Effect of Bed Width and Hill Spacing on Yield and Quality of Sugar Beet under Newly Reclaimed Soils

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ABSTRACT

This work aims to investigate the effect of bed width and hill spacing on growth, productivity and quality traits of sugar beet. In order to achieve such a purpose two field experiments were conducted at two successive seasons (2012/2013 and 2013/2014) in Nubaria Research Station, EL-Behera Governorate, Egypt to study the effect of three bed width (80,100 and 120 cm) and three hill spacing (15, 20 and 25 cm) on growth, yield and quality traits of sugar beet, (Kawamera variety).

The obtained results indicated that bed width and hill spacing had a significant effect on number of extractable roots/fed, root length and diameter, quality traits of sugar beet, (sucrose%, sugar recovery%, quality index, potassium, sodium and α-N contents as mill equivalent/100 gm beet) and root and recoverable sugar yields /fed.

It can be concluded that, bed width 80 cm with hill spacing 20 cm achieved the highest values of root and recoverable sugar yields (33.280 and 4.699 ton/fed, respectively).

Sugar beet (Kawamera variety) grown in row ridges or beds systems gave the highest values of root length and diameter, root weight, sucrose% and quality index as well as root and recoverable sugar yields/fed. Such results may be due to decrease plant stand and in turn decreased the competition between sugar beet plants and availed more light, nutrients and water which encouraged the vegetative growth and consequently, resulted big roots, which may be with higher moisture content. These results reflect the negative correlation between root size and gross sugar content.

In addition, the results showed that, the impurities (K, Na and α-amino N contents) decreased with increasing plant density (bed width and hill spacing).

Key wards: sugar beet, bed width, hill spacing, root yield, sugar content, recoverable sugar, K, Na and α-amino N contents and plant density.

INTRODUCTION

Sugar beet (*Beta Vulgaris* L.) has been introduced in Egypt as a second source for sugar production since 1981 to minimize the gap between the local production and the actual consumption.

Sugar produced from sugar beet increased from 7.36% in 1990 to 55% of the total local sugar production (2.298 million tons) in 2014 (CGSC, 2014).

Improvement of sucrose yield and potential root yield in sugar beet seemed to be a slow process and restricted because a negative correlation between sucrose concentration and root yield as well as needed to maintain an acceptable level of sucrose concentration.

Till now, studies are carrying out to find the proper technical recommendations for improving the productivity and quality of sugar beet under different conditions. Research on the extent to which the plant density influence the growth and formation of leaf area in particular development stages, especially those decisive for the yield and quality of sugar beet seed, has major scientific and production importance since it contributes a better seed utilization in final processing. It is though that number and distribution of plants per unit area, as well as appropriate fertilization are control problems in the technological production process of all field crops and especially in sugar beet seed production. Areas under seed sugar beet production are small in comparison with areas under other field crops. This is the main reason why there are very few professional or scientific studies from this area. Researches from North Africa (Campbell, 1968; Scott, 1968 and Longden, 1974) conducted with twice as many plants (300,000 plants/ha at harvest) as commonly recommended in other production regions.

Ismail and Allam (2007) showed that plant densities significantly affected root length and diameter, sodium% and sucrose% in the two seasons in addition to sugar yield in the 2nd season. They added that sowing sugar beet at 28000 and 42000 plants/fed had given the highest yield of roots and sugar (ton/fed) and quality traits, respectively.

Nafei *et al*., (2010) used three plant densities 28000 (50 cm between rows × 30 cm between hills), 33000 (50 cm between rows × 25 cm between hills) and 42000 (50 cm between rows × 20 cm between hills). They reported that increasing plant population from 28000 to 42000 plants/fed caused a significant response in root length, diameter, fresh weight/plant, sucrose%, total soluble solids, phosphorus% in roots

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beside tops, root and sugar yields (ton/fed) in the two seasons.

Refay (2010) investigated that root yield and quality traits of three sugar beet cultivars in relation to sowing date and stand densities. He showed that environmental variations due to planting date, plant population densities and varieties had an effect on yield and quality.

