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EFFECT OF PLANTING DENSITY, PHOSPHORUS AND POTASSIUM FERTILIZATION ON YIELD AND QUALITY OF SUGAR BEET

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ABSTRACT: *A field trial were carried out at Sakha Research Station, Kafr El-Shaikh Governorate (31°N,30° E at an altitude,elev 6 m) in 2009/2010 and 2010/2011 seasons to study the effect of twelve treatments represent the combination between three hill spaces (20, 25 and 30 cm) corresponding 42000, 33600 and 28000 plants/fed), two levels of phosphorus fertilizer (15 and 30 kg P_2O_5/fed) and two levels of potassium fertilizer (24 and 48 kg K_2O/fed) on yield and quality of sugar beet. A split plot design in three replications was used.*

The results showed that increasing plant density significantly increased root length, sucrose % , extractable sugar % and extractability % in both seasons and sugar yield in the 2nd one, while root diameter, root fresh weight/ plant, and sodium content were decreased. Sowing sugar beet at 28000 and 42000 plants/fed gave high values of yield and juice quality traits, respectively.

Increasing phosphorus level significantly increased root length, diameter, fresh weight, root yield, sugar yield, α-amino-N, Na and K contents in both seasons in addition to sucrose, sugar loss in molasses and extractable sugar percentages,while purity% was decreased. The optimum P- level was 30 kg P_2O_5/fed.

Increasing potassium level significantly increased root length, root diameter, root fresh weight, root yield, sugar yield, α-amino nitrogen content, sucrose % and extractable sugar % in both seasons next to potassium content and sugar loss in molasses % in the 2nd season, while purity% was decreased. The optimum K-level was 48 kg K_2O/fed.

Key words: *Sugar beet, plant density, phosphorus, potassium,purity and molasses.*

INTRODUCTION

Sugar beet growth is largely influenced by the agronomic practices such as crop stand and fertilization. It is known that too heavy population could restrict root growth to the point that very small beets will be lost during harvesting. On the contrary, in low stand large sized beets with little quality i.e. more fibers, water and less sucrose content will be produced.

Growth character of sugar beet were studied by many workers; Laurer (1995) compared plant densities of 37.100, 61.800, 86.500, and 111.200 plants/ha, he found that sucrose content increased by 5 g/kg as plant density increased from 37.000 to 111.200 plants/ha. Kemp *et al* (1996) applied 60,000, 80,000, 100,000, 120,000 and 140,000 plants/ha he found that maximum root fresh weight was obtained at 60,000 plants/ha, maximum sugar yield at 80,000 plants/ha and juice purity ranged from 89% at 140,000 plants to 82% at 60,000 plants. Arita *et al* (1998) evaluated sugar beet cultivars sown in rows 50 or 60 cm apart with 18, 21 or 24 cm. between plants in the row. They found that with 50 cm between rows and 24 cm. between plants in the row gave average root and sugar yields 55.6 and 10.02 t/ha, respectively. Caliskan *et al* (1998) reported that the highest root and sugar yields (73.00 and 12.21 t/ha), respectively were obtained with 30 cm spacing. Nassar (2001) found that increasing plant density from 33600 up to 70000 plant/fed increased sucrose and purity% and application of 42000 plant/fed produced the highest root and sugar yields. Sogut and Aroglu (2004) showed that sugar beet at 15 and 20 cm intra-row spacing produced higher root yield than 30 and 35 cm intra-row spacing between plants. El-Geddawy *et al* (2006) found that increasing plant density from 33600 up to 46666 plants/fed significantly increased purity% and root and sugar yields. Ferweez *et al.* (2010) found that the obtained results indicated that plant density (46670 plant / fed.) at beds of sugar beet produced the highest values of roots number /fed.. He added that at the highest plant density (46670 plant/fed.) achieved the highest values of pol and sugar recovery percentages and lowest values of K , Na and alfa- amino nitrogen contents.

