=**0.08**				**0.09** **0.09**			**0.91** **0.91**			**1.14** **1.14**		

***, ** significant and highly significant, respectively. NS = Not significant**

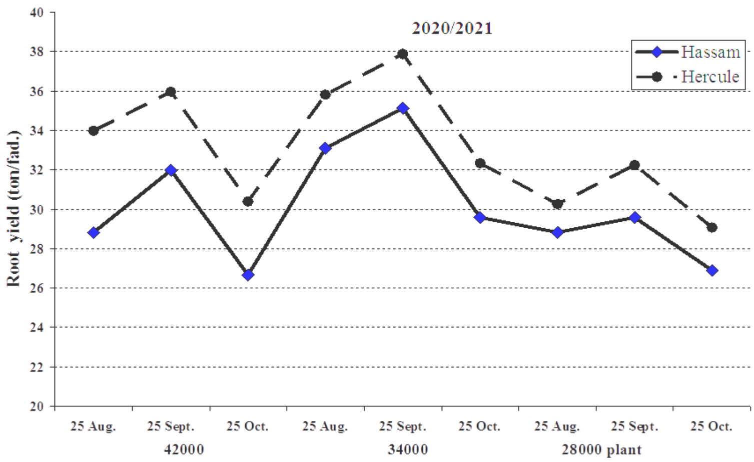

Figure 1. Root yield of the two sugar beet varieties as affected by planting densities and planting dates in the 2019/2020 growing season...

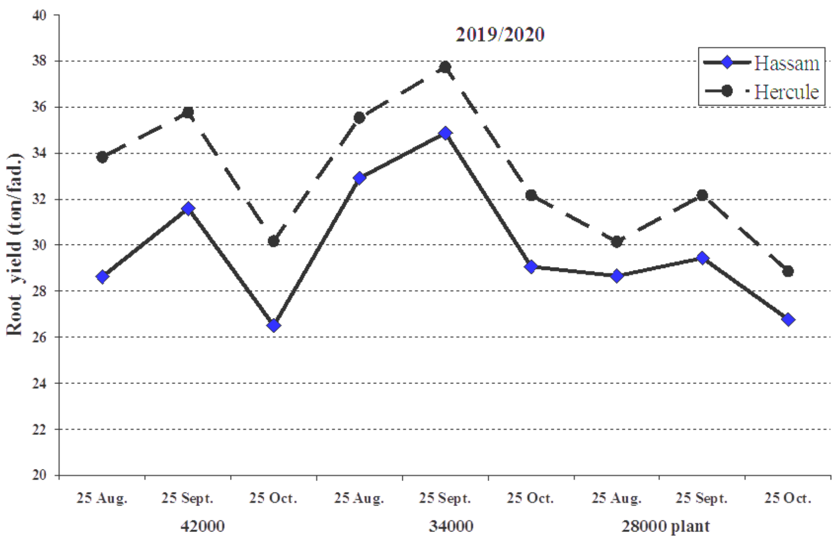

Figure 2. Root yield of the two sugar beet varieties as affected by planting densities and planting dates in the 2020/2021.

Table 4. Sucrose content and recoverable sugar% of two sugar beet varieties as affected by planting densities and planting dates in the 2019/2020 and 2020/2021 growing seasons. Plant densities.