Shalaby *et al*., (2011) studied the relative performance of sugar beet varieties under three plant densities in newly reclaimed soils. They found that increasing plant spacing from 15 to 25 cm significantly increased root length and diameter, fresh weight, sucrose%, root and sugar yields/fed. Impurities%, i.e. (N, Na, and K) were decreased significantly in the two seasons.

Plant density (bed width and hill spacing) and many other factors need to be taken into account for improving the productivity and quality of sugar beet.

Sugar beet grown in ridges or beds systems gave the highest values of root length and diameter, root weight, sucrose% and quality index as well as root and recoverable sugar yields/fed, (Abdou and Salim, 2008).

Smooth root sugar beet genotypes responded to plant density in different environments similarly to adapted standard root commercial cultivars. SR (sugar recovery%) had enhanced when sugar beets were grown at the higher density of 71760 plants ha^{-1} (46 cm row width x 30 cm plant spacing), (Theurer and Saunders 1995; El-Sheref, 2007 and Ferweez et al., 2010).

Leilah *et al*., (2005) studied the effect of planting dates, plant population and nitrogen fertilization on sugar beet productivity under newly reclaimed sandy soils in Egypt and found that the highest root and sugar yields ha^{-1} were obtained with sowing sugar beet on both sides of ridges, 70 cm width and 25 cm between plants (114240 plants ha^{-1}). Therefore, the increase of plant density was accompanied with a reduction in root and sugar yields/fed, (Taha, 1985; Kamel et al., 1989; EL-Khatib, 1991 and Ramadan, 1999). They also pointed out that sucrose% and sugar recovery% of beet roots were significantly increased with increasing plant density. In addition, they desired that the impurities (K, Na and α-amino N contents) decreased with increasing plant density.

The present investigation was conducted in order to study the effect of bed width and hill spacing on productivity and quality traits of sugar beet under Nubaria conditions.

MATERIALS AND METHODS

Two field experiments were carried out during 2012/2013 and 2013/2014 seasons at Nubaria Research Station, EL-Behera Governorate to study the effect of plant densities in terms of the combinations between bed width and hill spacing on growth, productivity and quality traits of sugar beet. The present study included nine treatments which were the combination between three bed width and three hill spacing within the two sides of bed.

A split plot design with four replications was used. Three different distances of bed width, i.e. 80, 100 and 120 cm were arranged in the main plots. Meanwhile, three hills spacing within the two sides of beds (15, 20 and 25 cm) were allocated to the sub plots.

Sub-plots area was 48.0 m^2 consisting of 12.0 meters wide and 4.0 meters long.

Sugar beet (Kawamera variety) used in this study was sowing dates were at 16th and 18th October in the tow seasons, respectively.

Nitrogen fertilizer was added at rate of 120 kg N/fed in two equal doses (the first was after the thinning, while the second added after 30 days later).

Phosphorus fertilizer was added at rate of 30 kg P_20_5/fed at planting, while potassium was added at rate of 24 kg K_2O /fed after thinning.

Soil of the experimental site has sandy texture. Physical and chemical properties of the experimental soils summarized in Table 1.

Data recorded

A- Growth characteristics:

At harvest (195 days from sowing) sample of 10 plants from each sub-plot was randomly taken to record root length and root diameter.

B- Quality parameters:

Twenty roots were taken randomly, send to the laboratory, cleaned with running tap water, dried, each sample was grated separately with grater into cassettes and mixed thoroughly to determine the quality characteristics as described by Cooke and Scott (1993).

Sucrose% was estimated in fresh samples of sugar beet roots, using saccharometer according to the method described in AOAC (2005).

Alpha amino nitrogen, sodium and potassium contents: estimated according to the procedure of Sugar Company by Auto Analyzer as describe in AOAC (2005) the results calculated as mill equivalent/100 gm beet.