Phosphorus and potassium elements are essentially in plant life. Phosphorus promotes root growth and is conductive for higher sugar accumulation through its role in the photosynthesis process. Potassium is a mobile element in the plant tissues. It has a role in physiological processes in the plant such as respiration, transpiration, translocation of sugars and carbohydrates, energy transformation and enzyme actions. Many investigators found that sugar beet yield and quality are greatly influenced by the applied PK levels. El-Essawy (1996) showed that the combination of 30 kg P_2O_5 + 24 kg K_2O/fed recorded increases for quality, root and sugar yields traits of sugar beet plants. Ibrahim (1998) found that 15 kg P_2O_5 + 48 kg K_2O/fed increased significantly values of root length, diameter, fresh weight/plant, root and sugar yields while sucrose and purity percentages were significantly decreased. Jaszczolt (1998) showed that phosphorus fertilizer amounts (400-640 kg/ha) did not significantly affect the crop yield, sugar yield or sugar content of beet. Khan *et al* (1998) found that sugar yield, sucrose and purity percentages were increased with increasing P rates up to 90 kg P_2O_5 El-Shafai (2000) obtained high root fresh weight, sugar yield and sucrose% from increasing K level up to 48 kg K_2O/fed while root yield and purity did not affect. Ismail *et al* (2002) obtained a significant increase in root fresh weight/plant, purity %, root and sugar yields sucrose, extractable sugar % and extractability % from application of 24 kg K_2O/fed with one spray of potassien compound. Ismail and Abo El-Ghait (2004) obtained highly root length, sucrose%, root yield and sugar yield from increasing K-level up to 48 kg K_2O/fed as well as sucrose percentage from increasing phosphorus levels up to 30 kg P_2O_5/fed. Moustafa *et al* (2006) found that decreasing soil K-fertilizer from 24 to 12 Kg K_2O/fed gave an obvious reduction in root diameter, length, fresh weight and yields of root and sugar as well as root impurities content (K and a-amino-N) and some technological parameters (sugar loss in molasses and extractable sugar%) while Purity% was increased. Moustafa and El-Masry (2006) obtained high root and sugar yield as well as sucrose%, purity%, impurities content (α-amino-N, Na, K) from increasing K-level up to 48 kg K_2O/fed.

The aim of the present work was to find out the optimal PK-level required for sugar beet sown at different plant densities at kafr El-sheikh region to obtain the maximum yield and quality of sugar beet. Abo El-Ghiat and EL-Geddawy(2013) cleared that application of 24 kg. K_2O/fed + one spray of potassium resulted in the highest root fresh weight/plant, sucrose % ,purity % , root and sugar yields,while the highest top yield was recorded by application of 24 kg. K_2O/fed + two spray of potassium. On the other hand, sugars loss to molasses% were not significantly affected by the tested varieties and/or potassium application of 24 kg. K_2O/fed + one spray of potassium compound.

MATERIALS AND METHODS

A field trial was carried out at Sakha Research Station, kafr El-Sheikh Governorate in the two growing seasons of 2009/2010 and 2010/2011 to study the effect of twelve treatments represented the combination between three plant hill spaces (20, 25 and 30 cm corresponding 42000, 33600 and 28000 plants/fed , two levels of phosphorus (15 and 30 kg P_2O_5/fed) and two levels of potassium (24 and 48 kg K_2O/fed) on yield and quality of sugar beet. Pleno variety was sown in both seasons. Soil samples were taken before sowing and were prepared to determinate mechanical and chemical soil properties according to Page (1982) in Table (1).

Table (1): Physical and Chemical analysis of the experimental soil .

Particle size			Soil textural	E.C. ds/m	Soil pH (1:2.5)	Organic matter %	CaCO3 %
Sand %	Silt %	Clay %	Clay soil				
17.64	33.52	48.84		2.12	7.82	1.52	3.08

Soluble Cations (meq/L)				Soluble anions(meq/L)				available contents (ppm)		
Ca++	Mg++	Na+	K+	CO3--	HCO3-	Cl-	SO4--	N	P	K
5.8	3.4	11.5	0.58	0.10	3.46	4.30	13.52	27.8	5.95	396

Plot area was 10.5 m^2 (3.0 m. in length and 3.5 m. in width) A split plot design in four replications was used where hill spaces were allocated in the main plots while the combination between phosphorus and potassium levels were distributed randomly in the sub plots Phosphorus and potassium fertilizer was added in form of calcium super phosphate (15.5% P_2O_5) and potassium sulfate (48% K_2O). The preceding crop was maize in both seasons. Phosphorus fertilizer was broadcast in rows after sowing , while potassium fertilizer was added in two equal doses with nitrogen fertilizer, immediately, after thinning and the other one month later. Other agricultural practices were done as recommended by Sugar Crops Research Institute.

Recorded data:

Sugar beet plants of the five guarded rows were up-rooted, topped, weighed was taken from each sub- plot to determine root and sugar yields. A sample of ten roots was taken to determine growth and quality

1-Root length (cm), root diameter (cm), root fresh weight (kg/plant).

2- Technological parameters, i.e. impurities content (mg/100g beet) including α-amino nitrogen (Carruthers *et al*,1962), K and Na (Page,1982), sucrose%, purity% and sugar loss in molasses % (Devillers,1988), extractable sugar % and Extractability % (Dexter *et al,*1967)] were determined using an Automatic French System (HYCEL), which were computed as follows:

Purity % = 99.36 – [14.27 (Na +K+α-amino N) / sucrose %].

Sugar loss in molasses (SM %) = [0.14(Na +K) +0.25 (α-amino N) + 0.5].

Extractable sugar (Ex %) = [sucrose % – (sugar loss in molasses % + 0.6)].

Extractability (Exb %) = [(extractable sugar % / sucrose %)] x100.

Sugar yield (tons/fed) = [root yield (tons/fed) x extractable sugar (Ex %)].

Analysis of variance was done according to the method described by Snedecor and Cochrane (1981). Least significant difference test (LSD) at 5% level of significance was used to compare means.

