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EFFECT OF PLANT DENSITIES AND POTASSIUM FERTILIZATION RATES ON YIELD AND QUALITY OF SUGAR BEET CROP IN SANDY RECLAIMED SOILS. (*Beta vulgaris* L.).

Nafei. A.I.; A.M.H. Osman and Maha M. El.Zeny
Agron. Dept., Sugar Crops Res. Inst., Agric. Res. Center, Giza.

ABSTRACT

Two field experiments were carried out during 2007/2008 and 2008/2009 seasons at Kafr El-Hammam Research Station, Sharkia Governorate to study the effect of planting densities and potassium fertilizer levels as well as their interaction on sugar beet productivity.

Increasing plant densities from 28000 to 42000 significantly increased root length, diameter, fresh weight/plants, sucrose%, total soluble solids (TSS%), phosphorus % in roots as well as top, root and sugar yields (ton/fed) in both seasons. Plant density at 42000 plants/fed was the best treatment, where it gave the highest values on most traits under study.

Potassium fertilizer level at 36 Kg K_2O/fed gave significant increase root length, diameter, fresh weight/plant, total soluble solids% and root yield in both seasons as well as sugar yield in the 1st season only. In general, potassium at the level 36 kg K_2O/fed was more effective than at 18 kg K_2O/fed.

Interaction between plant densities and potassium fertilization levels do not gave any significant increase on all studied traits.

In general it can be concluded that sowing sugar beet with 42000 plants/fed and potassium fertilizer levels at 36 kg K_2O/fed were the best treatment for maximizing sugar beet productivity in the newly reclaimed sandy soils under the environmental conditions of the present study.

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) ranks the second important sugar crop after sugar cane, producing annually about 40% of sugar production all over the world. Despite the newness of sugar beet in Egypt, it has a large importance where, there are wide newly reclaimed soils at the East parts of Egypt, that could be cultivated with sugar beet without competition from other winter crops because of its tolerance to salinity and the ability to produce high yields of sugar under saline soil and water conditions, compared with most of other traditional winter crops. The total sugar beet cultivated area reached 260000 fed with an average tonnage of 19 tons i.e., the total sugar beet production in 4791000 tons of sugar that contributed to about 30% of total sugar production in Egypt (Annual Report of Sugar Crops Council, 2008). Sugar beet growth is largely influenced by the agronomic practices as crop stand and fertilization, especially in the newly reclaimed soils characterized with low content of organic matter and nutrients, which ultimately affect root and sugar yields. 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 thin stand large sized beets with little quality i.e. more fibers, water and less sucrose content will be produced.

The optimum plant densities in sugar beet is very necessary to have high root yield with good quality. Laurer (1995) compared plant densities of 37100, 61800, 86500, and 111200 plants/ha and found that sucrose content increased by 5 g/kg as plant densities increased from 37000 to 111200 plants/ha. Kemp *et al*. (1996) sowing 60000, 80000, 100000, 120000 and 140000 plants/ha and found that maximum root fresh weight was obtained at 60000 plants/ha, maximum sugar yield at 80000 plants/ha and juice purity ranged from 89% at 140000 plants/ha to 82% at 60000 plants/ha. Arita *et al*. (1999) planted 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 between spacing. Nassar (2001) found that increasing plant densities from 33600 up to 70000 planst/fed increased sucrose and purity% and application of 42000 plants/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 densities from 33600 up to 46666 plants/fed significantly increased purity% and root as well as sugar yields. Ismail and Allam (2007) show that plant densities significantly affected root length and diameter, fresh weight/plants, as well as sodium% and sucrose% in both seasons in addition to sugar yield in the 2^{nd} one. They added that sowing sugar beet at 28000 and 42000 plants/fed gave the highest yield of root and sugar (tons/fed) and quality traits, respectively.

Potassium (K) 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. Potassium is essentially element in plant life, promotes root growth and is conductive for higher sugar accumulation through its role in the photosynthesis process. Sugar beet yield and quality are greatly influenced by the applied K fertilization levels. El-Essawy (1996) showed that the K fertilization at 24 kg K_2O/fed increased quality (sucrose% and purity %), as well as root and sugar yields of sugar beet plants. Ibrahim (1998) found that 48 kg K_2O/fed significantly increased values of root length, diameter and fresh weight/plants, sucrose and purity% as well as root and sugar yields (tons/fed). El-Shafai (2000) obtained that high root fresh weight, sugar yield (tons/fed) and sucrose% were recorded from increasing K level up to 48 kg K_2O/fed while root yield and purity did not affect. Ismail *et al.* (2002) found that a significant increase in root fresh weight/plants, sucrose%, purity %, root and sugar yields were obtained 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 and sugar yields at K level up to 48 kg K_2O/fed.