Table 1. Physical and chemical properties of the experimental soils

Seasons	Partial size			Soil	Soil	E.C.	$CaCO_3$ %	Organic matter %	Available contents%		
	Clay	Silt	Sand	pH 1:2.5	Textural	ds/m			N	P	K
2012/2013	3.0	3.3	93.7	7.7	Sandy	1.6	10.6%	0.75	4.4	3.21	132
2013/2014	3.6	4.7	91.7	7.8	Sandy	1.9	9.9%	0.90	6.5	3.01	120

Seasons	Soluble cautions (meq/l)				Soluble anions (meq/l)				Available contents (ppm)			
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_{3-}	HCO_{-3}	Cl^{-}	SO_{-4}	B	Fe	Zn	Mn
2012/2013	2.00	3.02	3.24	0.25	2.50	1.10	3.02	2.17	0.31	4.2	2.6	3.8
2013/2014	2.05	3.00	3.14	0.35	2.60	1.09	3.00	2.10	0.35	4.1	3.5	2.4

Sugar recovery% was calculated using the equation of Cooke and Scott (1993).

Sugar recovery% = sucrose% - [0.29 + 0.343 (K + Na) +<α - N (0.094)], Where, K, Na and α - N determined as mill equivalent/100 gm beet.

Quality index was calculated as by Cooke and Scott (1993) using the following formula:

Quality index% = sugar recovery% x sucrose% x 100

C- Productive traits:

Number of extractable roots/fed at harvest (195 days from sowing) was counted.

Roots yield (ton /fed) after (195 days from sowing) plants of sugar beet from the inner beds of each sub-plot were harvested, topped and cleaned to determine roots yield as ton /fed on fresh weight basis.

Recoverable sugar yield (ton/fed) was calculated from the following equation**:**

Recoverable sugar yield (ton/fed)= roots yield (ton/fed) x sugar recovery%.

The proper statistical analysis of all data was carried out according to lined by Gomez and Gomez (1984). Homogeneity of variance was examined before combined analysis. Combined analysis was carried out. Differences among treatments were evaluated by the least significant difference test (LSD) at 0.05 level of probability.

RESULTS AND DISCUSSIONS

A-Growth characters

Data in Tables (2 and 3) revealed that, bed width had a significant effect on growth traits of sugar beet, i.e. root length and diameter at the two growing seasons and their combined.

From combined analysis, it could be noticed that increasing bed width from 80 to 100 and 120 cm led to increase root length by 6.65 and 12.83%, while root diameter increased by 3.78 and 7.56%, respectively .

Increasing bed width combined with increasing hill spacing led to decrease plant density of sugar beet and less competition for growth elements, such observations may reflect the increase of root length and diameter. These results are in a harmony with those reported by Kamel *et al*., (1989); Ramadan (1999) and Ferweez *et al*., (2010).

Table 2. Effect of bed width and hill spacing on root length (cm) of sugar beet in the two seasons and their combined

Bed width (A)(cm)	2012/2013				20113/2014				Combined			
	Hill spacing(B)(cm)											
	15	20	25	Mean	15	20	25	Mean	15	20	25	Mean
80	27.07	29.09	31.92	29.36	28.12	30.36	32.12	30.20	27.59	29.72	32.02	29.78
100	29.39	31.26	32.19	30.95	30.18	32.30	34.27	32.25	29.78	31.78	33.73	31.76
120	31.30	33.13	35.23	33.22	32.13	33.82	34.82	33.59	31.71	33.48	35.63	33.61
Mean	29.25	31.16	33.11	31.17	30.14	32.16	33.74	32.01	29.69	31.66	33.79	31.72
F Value	**	**	**		**	**	**		**	**	**	
LSD0.05												
A	0.40				0.60				0.33			
B	0.47				0.32				0.27			
AB	N.S				0.55				0.46			

Table 3. Effect of bed width and hill spacing on root diameter (cm) of sugar beet in the two seasons and their combined

Bed width (A) (cm)	2012/2013				20113/2014				Combined			
	Hill spacing(B) (cm)											
	15	20	25	Mean	15	20	25	Mean	15	20	25	Mean
80	11.67	11.97	12.20	11.95	11.63	11.97	12.20	11.93	11.65	11.97	12.20	11.94
100	12.02	12.30	12.50	12.27	12.30	12.37	12.67	12.45	12.16	12.33	12.58	12.36
120	12.37	12.70	13.13	12.73	12.53	12.87	13.27	12.89	12.45	12.78	13.20	12.81
Mean	12.02	12.32	12.61	12.32	12.15	12.40	12.71	12.42	12.09	12.36	12.66	12.37
F Value	**	**	**		**	**	**		**	**	**	
LSD 0.05												
A	0.21				0.13				0.10			
B	0.17				0.15				0.11			
AB	0.11				0.35				0.33			

Concerning the hill spacing within the two sides of beds, it can be noticed from combined analysis in the following Tables that, hill spacing of sugar beet had a significant effect on the two studied growth traits of sugar beet, i.e. root length and diameter in the two growing seasons and combined.