RESULTS AND DISCUSSION

1. Effect of plant density on:

1.1. Yield and yield components:

Data illustrated in Table (2) revealed that yield and yield components of sugar beet were significantly affected by plant density in both seasons except sugar yield in the 1st season.

Increasing plant density from 28000 to 33600 and to 42000 plant/fed increased root length about 13.07 and 26.15% in the 1st season corresonding 15.02 and 20.55% in the 2nd season, respectively. The increasing of root length as the plant densities increased may be due to the competition between plants on water and nutrition .

On the other hand, root diameter, root fresh weight and root yield were decreased by increasing plant density/fed to 33600 and to 42000 plant/fed. The reduction were about (8.11 and 18.91%) for root diameter, (20.93 and 37.68%) for root fresh weight/plant and (9.71 and 22.05%) for root yield in the 1st season respectively, corresponding to (10.49 and 17.48%), (11.59 and 30.69%) and (6.99 and 13.33%) for the same traits in the 2nd season, respectively. These results may be indicate to the inverse by a relation between these traits and plant density where increasing plant density decreasing roots in diameter and weight. These finding coincide with those reported by Arita *et al* (1998), Caliskan *et al* (1999), Sogut and Aroglu (2004) and El-Geddawy *et al* (2006).

Table (2): Yield and yield components of sugar beet as affected by plant density (2009/2010 and 2010/2011 seasons)

Plant density (seeds/fed)	2009/2010season				
	root length (cm)	root diameter (cm)	root fresh weight (kg)	root yield (ton/fed)	sugar yield (ton/fed)
28000	26.0	14.8	1.696	31.746	4.842
33600	29.4	13.6	1.341	28.663	4.442
42000	32.8	12.0	1.057	24.746	4.114
LSD 0.05	2.7	0.3	0.266	2.549	N.S
Plant density (seeds/fed)	2010/2011 season				
	Root length	root diameter	root fresh weight	root yield	sugar yield
28000	25.3	14.3	1.587	28.266	3.533
33600	29.1	12.8	1.403	26.288	3.771
42000	30.5	11.8	1.100	24.497	3.746
LSD 0.05	1.8	1.5	0.137	0.606	0.134

Sugar yield was increased 0.238 tons/fed when plant density increased from 28000 to 33600 plant/fed then decreased 0.025 tons/fed with increasing plant density to 42000 plant/fed only in the 2nd season.

The difference was significant between the 1st densities (28000 plant) , however, insignificant between the 2nd and 3rd densities. This result may be due to increasing plant density caused a reduction in root size which result to increasing quality traits and consequently sugar yield as a final product. Similar result was attained by Kemp *et al* (1996) and Caliskan *et al* (1999), Nassar (2001) and El-Geddawy *et al* (2006).

1.2. Quality parameters:

Data presented in Table (3) showed that sodium content was significantly decreased by increasing plant density. The reduction in sodium was (0.1 and 0.24 mg) and (0.4 and 0.55 mg) in the 1st and 2nd seasons, respectively, when plant density was increased from 28000 to 33600 and to 42000 plant/fed. On the other hand, the differences in the values of α-amino-N, potassium and sugar losses to molasses % did not reach to the level of significance by increasing plant density in both seasons.

Results in the same Table pointed out that except purity % in the 1st season, increasing plant density increased gradually and significantly quality traits (sucrose, purity, extractable sugar and extractability percentages). Increasing plant density from 28000 to 33600 and to 42000 plant/fed produced increases about (0.21 and 1.33%), (0.23 and 1.38%) and (0.27 and 0.95%) for sucrose % , extractable sugar % and extractability % in the 1st season, corresponding to (1.59 and 2.44%), (1.76 and 2.40%), (1.83 and 2.77%) and (2.83 and 3.86%) for sucrose %, purity %, extractable sugar % and extractability % in the 2nd season, respectively. This finding could be due to root size which negatively correlated with juice purity parameters as it shown in table (3). This result is in agreement with that reported by Kemp *et al* (1996), Nassar (2001) and El-Geddawy *et al* (2006).

2. Effect of phosphorus levels on:

2.1. Yield and yield components:

Data in Table (4) pointed out that phosphorus levels significantly increased yield and yield components in the 1st and 2nd growing seasons. Application of 30 kg P_2O_5/fed gave increases about (13.82 and 5.07 %), (3.01 and 7.2 %), (8.23 and 10.50 %), (4.81 and 4.76 %) and (5.83 and 7.87 %) for root length, root diameter, root fresh weight, root yield and sugar yield compared with the other level of phosphorus fertilizer (15 kg P_2O_5/fed) in the 1st and 2nd season, respectively.

Table (3): Quality traits of sugar beet as affected by plant density (2009/2010 and 2010/2011 seasons).