Shafika and El- Masry (2006) found that decreasing soil K fertilizer from 24 to12 Kg K_2O/fed gave an obvious reduction in root diameter, length, fresh weight/plants and yields of root and sugar as well as root impurities content (K, Na and a-amino-N), while purity% was increased. Ismail and Allam (2007) show that Potassium level significantly affected root length, root diameter, root fresh weight, root yield, sugar yield, alfa-amino nitrogen content and sucrose% in both seasons, while potassium content and purity% were significantly influenced by potassium level only in the 2nd season. The aim of the present work was to find out the optimal K levels required for sugar beet sown in sandy reclaimed soil at different plant densities to obtain the maximum yield and quality of sugar beet.

MATERIALS AND METHODS

Two field trials were carried out at Kafr El-Hammam Research Station, Sharkia Governorate during 2007/2008 and 2008/2009 seasons, to study the effect of plant densities and potassium fertilizer levels as well as their interactions on growth, yield and quality of sugar beet. seeds of a multigerm sugar beet variety (Sultan) were planted on 15 November in both seasons. The experimental design was a split-plot design with four replication, three plant densities, 28000 plants/fed [on ridges in 50 cm width and 30 cm between hills)], 33600 plants/fed [on ridges in 50 cm width and 25 cm between hills)] and 42000 plant/fed [on ridges in 50 cm width and 20 cm between hills)] respectively, were allocated in the main plots and three potassium fertilizer levels i.e. 0, 18 and 36 kg K_2O/fed), respectively were randomly allotted in the sub-plots, each sub plot was 14 m^2 (7 meters in length x 2 meters in width) thus, the area of the plot 1/300 fed. Nitrogen fertilizer levels at the rate of 120 kg N/fed was applied in four equal portions, the first was applied after thinning and 15 days between the other. The source of nitrogen fertilizer level was mineral fertilizer, in the form of ammonium nitrate (33.5%). Super phosphate calcium (15.5% P_2O_5) at the rate of 30 kg P_2O_5/fed was added during land preparation. Potassium fertilizer levels were applied in four equal portions with nitrogen fertilizer in the form of potassium sulfate (48% K_2O). Manual planting was achieved in hills with approximately 3-4 seeds per hill and then plants were thinned at the fourth leaves stage (after 45 days from sowing) to obtain one plant per hill. Before soil preparation, soil samples were taken at a depth of 30-50 cm from different experimental sites, to determine physical and chemical properties of soil according to Piper, 1950 in Table 1.

Table 1: Physical and Chemical analysis of the experimental soil (as an averages of the two seasons).

Particle size			Soil textural	E.C. ds/m	Soil pH (1:2.5)	Organic matter %	CaCO$_3$ %
Sand %	Silt %	Clay %					
59.7	25.3	15.0	Sand silty loam	0.90	7.2	1.18	30.8

Soluble Cations (meq/L)				Soluble anions(meq/L)				available contents (ppm)		
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	N	P	K
2.03	3.02	4.24	0.15	0.15	0.11	6.02	3.27	17.9	20.2	56.3

Plants were harvested when the outside leaves of these plants turned yellow (after 210 days from sowing). At harvest, ten sugar beet plants were taken at random from each plot to estimate the following characters i.e. root length (cm), root diameter (cm), root fresh weight (g/plants), thereafter, roots and tops were separated and each was weighted in kg, then after, it was converted to estimate root and top yields (ton/fed). Sugar yield (ton/fed) was calculated by multiplying root yield by sucrose%, total soluble solids of roots (TSS%), which was determined in fresh root by using hand refractometer. Sucrose% was estimated polarimetrically on a lead acetate extract of fresh macerated roots according to Le-Docte (1927). Juice purity% was calculated by dividing sucrose% / TSS% according to the method of (Carruthers *et al.,* 1962). Some macro-elements (N, P and K g/100g beet) were determined according to the method described by A.O.A.C. (1988**)**.