Root length was proven to be longer under the narrowest bed width, which led to more elongation in the roots. These results may be due to different shares of utilized nutrients, water and other growth factors. The results are in agreement with those obtained by El-Sheref (2007); Hilal (2010) and Ferweez *et al*., (2010).

Significant interactions were recorded between bed width and hill spacing with regard to root length (cm) in the 2nd season and their combined as shown in Tables (2 and 3). It could be noticed from combined analysis in the following tables that bed width at 120 cm and sowing seeds at 25 cm spacing contained the highest values of root length and diameter (35.63 and 13.20 cm). On the other hand, the lowest values of root length and diameter (27.59 and 11.65 cm) were scored for bed width 80 cm and seed spacing 15 cm of sugar beet. These results may be due to different shares of utilized nutrients, water and other growth factors. Such results confirmed the previously reported by Ramadan (1999); El- Sheref (2007); Hilal (2010) and Ferweez *et al.*, (2010).

B-Quality properties

Results in this part of study (Tables 4 -9) clarified that there were significant differences among the studied bed width distances with respect to quality traits of sugar beet, i.e. sucrose%, sugar recovery%, quality index, potassium, sodium and α- N content of sugar beet in the two growing seasons and combined. These results are in a harmony with those obtained by Abdou and Salim (2008) since they reported that the increase in root length and diameter may be due to less competition among plants and also for the same reasons of increasing ridge width allowed more solar radiation penetration among beet leaves and that caused more photosynthesis that increased sucrose content in root besides purity%. Similar results were obtained by Hassanin (2001); Ahmed (2003) and El-Bakary (2006).

Table 4. Effect of bed width and hill spacing on sucrose% of sugar beet in the two seasons and their combined

Bed width (A) (cm)	2012/2013				20113/2014				Combined			
	Hill spacing(B) (cm)											
	15	20	25	Mean	15	20	25	Mean	15	20	25	Mean
80	16.23	16.40	16.03	16.22	16.43	16.57	16.13	16.38	16.33	16.48	16.08	16.30
100	15.10	15.90	14.93	15.31	15.17	15.93	15.03	15.38	15.13	15.92	14.98	15.34
120	14.40	14.69	14.10	14.40	14.37	14.78	14.20	14.45	14.38	14.73	14.15	14.42
Mean	15.24	15.66	15.02	15.31	15.32	15.76	15.12	15.40	15.28	15.71	15.07	15.35
F Value	**	**	**		**	**	**		**	**	**	
LSD 0.05												
A	0.08				0.22				0.10			
B	0.06				0.11				0.08			
AB	0.10				0.18				0.10			

Table 5. Effect of bed width and hill spacing on sugar recovery% of sugar beet in the two seasons and their combined

Bed width (A) (cm)	2012/2013				20113/2014				Combined			
	Hill spacing(B)(cm)											
	15	20	25	Mean	15	20	25	Mean	15	20	25	Mean
80	13.79	14.02	13.40	13.74	13.93	14.23	13.50	13.89	13.86	14.12	13.45	13.81
100	12.38	13.34	12.09	12.60	12.49	13.40	12.28	12.72	12.43	13.37	12.19	12.66
120	11.47	11.68	11.13	11.43	11.53	12.04	11.33	11.63	11.50	11.86	11.23	11.53
Mean	12.55	13.01	12.21	12.59	12.65	13.22	12.37	12.75	12.60	13.12	12.29	12.67
F Value	**	**	**		**	**	**		**	**	**	
LSD 0.05												
A	0.15				0.19				0.10			
B	0.11				0.12				0.08			
AB	0.19				0.21				0.13			