Plant density (seeds/fed)	2009/2010 season							
	α-amino nitrogen (mg)	Sodium (mg)	Potassium (mg)	Sucrose %	Purity %	SM%	Ex %	Exb%
28000	0.40	0.57	1.86	16.79	96.95	0.94	15.25	90.82
33600	0.34	0.47	1.88	17.00	97.10	0.91	15.48	91.09
42000	0.29	0.33	1.95	18.12	97.34	0.89	16.63	91.77
LSD 0.05	N.S	0.17	N.S	0.93	N.S	N.S	0.81	0.31
Plant density (seeds/fed)	2010/2011 season							
	α-N(mg)	Na (mg)	K(mg)	S%	Pur%	SM%	Ex%	Exb%
28000	1.08	1.15	2.56	14.38	94.61	1.29	12.49	86.86
33600	0.69	0.75	1.91	15.97	96.37	1.04	14.32	89.69
42000	0.66	0.60	1.50	16.82	97.01	0.96	15.26	90.72
LSD 0.05	N.S	0.19	N.S	0.18	0.66	N.S	0.10	0.54

α-N: α-amino nitrogen (mg/100g beet) SM: sugar loss in molasses Ex: extractable sugar % Exb: extractability %

Table (4): Yield and yield components of sugar beet as affected by phosphate level (2009/2010 and 2010/2011 seasons).

Phosphate level (Kg P_2O_5/fed)	2009/2010 season				
	root length (cm)	root diameter (cm)	root fresh weight (kg)	root yield (ton/fed)	sugar yield (ton/fed)
15	27.5	13.3	1.311	27.719	4.339
30	31.3	13.7	1.419	29.052	4.592
LSD 0.05	*	*	*	*	*
Phosphate level (Kg P_2O_5/fed)	2010/2011 season				
	Root length	Root diameter	root fresh weight	root yield	sugar yield
15	27.6	12.5	1.295	25.738	3.544
30	29.0	13.4	1.431	26.962	3.823
LSD 0.05	*	*	*	*	*

These increases may be due to phosphorus role in plant physiology through energy storage and transfer as well as promotes root growth and consequently increasing sugar yield as a final product. This result is in agreement with that reported by El-Essawy (1996), Ibraham (1998) and Ismail and Abo El-Ghait (2004).

2.2. Quality parameters:

Results illustrated in Table (5) revealed that α-amino N, sodium and potassium contents were significantly increased by increasing phosphorus level to 30 kg P_2O_5/fed in both seasons. The increases were about (0.08 and 0.10 mg), (0.06 and 0.21mg) and (0.18 and 0.10 mg) for α-amino N, sodium and potassium contents in the 1st and 2nd seasons, respectively.

Sucrose, purity, sugar loss in molasses and extractable sugar percentages were appreciably influenced by the studied levels of phosphorus only in 2nd season. The results clarified that the highest value of sucrose% (15.94) and extractable sugar % (14.21) were obtained by applying 30 kg

P_2O_5/fed. These increases are about (0.44 and 0.37%) for sucrose and extractable sugar percentages, respectively. Otherwise, application of 15 kg P_2O_5/fed recorded the lowest sugar loss in molasses (1.06%) and the highest purity (96.14%). Generally, most quality traits did not reach a significant level by increasing Phosphorus levels in the 1st season. This effect may be due to increase impurities content in juice. These results coincide with those reported by Khan *et al* (1998) and Ismail and Abo El-Ghait (2004).

3. Effect of potassium level on:

3.1. Yield and yield components:

Data in Table (6) pointed out that K fertilizer levels markedly increased root length, root diameter, root fresh weight, root yield and sugar yield in the 1st and 2nd season, respectively. Application of 48 kg K_2O/fed recorded an increase in root length amounted by (1.4 and 1.9 cm) for root length, (0.7 and 1.1 cm) for root diameter, (0.131 and 0.083 kg/plant) for root fresh weight, (1.223 and 2.428 tons/fed) for root yield and (0.286 and 0.483 tons/fed) for sugar yield compared with the other level (24 kg K_2O/fed) in the 1st and 2nd seasons, respectively. This increase in yield and yield components may be due to that potassium is a mobile element in the plant tissues and it plays an important role in photosynthesis through carbohydrate metabolism, osmotic regulation, nitrogen uptake, protein synthesis, translocation of assimilates. This result is in agreement with that obtained by El-Essawy (1996), Ibrahim (1998), El-Shafai (2000) and Moustafa and El-Masry (2006).

Table (5): Quality traits of sugar beet as affected by phosphate level (2009/2010 and 2010/2011 seasons).