Plant densities	Sowing date	Sucrose (%)						Recoverable sugar (%)					
		2019/2020			2020/2021			2019/2020			2020/2021		
		Husam	Hercules	Mean	Husam	Hercules	Mean	Husam	Hercules	Mean	Husam	Hercules	Mean
42000	25 Aug.	14.37	15.11	14.74	14.43	15.18	14.81	11.08	11.66	11.37	11.71	11.99	11.85
	25 Sept.	15.11	15.73	15.42	15.30	15.79	15.55	10.48	10.72	10.60	11.11	11.70	11.41
	25 Oct.	13.87	14.34	14.11	13.90	14.40	14.15	11.04	11.45	11.25	10.47	10.74	10.61
Mean		14.45	15.06	14.76	14.54	15.12	14.83	10.87	11.28	11.07	11.09	11.48	11.29
34000	25 Aug.	13.76	14.11	13.94	13.82	14.18	14.00	10.62	10.74	10.68	10.72	11.12	10.92
	25 Sept.	14.06	14.62	14.34	14.11	14.71	14.41	9.80	10.39	10.10	10.64	10.76	10.70
	25 Oct.	13.09	13.83	13.46	13.16	13.91	13.54	10.38	10.73	10.55	9.84	10.43	10.14
Mean		13.64	14.19	13.91	13.70	14.27	13.98	10.27	10.62	10.44	10.40	10.77	10.59
28000	25 Aug.	13.53	13.87	13.70	13.66	13.94	13.80	10.49	10.67	10.58	10.72	10.85	10.79
	25 Sept.	13.96	14.26	14.11	14.01	14.32	14.17	9.80	9.89	9.84	10.58	10.70	10.64
	25 Oct.	12.96	13.23	13.10	13.07	13.33	13.20	10.33	10.46	10.40	9.87	9.95	9.91
Mean		13.48	13.79	13.64	13.58	13.86	13.72	10.20	10.34	10.27	10.39	10.50	10.45
Overall mean of densities	25 Aug.	13.89	14.36	14.13	13.97	14.43	14.20	10.73	11.02	10.88	11.05	11.32	11.19
	25 Sept.	14.38	14.87	14.63	14.47	14.94	14.71	10.03	10.34	10.19	10.78	11.05	10.92
	25 Oct.	13.31	13.80	13.56	13.38	13.88	13.63	10.58	10.88	10.73	10.06	10.38	10.22
Mean all varieties		13.86	14.34		13.94	14.42		10.45	10.75		10.63	10.92	
L.S.D 0.05	A=0.02	B= 0.03	AB= 0.04	C=**	A=0.02 B=0.03 C= ** AB=0.04		A=0.03 B=0.04 C= ** AB=0.06				A=0.03 B=0.05 C= ** AB=0.07		
	AC=0.03 BC=0.03 ABC=0.05				0.04 0.04 0.06		0.05 0.05 0.07				0.06 0.06 0.08		

*, ** significant and highly significant, respectively. NS = Not significant.

Effect of planting densities, planting dates and varieties on sucrose content and recoverable sugar (RS)%

Planting densities and planting dates revealed significant effects on sucrose content and recoverable sugar (RS)% in both growing seasons (Table 4). Sowing sugar beet plants at a higher planting density of 42,000 plants/fed. produced the highest sucrose content (14.76 and 14.83%) and recoverable sugar (RS)% (11.07 and 11.29%) in the first and second growing seasons, respectively (Table 4). Meanwhile, the lowest sucrose% and RS% in the two growing seasons were produced from planting sugar beet at a low planting density of 28,000 plants/fed. These results could be due to the dilution effect as sugar percentage is reduced in response to increasing root weight **(Aljabri et al. 2021).** Cultivating sugar beet on September 25th resulted in the highest sucrose% and RS% (14.63 and 14.71%) and (10.19 and 10.92%) in the first and second growing seasons, respectively (Table 3). This could be due to that the prevailing environmental conditions under this planting date was in favor of partitioning more photo assimilates towards the storage roots (Alotaibi et al. 2021). Meanwhile, the lowest sucrose and RS percentages were produced from delaying sugar beet planting to October 25th produced. Significant differences between the two varieties were observed in sucrose% and RS% in the two growing seasons, with superiority in both traits was recorded to the Hercules variety, which might be due to the genetic variations between the two varieties which was in favor of promoting more sucrose storage in the roots of the Hercules variety plants.