Table 6. Effect of bed width and hill spacing on quality index of sugar beet in the two seasons and their combined

Bed width (A) (cm)	2012/2013				20113/2014				Combined			
	Hill spacing(B) (cm)											
	15	20	25	Mean	15	20	25	Mean	15	20	25	Mean
80	85.46	84.83	83.56	84.62	85.89	84.76	83.67	84.77	85.86	84.79	83.61	84.75
100	83.75	81.94	80.97	82.22	84.10	82.34	81.71	82.72	83.92	82.14	81.34	82.47
120	80.72	79.53	78.91	79.72	81.50	80.27	79.80	80.52	81.11	79.90	79.36	80.12
Mean	83.31	82.10	81.15	82.19	83.83	82.46	81.73	82.67	83.63	82.28	81.44	82.45
F Value	**	**	**		**	**	**		**	**	**	
LSD 0.05												
A	0.35				0.14				0.16			
B	0.37				0.38				0.25			
AB	0.09				0.10				0.08			

Table 7. Effect of bed width and hill spacing on potassium content * of sugar beet in the two seasons and their combined

Bed width (A) (cm)	2012/2013				20113/2014				Combined			
	Hill spacing(B) (cm)											
	15	20	25	Mean	15	20	25	Mean	15	20	25	Mean
80	2.73	3.00	3.30	3.01	2.83	3.03	3.33	3.06	2.78	3.02	3.32	3.04
100	3.17	3.57	3.77	3.50	3.10	3.47	3.63	3.40	3.13	3.52	3.70	3.45
120	3.77	3.90	4.00	3.89	3.57	3.77	3.77	3.70	3.67	3.83	3.88	3.79
Mean	3.22	3.49	3.69	3.47	3.17	3.42	3.58	3.39	3.19	3.46	3.63	3.43
F Value	**	**	**		**	**	**		**	**	**	
LSD 0.05												
A	0.15				0.09				0.02			
B	0.11				0.11				0.07			
AB	0.07				0.08				0.13			

*= Potassium content as mill equivalents /100 gm beet.

Table 8. Effect of bed width and hill spacing on sodium content * of sugar beet in the two seasons and their combined

Bed width (A)(cm)	2012/2013				20113/2014				Combined			
	Hill spacing(B)(cm)											
	15	20	25	Mean	15	20	25	Mean	15	20	25	Mean
80	1.52	1.62	1.67	1.60	1.31	1.57	1.64	1.51	1.42	1.60	1.65	1.56
100	1.92	1.66	1.79	1.79	1.58	1.63	1.66	1.62	1.59	1.65	1.73	1.66
120	1.76	1.90	1.93	1.86	1.68	1.77	1.87	1.77	1.72	1.83	1.90	1.82
Mean	1.73	1.73	1.80	1.75	1.52	1.66	1.72	1.63	1.58	1.69	1.76	1.68
F Value	*	*	*		*	*	*		*	*	*	
LSD 0.05												
A	0.15				0.12				0.08			
B	0.06				0.15				0.07			
AB	0.11				0.09				0.11			

*= Sodium content as mill equivalents /100 gm beet.

Table 9. Effect of bed width and hill spacing on α-amino nitrogen content of sugar beet in the two seasons and their combined

Bed width (A) (cm)	2012/2013				20113/2014				Combined			
	Hill spacing(B) (cm)											
	15	20	25	Mean	15	20	25	Mean	15	20	25	Mean
80	1.81	1.86	1.88	1.85	1.72	1.82	1.86	1.80	1.77	1.84	1.87	1.83
100	1.84	1.89	1.92	1.88	1.84	1.87	1.89	1.87	1.84	1.88	1.90	1.87
120	1.93	1.95	1.95	1.94	1.92	1.93	1.93	1.93	1.93	1.94	1.94	1.94
Mean	1.86	1.90	1.92	1.89	1.83	1.87	1.89	1.86	1.84	1.89	1.90	1.88
F Value	N.S	N.S	N.S		*	*	N.S		*	*	N.S	
LSD 0.05												
A	0.06				0.04				0.03			
B	0.04				0.03				0.02			
AB	N.S				0.04				0.04			

*= α- amino nitrogen as mill equivalents / 100 gm beet

It could be noticed from combined analysis that increasing bed width distance from 80 to 100 and 120 cm led to decrease sucrose% by 5.38 and 11.53%, sugar recovery% by 8.33 and 16.51% as well as quality index by 2.69 and 5.46%, while K content of beet root increased by 13.49 and 24.67%, Na content of beet root increased by 7.1 and 17.42%, as well as α- N content of beet root increased by 2.19 and 6.01%, respectively.