Phosphate level (Kg P_2O_5/fed)	2009/2010 season							
	α-amino nitrogen (mg)	Sodium (mg)	Potassium (mg)	Sucrose %	Purity %	SM%	Ex %	Exb%
15	0.30	0.43	1.81	17.24	97.09	0.91	15.72	91.19
30	0.38	0.49	1.99	17.36	97.17	0.91	15.85	91.27
LSD 0.05	*	*	*	NS	NS	NS	NS	NS
Phosphate level (Kg P_2O_5/fed)	2010/2011 season							
	α-N(mg)	Na (mg)	K(mg)	S%	Pur%	SM%	Ex%	Exb%
15	0.76	0.73	1.94	15.50	96.14	1.06	13.84	89.16
30	0.86	0.94	2.04	15.94	95.85	1.13	14.21	89.01
LSD 0.05	*	*	*	*	*	*	*	NS

α-N: α-amino nitrogen (mg/100g beet SM: sugar loss in molasses Ex: extractable sugar % Exb: extractability %

Table (6): Yield and yield components of sugar beet as affected by potassium level (2009/2010 and 2010/2011 seasons)

Potassium level (Kg K_2O/fed)	2009/2010 season				
	root length (cm)	root diameter (cm)	root fresh weight (kg)	root yield (ton/fed)	sugar yield (ton/fed)
24	28.7	13.1	1.299	27.774	4.323
48	30.1	13.8	1.430	28.997	4.609
LSD 0.05	*	*	*	*	*
Potassium level (Kg K_2O/fed)	2010/2011 season				
	root length	root diameter	root fresh weight	root yield	sugar yield
24	27.4	12.4	1.322	25.136	3.442
48	29.3	13.5	1.405	27.564	3.925
LSD 0.05	*	*	*	*	*

3.2. Quality parameters:

Data exhibited in Table (7) revealed that increasing potassium levels from 24 to 48 kg K_2O/fed significantly increased α- amino N content, sucrose % and extractable sugar % in both seasons. The increases were accounted by 0.12 and 0.21 mg) for α-amino N, (0.36 and 0.62%) for sucrose% and (0.32 and 0.53%) for extractable sugar % in the 1st and 2nd seasons, respectively. These increases may be due to potassium role in physiological processes in the plant such as respiration, transpiration, translocation of sugars and carbohydrates. This result is in agreement with those obtained by El-Essawy (1996), Ibrahim (1998), El-Shafai (2000), Moustafa and El-Masry (2006) and Moustafa *et al* (2006).

Regards to , sodium content, potassium content, sugar loss in molasses % and purity % traits, it is obvious that increasing potassium levels up to 48 kg K_2O/fed gave an increase about 0.06 mg/100 g beet in Na-content in the 1st season and 0.2 mg in K content and 0.09 % in sugar loss in molasses % in the 2nd season. Purity % was decreased by 1.32 % when potassium level increased to 48 kg K_2O/fed. The decrease in purity % may be attributed to increasing impurities content in juice (Table 7). This result coincides with that reported by Ibrahim (1998), Ismail *et al* (2002) and Moustafa and El-Masry (2006).

4. Effect of the interactions:

4.1. Plant density x phosphorus level:

Data presented in Table (8) showed that root length, root yield and purity % were significantly affected by the interaction between plant density and phosphorus levels in both seasons. It could be noticed that sowing 42000 plant with 15 kg P_2O_5/fed produced the highest purity% (97.68 and 97.09%) while , the same plant density with 30 kg P_2O_5/fed recorded the highest root length (34.3 and 31.3 cm) compared with the other interactions in the 1st and 2nd seasons, respectively. On the other hand, interaction effect of plant density x P level at plant density of 28000 plant with 30 kg P_2O_5/fed gave the highest root yield (31.979 and 28.310 tons/fed) while sowing of 42000 plant with 15 kg P_2O_5/fed recorded the lowest yield (23.996 and 23.247 tons/fed) in the 1st and 2nd seasons, respectively.

Root diameter, Na content, K content, sugar loss in molasses % and extractable sugar % in the 1st season and root fresh weight kg and sugar yield (ton/fed) in the 2nd season were significantly affected by the interaction between plant density and phosphorus level. The results in Table (8) showed that growing of 28000 plant/fed with 30 kg P_2O_5/fed recorded higher root diameter and fresh weight (15.0 cm and 1.618 kg/plant) but lower K-content (1.54 mg/100 g beet).

Table (7): Quality traits of sugar beet as affected by potassium level (2009/2010 and 2010/2011 seasons).

Potassium level (Kg K_2O/fed)	2009/2010 season							
	α-amino nitrogen (mg)	Sodium (mg)	Potassium (mg)	Sucrose %	Purity %	SM%	Ex %	Exb%
24	0.28	0.43	1.91	17.12	97.17	0.90	15.63	91.23
48	0.40	0.49	1.89	17.48	97.09	0.93	15.95	91.22
LSD 0.05	*	*	NS	*	NS	NS	*	NS
Potassium level (Kg K_2O/fed)	2010/2011 season							
	α-N(mg)	Na (mg)	K(mg)	S%	Pur%	SM%	Ex%	Exb%
24	0.71	0.78	1.89	15.41	96.16	1.05	13.76	89.17
48	0.92	0.88	2.09	16.03	95.84	1.14	14.29	89.01
LSD 0.05	*	NS	*	*	*	*	*	NS

α-N: α-amino nitrogen (mg/100g beet) **SM**: sugar loss in molasses **Ex**: extractable sugar % **Exb**: extractability %

Table (8): Growth, yield and quality traits of sugar beet as affected by plant density x phosphorus level interaction (2009/2010 and 2010/2011 seasons).