Statistical analysis: The proper statistical analysis of the recorded data was carried out according to Gomez and Gomez (1984). The differences between means of the treatments were compared using the least significant difference (LSD) at 5% level.

RESULTS AND DISCUSSION

A.1. Effect of plant density on top, root and sugar yield (tons/fed) of sugar beet crop during 2007/2008 and 2008/2009 seasons.

Data in Table 2 reveal that the effect of plant densities namely 28000, 33600 and 42000 plants/fed on top, root and sugar yield (tons/fed) of sugar beet plant. Significantly differences in top, root and sugar yield (tons/fed) as affect by plant densities in both seasons. The maximum yields of top, root and sugar (tons/fed) were obtained at 42000 plants/fed were 16.42, 35.35 and 5.72 in the 1st season and 17.91, 38.53 and 6.40 in the 2nd season, respectively, as compared with other plant densities Similar observations were obtained by Sogut and Aroglu (2004), El-Geddawy *et al.* (2006) and Ismail and Allam (2007).

Table 2: Effect of plant densities on top, root and sugar yield (tons/fed) and nitrogen, phosphorus and potassium % of sugar beet roots during 2007/2008 and 2008/2009 seasons

			2007/2008			
Plant densities	**Top yield (tons/fed)**	**Root yield (tons/fed)**	**Sugar yield (tons/fed)**	**N %**	**P %**	**K %**
28000	15.10	31.55	4.53	1.079	0.387	1.073
33600	15.81	33.23	5.05	1.093	0.399	1.074
42000	16.42	35.35	5.72	1.120	0.460	1.101
F. Test	*	*	*	NS	*	NS
LSD at 5%	0.81	1.42	0.24	-	0.03	-
			2008/2009			
28000	17.26	37.28	5.67	1.073	0.392	1.079
33600	17.84	35.65	6.08	1.070	0.434	1.093
42000	17.91	38.53	6.40	1.106	0.453	1.119
F. Test	*	*	*	NS	*	NS
LSD at 5%	0.55	1.15	0.32	-	0.05	-

A.2. Effect of plant density on macro-elements (N, P and K g/100g beet) of sugar beet roots during 2007/2008 and 2008/2009 seasons.

Minerals imparticular potassium disturbs crystallization during sugar processing and thus affects the sugar output and its purity. Data in Table 2 show that the effect of plant densities on nitrogen, phosphorus and potassium%. Generally, phosphorus% was significant difference, the highest values obtained from 42000 plants/fed were 0.460, 0.453 in both seasons, respectively. This result is in agreement with that obtained by Ismail and Allam (2007).

B.1. Effect of potassium fertilizer levels (K_2O/fed) on top, root and sugar yield (tons/fed) of sugar beet crop during 2007/2008 and 2008/2009 seasons.

Data in Table 3 show that the effect of potassium fertilization levels namely 0, 18 and 36 kg K_2O/fed on top, root and sugar yield (tons/fed) of sugar beet plant. It is notice that increase potassium fertilization levels up to 36 kg K_2O/fed significantly increase root yield of sugar beet in both seasons. Also, sugar yield in the 1st season only and obtained the maximum values of top, root and sugar yield (tons/fed) were 16.74, 35.45 and 5.58 in the 1st season and 18.27, 39.90 and 6.53 in the 2nd season, respectively. These increase in root and sugar yields may be due to that potassium fertilizer 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. These findings are in line with those observed by Ismail and Abo El-Ghait (2004), Shafika and El- Masry (2006) and Ismail and Allam (2007).

Table 3: Effect of potassium fertilizer levels on top, root and sugar yield (tons/fed) and nitrogen, phosphorus and potassium % of sugar beet roots during 2007/2008 and 2008/2009 seasons

Potassium fertilizer levels (K_2O/fed)	Top yield (tons/fed)	Root yield (tons/fed)	Sugar yield (tons/fed)	N %	P %	K %
2007/2008						
0	14.23	29.45	4.35	1.091	0.410	1.073
18	16.36	35.23	5.38	1.074	0.390	1.083
36	16.74	35.45	5.58	1.127	0.446	1.092
F. Test	NS	*	*	NS	NS	NS
LSD at 5%	-	4.08	0.99	-	-	-
2008/2009						
0	16.83	35.44	5.39	1.073	0.461	1.090
18	17.91	39.12	6.23	1.083	0.423	1.074
36	18.27	39.90	6.53	1.092	0.396	1.127
F. Test	NS	*	NS	NS	NS	NS
LSD at 5%	-	3.44	-	-	-	-

B.2. Effect of potassium fertilizer levels (K_2O/fed) on macro-elements (N, P and K g/100g beet) of sugar beet roots during 2007/2008 and 2008/2009 seasons.