These results may be explained as follows, increasing bed width led to increase root volume and consequently, increased the root juice impurities, which reduced sucrose%, sugar recovery% and quality index of sugar beet. Rice (1999) reported that the low plants counts had a significant effect on sucrose% and sugar recovery % of sugar beet. The present results are in the same line with those reported by Kamel *et al*., (1989); Ramadan (1999); Awad (2000) and Ferweez *et al*., (2010) since they showed that sucrose%, sugar recovery% and quality index significantly increased with decreasing bed width of sugar beet in both seasons.

With regard to hill spacing within the two sides of beds, the data given in Tables (4 -9) revealed that seeds spacing exhibited a significant effect on the quality traits of sugar beet, i.e. sucrose%, sugar recovery%, quality index, potassium and sodium content of sugar beet in the two growing seasons and combined, except α- amino nitrogen in the first season.

It could be noted from combined analysis that increasing hill spacing of sugar beet from 15 to 20 cm led to increase sucrose% and sugar recovery% by 2.81 and 4.13%, respectively. While, increasing hill spacing from 20 to 25 cm caused decreases in sucrose% and sugar recovery% by 1.37 and 2.46%, respectively.

On the other hand, increasing hill spacing of sugar beet from 15 to 20 and 25 cm led to decrease quality index by 1.54 and 2.55%, while increasing K content of sugar beet by 8.46 and 13.79%, Na content by 6.96 and 11.39% and α-amino N content by 2.72 and 3.26%, respectively.

These results may be explained as increasing hill spacing led to increase of root volume and consequently, reduced sucrose%, sugar recovery%, quality index of sugar beet as well as increased the impurities of root juice. These findings are in agreement with those obtained by Awad (2000); El-Sheref (2007); Hilal (2010) and Ferweez *et al*., (2010).

The interaction between bed width and hill spacing was significant for sucrose% and sugar recovery% in the two growing seasons and combined as shown in Table (4).

The results revealed that applying bed width at 80 cm and hill spacing at 15 cm gave the highest values of sucrose% (16.33), but the highest value of sugar recovery% (14.12) was produced from the combined of bed width at 80 cm and hill spacing at 20 cm of sugar beet.

Largest spacing in both within and between beds produced largest beets than closer spacing consequently, the lowest quality of beet roots.

C- Productive traits

The results in Tables (10-12) indicated that bed width exhibited a significant effect on productive traits of sugar beet, i.e. number of extractable roots/fed, root and recoverable sugar yields (ton/fed) in the two growing seasons and combined.

From combined analysis it could be observed that increasing bed width from 80 to 100 and 120 cm led to decrease number of actual roots/fed at harvest by 17.02 and 30.96%, root yield (ton/fed) of sugar beet by 9.41 and 19.50% and recoverable sugar yield by 16.76 and 32.73%, respectively.

These results may be due to the decrease in both number of roots/fed at harvest and sucrose% of sugar beet with increasing the bed width from 80 to 100 and 120 cm (Tables 2-5). Rice (1999) reported that the low plant counts had a significant effect on root and recoverable sugar yields of sugar beet.

Stebbing *et al*., (2000) found that sugar beet root yield decreased by 18% when row width increased from 56 to 76 cm and by 25% when row spacing increased from 46 to 76 cm. These findings are in harmony with those scored by Lauer (1995); Ramadan (1999) and Ferweez *et al*., (2010).

Regarding hill spacing within the two sides of beds, the data given in the previous tables revealed that hill spacing exhibited a significant effect on productive traits of sugar beet, i.e. number of actual roots/fed, root and recoverable sugar yields (ton/fed) in the two growing seasons and combined.