Plant density x phosphorus level interaction	2009/2010 season							
	root length (cm)	: root yield (ton/fed)	purity %	root diameter (cm)	K (mg/ 100g beet)	Na: (mg/ 100g beet)	sugar loss in molasses %	Exb extractability %
28000 plant + 15 kg P_2O_5/fed	23.1	31.913	96.65	14.7	2.17	0.58	0.99	90.48
33600 plant + 15 kg P_2O_5/fed	28.0	27.247	96.93	13.6	2.11	0.50	0.93	90.95
42000 plant + 15 kg P_2O_5/fed	31.3	23.996	97.68	11.6	1.68	0.22	0.82	92.13
28000 plant + 30 kg P_2O_5/fed	28.9	31.979	97.25	15.0	1.54	0.57	0.89	91.16
33600 plant + 30 kg P_2O_5/fed	30.8	30.080	97.26	13.6	1.66	0.45	0.89	91.23
42000 plant + 30 kg P_2O_5/fed	34.3	25.496	97.00	12.4	2.23	0.44	0.96	91.42
LSD 0.05	1.3	1.665	0.37	0.4	0.28	0.07	0.06	0.55

Plant density x phosphorus level Interaction	2010/2011 season				
	root length (cm)	: root yield (ton/fed)	purity %	root fresh weight (kg/plant)	sugar yield (ton/fed)
28000 plant + 15 kg P_2O_5/fed	24.6	28.222	94.90	1.556	3.490
33600 plant + 15 kg P_2O_5/fed	28.5	25.746	96.44	1.340	3.648
42000 plant + 15 kg P_2O_5/fed	29.8	23.247	97.09	0.988	3.492
28000 plant + 30 kg P_2O_5/fed	26.0	28.310	94.32	1.618	3.576
33600 plant + 30 kg P_2O_5/fed	29.6	26.830	96.29	1.465	3.895
42000 plant + 30 kg P_2O_5/fed	31.3	25.746	96.94	1.211	4.000
LSD 0.05	1.1	0.732	0.05	0.059	0.148

Also, growing of 42000 plant/fed with 15 kg P_2O_5/fed recorded higher extractability (92.13%) but lower root diameter (11.6 cm), Na content (0.22 mg) and sugar loss in molasses (0.82%) compared with the other interactions.

Otherwise, growing of 42000 plant/fed with 30 kg P_2O_5/fed attained the highest quantity of sugar yield (4.0 tons/fed) while the lowest quantity (3.490 tons/fed) was obtained from 28000 plant/fed with 15 kg P_2O_5/fed. These results may be due to that the available amount of phosphorus was enough to appear the fruitful effect of phosphorus on these traits. Moreover, phosphorus promotes root growth and is conductive for higher sugar accumulation through its role in the photosynthesis process. Also, the small size of roots as a result of increasing plant density increasing quality traits and therefore, sugar yield as a final product. This result is in agreement with those obtained by Khan, *et al*. (1990); El-Essawy (1996) and Ibrahim (1998).

4.2. Plant density x potassium level interaction:

Data illustrated in Table (9) clarified that root diameter was significantly affected by the interaction of plant density x potassium level in both season. The thickest root was obtained from sowing 28000 plant with 48 kg K_2O/fed in both seasons where it gave (15.0 and 14.6 cm) while sowing of 42000 plant/fed with 24 kg K_2O/fed recorded the thinnest root (11.4 and 11.3 cm) in the 1st and 2nd seasons, respectively. The thickness of root may be attributed low plant density/unit area and high K-level. This finding coincides with that reported by Moustafa *et al* (2006).

4.3. Phosphorus level x potassium level interaction:

Results given in Table (10) pointed out potassium%, purity % and sugar loss in molasses were significantly affected by the interaction between phosphorus and potassium levels in 2009/2010 season. From results, it is noticed that applying 30 kg P_2O_5/fed + 24 kg K_2O/fed recorded the highest value of Purity (97.32%) while the same interaction attianed the lowest value of potassium content (1.7 mg) and sugar loss in molasses (0.88%) compared with the other interactions. On the contrary, these results showed a reverse result between purity% from side and each of potassium content and sugar loss in molasses% from the other side. In general, the increasing quality traits values, the decreasing impurities content values. This result may be due to the balanced amounts of phosphorus and potassium which are enough to appear the fruitful effect of PK on these traits. This result is in accordance with that obtained by Ibrahim (1998), Khan *et al* (1998) and Ismail and Abo El-Ghait (2004).

Table (9): Root diameter of sugar beet as affected by plant density x potassium level interaction (2009/2010 and 2010/2011 seasons).