Table 5. Quality index (Qz) and Impurities of two sugar beet varieties as affected by planting densities and planting dates in the 2019/2020 and 2020/2021growing seasons.

Plant densities	Sowing date					Quality index (Qz%)				Impurities (%)			
						2019/2020				2020/2021			
		Husam	Hercules	Hercules	Mean	Husam	Hercules	Mean	Husam	Hercules	Mean		
42000	25 Aug.	76.48	76.14	76.31	76.51	75.96	76.24	3.29	3.45	3.37	3.59	3.80	3.70
	25Sept.	77.13	77.19	76.96	77.04	77.00	3.39	3.62	3.50	3.32	3.48	3.40	
	25 Oct.	75.53	74.78	75.31	74.60	74.96	3.41	3.61	3.51	3.43	3.66	3.54	
Mean	76.38	76.04	76.21	76.26	75.87	76.06	3.36	3.56	3.46	3.45	3.65	3.55	
34000	25 Aug.	76.16	75.71	75.94	75.98	75.58	75.78	3.14	3.37	3.26	3.39	3.59	3.49
	25Sept.	77.17	76.08	77.01	75.92	76.47	3.29	3.44	3.37	3.18	3.42	3.30	
	25 Oct.	74.89	75.15	74.75	75.01	74.88	3.26	3.45	3.36	3.32	3.48	3.40	
Mean	76.07	75.65	75.86	75.91	75.50	75.71	3.23	3.42	3.33	3.30	3.49	3.40	
28000	25 Aug.	76.69	75.97	76.33	76.51	75.80	76.16	3.04	3.20	3.12	3.29	3.47	3.38
	25Sept.	77.51	76.93	77.48	76.78	77.13	3.16	3.34	3.25	3.08	3.24	3.16	
	25 Oct.	75.59	74.75	75.53	74.66	75.10	3.15	3.32	3.24	3.20	3.38	3.29	
Mean	76.60	75.88	76.24	76.51	75.75	76.13	3.12	3.29	3.21	3.19	3.36	3.27	
Overall mean of densitie s	25 Aug.	76.44	75.94	76.17	76.33	75.78	76.04	3.16	3.34	3.25	3.43	3.62	3.53
	25Sept.	77.27	76.73	77.15	76.58	76.83	3.28	3.46	3.37	3.19	3.38	3.29	
	25 Oct.	75.34	74.89	75.20	74.76	74.96	3.27	3.46	3.36	3.32	3.50	3.41	
Mean all varieties	76.35	75.86		75.71	3.24	3.42	3.31	3.50					
L.S.D 0.05	A=–			C= *	A=-- B=0.70 C= * AB=0.70 AC=-- BC=0.67 ABC=--	A=0.09 B=12 0.C=* AB=0.14 AC=0.13 BC=0.13 ABC=0.17	A=0.11 B=15 0.C=* AB=17 0.AC=0.14 BC=0.14 ABC=0.19						

*, ** significant and highly significant, respectively. -- NS = Not significant.

Effect of planting densities, planting dates and varieties on juice impurities and quality index (Qz).