From combined analysis it could be noticed that, increasing seed spacing from 15 to 20 and 25 cm led to decrease number of actual roots/fed at harvest by 18.63 and 32.34% consequently, increasing seed spacing from 20 to 25 cm led to decrease root yield (ton/fed) of sugar beet by 5.92% and recoverable sugar yield (ton/fed) of sugar beet by 8.14%, although increasing seed spacing from 15 to 20 cm led to increase root yield (ton/fed) of sugar beet and recoverable sugar yield (ton/fed) of sugar beet by 13.03 and 17.41%, respectively.

Traditional recommendation of plant density in Egypt have been about 30,000-40,000 plants/fed. Stebbing *et al*., (2000) revealed that when the distance between plants increased, intra-plant competition became less. These findings are in the same trend with those obtained by El-Sheref (2007); Hilal (2010) and Ferweez *et al*., (2010).

The interactions of bed width and hill spacing (AB) were significant for number of actual roots/fed, root and recoverable sugar yields of sugar beet in the two growing seasons and combined, as shown in Tables (10-12).

Table 10. Effect of bed width and hill spacing on number of roots of sugar beet in the two seasons and their combined

Bed width (A)(cm)	2012/2013				20113/2014				Combined			
	Hill spacing(B)(cm)											
	15	20	25	Mean	15	20	25	Mean	15	20	25	Mean
80	37570	30400	26470	31480	37400	29570	26970	31310	37980	29980	26720	31560
100	32030	26130	19230	25800	32970	26770	20000	26580	32500	26450	19620	26190
120	27300	21270	18170	22250	27400	21830	18800	22680	25350	21550	18480	21790
Mean	32300	25930	21290	26510	32590	26060	21920	26860	31940	25990	21610	26510
F Value	**	**	**		**	**	**		**	**	**	
LSD 0.05												
A	0.5				1.06				0.4			
B	0.77				0.23				0.38			
AB	1.33				0.39				0.66			

Table 11. Effect of bed width and hill spacing on sugar beet root yield (ton/fed) of sugar beet in the two seasons and their combined

Bed width (A) (cm)	2012/2013				20113/2014				Combined			
	Hill spacing(B)(cm)											
	15	20	25	Mean	15	20	25	Mean	15	20	25	Mean
80	30.84	32.81	27.80	30.48	30.71	33.74	31.58	32.01	30.77	33.28	29.04	31.03
100	27.01	31.11	23.60	27.24	26.83	31.83	26.27	28.31	26.92	31.47	25.93	28.11
120	24.12	27.91	21.97	24.67	24.60	28.33	22.70	25.21	24.48	28.12	22.33	24.98
Mean	27.32	30.61	24.46	27.46	27.38	31.30	26.85	28.51	27.39	30.96	25.77	28.04
F Value	**	**	**		**	**	**		**	**	**	
LSD 0.05												
A	1.59				0.46				0.60			
B	1.44				0.43				0.71			
AB	2.49				0.74				1.23			

Table 12. Effect of bed width and hill spacing on recoverable sugar yield (ton/fed) of sugar beet in the two seasons and their combined

Bed width (A) (cm)	2012/2013				20113/2014				Combined			
	Hill spacing(B) (cm)											
	15	20	25	Mean	15	20	25	Mean	15	20	25	Mean
80	4.253	4.600	3.725	4.193	4.278	4.801	4.263	4.447	4.265	4.699	3.906	4.290
100	3.344	4.150	2.853	3.449	3.351	4.265	3.226	3.614	3.346	4.207	3.161	3.571
120	2.766	3.260	2.445	2.824	2.836	3.411	2.572	2.940	2.815	3.335	2.508	2.886
Mean	3.454	4.003	3.008	3.489	3.488	4.159	3.354	3.667	3.475	4.080	3.192	3.582
F Value	**	**	**		**	**	**		**	**	**	
LSD 0.05												
A	0.21				0.46				0.10			
B	0.18				0.43				0.09			
AB	0.31				0.74				0.16			

It could be noticed from combined analysis that bed width at 80 cm and hill spacing at 20 cm achieved the highest values of root and recoverable sugar yields (33.28 and 4.699 tons/fed). While the lowest values of actual roots number/fed at harvest (18480 roots/fed), root and recoverable sugar yields (22.33 and 2.508 tons/fed) were scored with bed width at 120 cm and hill spacing at 25 cm, respectively. Sugar beet root yield, sugar percentage, and purity were higher for sugar beet planted in 40 cm rows compared with sugar beet planted in 60 cm rows (O'Connor, 1983).