Plant density x potassium level interaction	2009/2010 season	2010/2011 season
28000 plant + 24 kg K_2O/fed	14.7	13.9
33600 plant + 24 kg K_2O/fed	13.3	11.9
42000 plant + 24 kg K_2O/fed	11.4	11.3
28000 plant + 48 kg K_2O/fed	15.0	14.6
33600 plant + 48 kg K_2O/fed	13.9	13.7
42000 plant + 48 kg K_2O/fed	12.6	12.4
LSD 0.05	0.4	0.4

Table (10): Potassium content, purity% and sugar loss in molasses % of sugar beet as affected by phosphorus level x potassium level interaction (2009/2010 season).

Phosphorus level x potassium level interaction	K (mg/100 beet)	Purity%	Sugar loss in molasses%
15 kg P_2O_5/fed+24 kg K_2O/fed	2.12	97.01	0.91
30 kg P_2O_5/fed+24 kg K_2O/fed	1.70	97.32	0.88
15 kg P_2O_5/fed+48 kg K_2O/fed	1.86	97.17	0.92
30 kg P_2O_5/fed+48 kg K_2O/fed	1.92	97.01	0.95
LSD 0.05	0.23	0.30	0.05

Otherwise, the 1st and 2nd interactions order among plant density, phosphorus level and potassium level which did not reach a significant level will respect to the studied traits in both seasons were removed from the previous Tables.

REFERENCES

Abo EL- Ghait, R.A. and Dalia I.H.EL-Geddawy (2013). Yield and quality of some sugar beet varieties as affected by different methods of potassium application . Minufiya .J.Agric Res. Vol (38) No. 1(1): 139-147.

Arita, T., T. Kajiyama and M. Tezuka (1998). Effect of increased plant population by narrow row width (50 cm) on directly sown sugarbeet. Bull. Hokkaido Prefectural Agric. Exp. Stat., 77, 23-26.

Caliskan, M.E., N. Isler, E. Gunel and M.B. Guler (1998). Effects of sowing date and row spacing on yield and quality of some sugarbeet (*Beta vulgaris* L.) cultivars in Hatay. Turkish J. Agric. and Forestry., 23, Supplement 5, 1155-1161.

Carruthers, A., J.F.T. Oldfield and H.J. Teague (1962). Methods for assessment of beet quality. 15th Annual Technical Conference, British Sugar Corporation LTD. 36pp. (C.F. The Sugar Beet Crop Book, 572-573, 1st

Edition published by Chapman and Hall, Univ. Press, Cambridge, UK.).

Devillers, P. (1988). Prevision du sucre melasse. Sucrerie francases. 129, 190-200. (C.F. The Sugar Beet Crop. Book, 575-576, 1st Edition published by Chapman and Hall, Univ. Press, Cambridge, UK.) .

Dexter, S.T., M.G. Frankes and F.W. Snyder (1967). A rapid and practical method of determining of extractable white sugar as may be applied to the evaluation of agronomic practices and grower deliveries in the sugar beet industry. J. Am. Soc. Sugar Beet Technol. 14, 433-454.

El-Essawy, I.I. (1996). Effect of nitrogen, phosphorus and potassium fertilizers on yield and quality of sugar beet, J. Agric. Res., Tanta Univ., 22(2): 270-278.

El-Geddawy, I.H., A.M. A. El-Shafai and A.B. Azzazy (2006). Yield and quality of some sugar beet varieties as affected by planting densities and nitrogen fertilization. J. Agric. Sci. Mansoura Univ, 31 (1): 43-54.

El-Shafai, A.M.A. (2000). Effect of nitrogen and potassium fertilization on yield and quality of sugar beet in Sohag. Egypt. J. Agric. Res., 78(2): 759-767.

Ferweez, H., Maha M. EL-Zeny and A.M. Allwan (2010). Effect of planting densities on productivity and quality of sugar beet(*Beta vulgaris* ,L) under Middl Egypt conditions. Minia J.of Agric. Res. And Devlop. Vol. (30) No.3 : 363-376.

Ibrahim, M.F.M. (1998). The effect of some fertilization elements on the yield and quality of sugar beet. Ph.D. Thesis, Fac. Agric., Moshtohor, Zagazig Univ., Egypt.

Ismail, A.M.A. and R. Abo El-Ghait (2004). Effect of balanced fertilization of NPK on yield and quality of sugar beet._Egypt. J. Agric. Res., 82(2): 717-729.

Ismail, A.M.A., Kh. A. Aboushady and S. M. Allam (2002). Response of some sugar beet varieties to methods of potassium application. Egypt. J. Appl. Sci., 17(2): 86-101.

Jaszczolt, E. (1998). Sugarbeet fertilization with phosphorus in relation to the richness of soil in available phosphorus. Gazeta Cukrownicza., 106 (4): 72-73.

Kemp, P.D., A.M. Khani and J.P. Millner (1996). The effect of plant population and nitrogen level on sugar yield and juice purity of sugar beet (*Beta vulgaris*). Proc. Annl Conf. Agron. Soc. New Zealand., 24: 131-134.

Khan, M.A.A., R.A. Singhania, B. Hameedunnisa, K. Lakshminarayana, T. Srinivas and H. Begum (1998). Effect of nitrogen and phosphorus fertilization on nutrient status and uptake in sugarbeet. Intern. J. Tropical Agric., 14(1-4): 169-175.