The planting dates showed significant effects on the quality index (Qz%) in the two growing seasons (Table 5). While the lowest quality index (Qz%) was 75.02 and 74.88% in the two growing seasons of sugar beet cultivation with a low planting density of 34,000 plants/fed at the planting date of October 25th. These results may be due to a thinning effect as the quality index (Qz%) is reduced in response to the increased rootweight (Alotaibi et al. 2021). Sugar beet cultivation on September 25th resulted in the highest quality index (Qz%) 77.22 and 77.13% in the first and second planting seasons, respectively (Table 5). This may be because the environmental conditions prevailing under this cultivation history favored dividing more replicas towards storage roots **(Alotaibi et al. 2021).** Whereas, the lowest quality index (Qz%) was produced as a result of delaying sugar beet cultivation until October 25th. Significant differences were observed between the two cultivars in the quality index (Qz%) in the two growing seasons, with both cultivars having superiority over Husam, which may be due to genetic differences between the two cultivars and which was in favor of encouraging more storage with quality index (Qz%) In the roots of plants of the Husam group. The highest-quality index Qz 77.27 and 77.15% were produced in the first and second planting seasons, respectively, of sugar beet cultivation on September 25th at a planting density of 28000. plants/fed . Planting densities and planting dates showed significant effects on the percentage of impurities in the two growing seasons (Table 5). Cultivation of sugar beet plants with a higher planting density of 42,000 plants/acre. It produced the highest impurities of 3.46 and 3.55% in the first and second growing seasons, respectively (Table 5). While the lowest indicator of the percentage of impurities (%) was recorded in the two growing seasons of sugar beet cultivation with a low planting density of 28.000 plants / feddan. These results may be due to the effect of thinning where the percentage of inclusions is reduced in response to the increase in root weight (Aljabri et al. 2021). Sugar beet cultivation on August 25th resulted in the highest percentage of impurities (%) (3.43 and 3.53%) in the first and second growing seasons, respectively (Table 5). This may be because the environmental conditions prevailing under this cultivation history

favored dividing more replicas towards storage roots (Alotaibi et al. 2021). While the lowest levels of impurities (%) were produced a result of delaying the cultivation of sugar beet until October 25th. Significant differences were observed between the two cultivars in the
percentage of impurities (%) in the two growing seasons, with superiority in differences were observed between the two cultivars in both cultivars over the Hercules cultivar, which may be due to genetic differences between the two cultivars, which was in favor of encouraging more storage by impurities in the roots of the plants of the Hercules group The interactions between planting densities, planting dates, and cultivars showed significant differences in the percentage of impurities (%) in the two growing seasons. The highest percentage of impurities (3.51% and 3.54%) were produced in the first and second growing seasons, respectively, of sugar beet cultivation on October 25th, with a planting density of 42000. plants/fed. (Table 5). Moreover, Hercules cultivar had the highest percentage of impurities by 3.61 and 3.66 % when it was planted on October 25th at a planting density of 42000 plants/fed. in both growing seasons.

Effect of planting densities, planting dates and varieties on recoverable sugar yield (RSY)

Planting densities and planting dates exhibited significant effects on recoverable sugar yield (RSY) in both growing seasons (Table 6). The highest recoverable sugar yield (3.82 and 3.85 ton/fed.), in the first and second growing seasons respectively, resulted from cultivating sugar beet plants at a higher planting density of 42,000 plants/fed. Meanwhile, the lowest RSY of 3.18 and 3.21 ton/fed. in the first and second growing seasons, respectively, were produced from the lowest planting density of 28,0000 plants/fed. These results could be due to the higher root yield in combination with the high recoverable sugar percentage obtained from the high planting density (PD1) compared to the low planting density (PD3). Moreover, planting sugar beet plants on September 25th produced the highest values of RSY (4.92 and 4.97 ton/fed.) in the first and second growing seasons, respectively (Table 6). This could be ascribed to the high root yield and recoverable sugar% achieved under this planting date. Meanwhile, the lowest RSY was produced from the latest planting date on October 25th in both growing seasons. Varieties exhibited significant differences in RSY, with superiority was scored to the Hercules variety (4.73 and 4.78 ton/fed.) in both growing seasons.

These varietal variations The interactions between planting densities planting dates and varieties exhibited significant differences in RSY in the two growing seasons. The highest RSY (3.97 and 4.02 ton/fed.),

in the first and second growing seasons respectively, were produced from planting sugar beet on September 25th at a planting density of 42,000 plants/fed. (Table 6; Figure 3 and 4). The variety Hercules was superior in RSY when sown on September 25th at a planting density of 42,000 plants/fed. in both growing seasons.

Table 6. Recoverable sugar yield of two sugar beet varieties as affected by planting densities and planting dates in the 2019/2020 and 2020/2021 growing seasons.