Narrower rows, such as 45 cm are more likely to produce large root yields and recoverable sugar because they help to compensate for poor plant establishment (Anonymous, 1995). Rice (1999) reported that there was a fall in root and sugar yields in the widest rows. Stebbing *et al*., (2000) showed that, row spacing of 40 cm in India, gave the highest yields of root and sugar, while that of 50 and 60 cm gave similar yields. Such data confirmed the previous reports of EL-Sheref (2007) and Hilal (2010).

CONCLUSION

From the previous data, it could be concluded that bed width at 80 cm and hill spacing at 20 cm was recommended under these conditions because it achieved the highest values of root and recoverable sugar yields (33.280 and 4.699 tons/fed, respectively) increasing income value of grower and sugar production for the factory, as well as water use efficiency and weed competition.

This is also helping in reducing the gap between sugar consumption and production at the national level. Therefore, it is recommended that to study bed width and hill spacing for different varieties to achieve the highest production.

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الملخص العربي

تأثير عرض المصطبة والمسافة بين الجور على إنتاجية وجودة بنجر السكر فى الاراضى الجديدة

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أجريت تجربتان حقليتان فى موسمي ٢٠١٣/٢٠١٢ و٢٠١٤/٢٠١٣ فى محطة البحوث الزراعية بالنوبارية بمحافظة البحيرة وذلك بهدف دراسة تأثير عرض المصاطب والمسافة بين الجور على إنتاجية وجودة بنجر السكر فى الاراضى الجديدة.

تعتبر عملية تحسين الانتاج من الجذور والسكر فى بنجر السكر عملية صعبة، بسبب العلاقة العكسية بين تركيز السكر وحجم ووزن الجذور وبين عدد الجذور الصالحة للتصنيع وتركيز السكر فى الجذور.

ولهذه الأسباب أقيمت هاتان التجربتان لدراسة تأثير عرض المصطبة(٨٠ و١٠٠ و١٢٠ سم) والتى وضعت فى القطع الرئيسية و تم توزيعها عشوائيا والمسافة بين الجور (١٥ و٢٠ و٢٥ سم) والتى وزعت بصورة عشوائية فى القطع الفرعية على الصفات الخضرية وكذلك صفات الجودة والصفات الانتاجية لبنجر السكر صنف Kawamera.

وقد أوضحت النتائج المتحصل عليها وجود تأثير معنوى لعرض المصطبة والمسافة بين الجور على الصفات الخضرية لجذور بنجر السكر(عدد الجذور الصالحة للتصنيع بألف/فدان، طول وقطر الجذور سم)، وكذلك صفات الجودة(نسبة السكروز، نسبة السكر القابل للاستخرج، معامل الجودة، كميات البوتاسيوم، والصوديوم، وألفا أمينو نيتروجين مللي مكافئ/١٠٠ جم بنجر) ونواتج المحصول لجذور بنجر السكر (ناتج الجذور النظيفة وناتج السكر القابل للاستخراج طن/فدان).

وأوضحت نتائج الدراسة ان استخدام عرض المصطبة ٨٠ سم التى تزرع على الجانبين مع المسافة بين الجور ٢٠ سم حققت افضل النتائج الخاصة بمحصول الجذور النظيفة والسكر القابل للاستخراج(٣٣,٢٨٠ و٤,٦٩٩طن/فدان على التوالي) والذي يحقق زيادة لدخل المزارع وإنتاج السكر للمصنع وزيادة كفاءة استخدام المياه ومنافسة الحشائش وهذا يساعد في تقليل الفجوة بين إنتاج واستهلاك السكر على المستوى المحلى.