Laurer, J.G. (1995). Plant density and nitrogen rate effects on sugar beet yield and quality early in harvest. Agron. J. 87(3): 586-591.

Moustafa, Shafika, N. and A.A. EL Masry (2006). Effect of nitrogen and potassium fertilization with or without spraying by iron combined with manganese on some physio- chemical properties, productivity and quality of sugar beet crop. Annals Of Agric. Sc., Moshtohor 44 (4): 1431- 1446.

Moustafa, Zeinab, R., Shafika, N. Moustafa, K. A. Aboushady and K. E. Mohamed (2006). Effect of foliar spray with IAA and/or kinetin on physio-chemical properties and yields of sugar beet plants. Egypt. J. Agric. Res., 84(2): 477-492.

Nassar, A.M. (2001). Effect of plant densities on the productivity of some sugar beet varieties. J. Agric. Sci. Mansoura Univ., 26(12): 7533-7546.

Page, A.L. (1982). "Methods of Soil Analysis". Chemical and Microbiological Properties. 2nd Ed., Amer. Soc. Agron. Inc. Publ. Madison, Wisconsin, USA.

Snedecor, G.W. and W.G. Cochran (1981). Statistical Methods. Seventh Ed. Iowa State Univ. Press, Ames., Iowa, USA.

Sogut, T. and H. Aroglu (2004). plant densities and sowing date effects on sugar beet yield and quality. J. Agron., 96(3): 215-218. (c.f. CAB Abstracts, record 73 of 649).

تأثير الكثافة النباتية والتسميد الفوسفاتى والبوتاسى على محصول وجودة بنجر السكر

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أقيمت تجربة حقلية بمحطة بحوث سخا بمحافظة كفر الشيخ (خط عرض٣١° شمال خط الاستواء وخط طول٣٠° شرق خط جرينتش) خلال موسم٢٠٠٩/٢٠١٠ و ٢٠١٠/٢٠١١ واشتملت الدراسة على ثلاثة كثافات نباتية هى (٤٢٠٠٠ و ٣٣٦٠٠ و ٢٨٠٠٠ نبات/فدان) وذلك بالزراعة فى جور على مسافات(٢٠ و ٢٥ و ٣٠ سم بين الجور) على الترتيب ، ومستويين من التسميد الفوسفاتى (١٥ و٣٠ كجم فو٢أ٥/فدان) ومستويين من التسميد البوتاسى (٢٤ و ٤٨ كجم بو٢أ/فدان).

أستخدم تصميم القطع المنشقة مرة واحدة فى ثلاث مكررات وكان الصنف (بلينو) هو الصنف المستخدم فى التجربة وقد أوضحت نتائج التجربة مايلى:

زادت قيم صفات طول الجذر والنسبة المئوية للسكروز والنسبة المئوية للسكر المستخلص بزيادة الكثافة النباتية الى ٤٢٠٠٠ نبات/فدان فى الموسمين ومحصول السكر والنسبة المئوية للنقاوة فى الموسم الثانى فقط بينما انخفضت قيم صفات سمك الجذر والوزن الطازج الجذر ومحصول الجذور ومحتوى الصوديوم فى الموسمين.

زادت قيم صفات طول الجذر وسمك الجذر والوزن الطازج الجذر ومحصول الجذور ومحصول السكر ومحتوى الصوديوم والفا امينو نيتروجين بزيادة مستويات التسميد الفوسفاتى الى ٣٠ كجم فو٢أ٥ للفدان فى الموسمين وصفات النسبة المئوية للسكروز ونسبة السكر المفقود فى المولاس والنسبة المئوية للسكر المستخلص فى الموسم الثانى بينما انخفضت النسبة المئوية للنقاوة.

زادت قيم صفات طول الجذر وسمك الجذر والوزن الطازج الجذر ومحصول الجذور و محصول السكر ومحتوى الفا امينو نتروجين والنسبة المئوية للسكروز و والنسبة المئوية للسكر المستخلص بمستويات التسميد البوتاسى الى٤٨ كجم فو٢أ٥ للفدان فى الموسمين وصفات محتوى البوتاسيوم والنسبة المئوية للسكر المفقود فى المولاس فى الموسم الثانى بينما انحفضت النسبة المئوية للنقاوة.

وكان للتفاعل بين عوامل الدراسة (الكثافة النباتية والتسميد الفوسفاتى والتسميد البوتاسى) تأثير معنوى على بعض الصفات المحصولية والتكنولوجية لبنجر السكر.

يوصى هذا البحث بزراعة تقاوى بنجر السكر(صنف بلينو) بمعدل ٤٢٠٠٠ نبات/فدان مع التسميد الفوسفاتى والبوتاسى بمعدل (٣٠ كجم فو٢أ٥/فدان + ٤٨ كجم بو٢أ/فدان) للحصول على أعلى محصول جذور وسكر تحت ظروف محطة بحوث سخا بمحافظة كفر الشيخ.