Plant densities	Sowing date	Recoverable sugar yield (ton/fed.)					
		2019/2020			2020/2021		
		Husam	Hercules	Mean	Husam	Hercules	Mean
42000	25 Aug.	**3.17**	**3.94**	**3.55**	**3.20**	**3.97**	**3.58**
	25Sept.	**3.65**	**4.28**	**3.96**	**3.74**	**4.31**	**4.02**
	25 Oct.	**2.77**	**3.23**	**3.00**	**2.79**	**3.26**	**3.02**
Mean		76.47	**3.20**	**3.82**	**3.51**	**3.24**	**3.85**
34000	25 Aug.	**3.49**	**3.81**	**3.65**	**3.52**	**3.85**	**3.68**
	25Sept.	**3.73**	**4.17**	**3.95**	**3.76**	**4.21**	**3.98**
	25 Oct.	**2.84**	**3.34**	**3.09**	**2.88**	**3.37**	**3.12**
Mean		77.13	**3.35**	**3.77**	**3.56**	**3.39**	**3.81**
28000	25 Aug.	**3.00**	**3.21**	**3.11**	**3.05**	**3.23**	**3.14**
	25Sept.	**3.15**	**3.48**	**3.31**	**3.17**	**3.49**	**3.33**
	25 Oct.	**2.62**	**2.85**	**2.73**	**2.65**	**2.89**	**2.77**
Mean		76.87	**2.92**	**3.18**	**3.05**	**2.95**	**3.20**
Overall mean of densities	25 Aug.	**4.17**	**4.76**	**4.46**	**4.22**	**4.81**	**4.51**
	25Sept.	**4.59**	**5.23**	**4.91**	**4.66**	**5.28**	**4.97**
	25 Oct.	**3.65**	**4.19**	**3.92**	**3.69**	**4.24**	**3.97**
Mean all varieties		**4.14**	**4.73**		**4.19**	**4.78**	
L.S.D 0.05	A=0.04	B=0.05 C=** AB=0.04			A=0.05 B=0.05 C=** AB=0.08		
		0.06AC= **0.06**BC= ABC=0.08			**0.07** **0.07** 0.09		

***, ** significant and highly significant, respectively. -- NS = Not significant.**

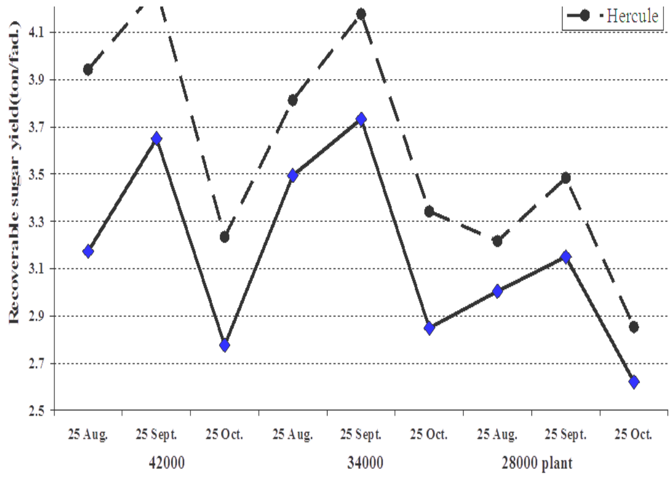

Figure 3. Recoverable sugar yield of the two sugar beet varieties as affected by planting densities and planting dates in the 2019/2020 growing season.

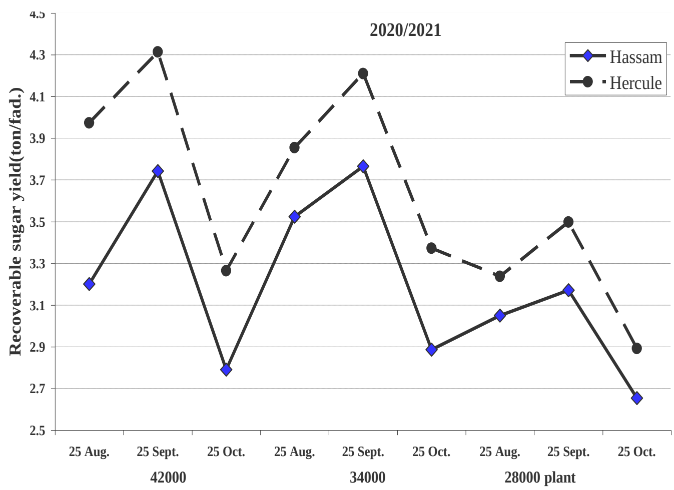

Figure 4. Recoverable sugar yield of the two sugar beet varieties as affected by planting densities and planting dates in the 2020/2021 growing season.

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الملخص العربي

تأثير مواعيد الزارعة والكثافات النباتية على محصول وجودة بنجر السكر

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يعتبر بنجر السكر المصدر الثاني للسكر في جميع أنحاء العالم وفي مصر. لذلك، يجب تعديل العديد من الممارسات الزراعية لرفع الجودة وتعظيم كمية إنتاج سكر البنجر. أجريت تجربتَن حقلية خلال الموسمين الزراعيين 2020/2019 و2021/2020 بمنطقة الدميرد - بلقاس بمحافظة الدقهلية لدراسة تأثير ثلاث كثافات نباتية هي : 42000 نبات (15 سم بين النباتات)، 34000 نبات (20 سم بين النباتات)، 28000 نبات (25 سم بين النباتات) في الفدان وثلاثة مواعيد للزراعة هي 25 أغسطس و25 سبتمبر و25 أكتوبر على صنفين من بنجر السكر هما هرقل وحسام. كان التصميم التجريبي عبارة عن تصميم قطع منشقة مرتين في ثلاث مكررات ووضعت الكثافات النباتية في القطع الرئيسية ووضعت المواعيد في القطع المنشقة الأولى ووضعت الاصناف في القطع المنشقة الثانية. أظهرت النتائج وجود فروق معنوية بصفة عامة بين الكثافات والمواعيد والاصناف والتفاعلات الثانوية والثلاثية في جميع الصفات المدروسة عدا صفتي النقاوة ومؤشر الجودة. أظهرت كثافات الزراعة ومواعيد الزراعة والأصناف بالإضافة إلى تفاعلاتها تأثيرات معنوية على جميع الصفات المدروسة بما في ذلك طول الجذر وقطره ومحصول الجذور والعروش وكذلك محتوى السكروز ونسبة الشوائب ومعامل الجودة ونسبة السكر القابل للاستخلاص ومحصول السكر القابل للاستخلاص. وقد نتج أعلى طول وقطر للجذر من زراعة بنجر السكر بكثافة 28000 نبات / فدان في كلا موسمي الزراعة. وفي الوقت نفسه ،

تم إنتاج أعلى قيم للصفات المدروسة المتبقية من زراعة بنجر السكر عند 42000 نبات / فدان. تفوقت النباتات المنزعة في 25 سبتمبر على النباتات المنزرعة في المواعيد الأخرى في جميع الصفات المدروسة. تفوق الصنف هرقل على الصنف حسام في جميع الصفات المرغوبة التي تم تقديرها في كلا موسمي الزراعة. علاوة على ذلك ، أنتج الصنف هرقل أعلى قيم لمحصول الجذور والعروش ومحتوى السكروز ونسبة الشوائب ومعامل الجودة ونسبة السكر القابل للاستخلاص ومحصول السكر القابل للاستخلاص عند زراعته بكثافة زراعة تبلغ 42000. نبات / فدان في 25 سبتمبر في كلا موسمي الزراعة .