Minerals imparticular potassium disturbs crystallization during sugar processing and thus affects the sugar output and its purity. Data in Table 3 show that the effect of potassium fertilization levels on nitrogen, phosphorus and potassium%. It is also found that increase of potassium fertilizer level up to 36 kg K_2O/fed did not cause any significant for nitrogen, phosphorus and potassium% in both seasons. Our results are in accordance with that observed by Shafika and El- Masry (2006) and Ismail and Allam (2007).

C.1. Effect of plant densities on some root growth characters of sugar beet crop during 2007/2008 and 2008/2009 seasons:

Data in Table 4 indicate that the effect of plant densities at 28000, 33600 and 42000 plants/fed on root length, diameter and fresh weight/plant in both seasons. It is notice that, increase plant densities up to 42000 plants/fed were significant increase on root length, diameter and fresh weight/plant in both seasons, which ranked first, followed by plant density was 33600 plants/fed and the last was 28000 plants/fed. Plant density at 42000 plants/fed gave the highest values were 27.40, 15.72 and 1178.3 in the 1st season and 26.57, 17.18 and 1288.3 in the 2nd season, respectively. These results are in accordance with those reported by Kemp *et al.* (1996) and Ismail and Allam (2007).

Table 4: Effect of plant densities on root characters and juice quality% of sugar beet crop during 2007/2008 and 2008/2009 seasons

Plant densities	Root length (cm)	Root diameter (cm)	Root fresh weight (g)	Total Soluble solids (TSS%)	Sucrose %	Purity %
2007/2008						
28000	25.74	14.02	1051.7	19.10	14.35	75.24
33600	26.49	14.77	1079.4	19.61	15.19	77.80
42000	27.40	15.72	1178.3	20.24	16.16	80.10
F. Test	*	*	*	*	*	NS
LSD at 5%	0.63	0.63	47.39	0.44	0.64	-
2008/2009						
28000	25.62	16.57	1242.5	20.80	15.15	72.91
33600	26.26	17.12	1284.2	20.90	15.70	75.46
42000	26.57	17.18	1288.3	21.44	16.47	76.48
F. Test	*	*	*	*	*	NS
LSD at 5%	0.28	0.51	38.18	0.48	0.58	-

C.2. Effect of plant densities on root juice quality characters of sugar beet crop during 2007/2008 and 2008/2009 seasons:

Sugar beet quality depends primarily on sugar content, the content of total soluble solids (TSS%) and purity%. Data in Table 4 revealed that plant densities at 42000 plants/fed gave significant increase for TSS% and sucrose% comparing with plant densities 33600 and 28000 plants/fed. The highest mean values were 20.24 and 16.16 in the 1st season and 21.44 and 16.47 in the 2nd season, respectively. It is also found that plant densities from 28000 to 42000 plants/fed did not cause any significant for purity% in both seasons. This finding could be attributed to increase root size and impurities content resulted to increase plant density up to 42000 plants/fed. These findings are in good agreement with those obtained by Laurer (1995) and Ismail and Allam (2007).

D.1. Effect of potassium fertilizer levels (K_2O/fed) on some root growth characters of sugar beet crop during 2007/2008 and 2008/2009 seasons.

Data in Table 5 indicate that the effect of potassium fertilizer levels at 0, 18 and 36 kg K_2O/fed on root length, diameter and fresh weight/plant in both seasons. Increase potassium fertilizer levels up to 36 kg K_2O/fed significant increase in root length and diameter, as well as root fresh weight, which ranked first, followed by 18 kg K_2O/fed and control (zero K_2O/fed) in aforementioned characters. Potassium fertilizer level at the rate of 36 kg K_2O/fed was the favorable which recorded the highest mean values were 27.58, 15.76 and 1181.56 in the 1st season and 27.01, 17.73 and 1330.01 in the 2nd season, respectively, Our results are in accordance with that observed by Ismail and Abo El-Ghait (2004), Shafika and El- Masry (2006) and Ismail and Allam (2007).

Table 5: Effect of potassium fertilizer levels on root characters and juice quality% of sugar beet roots during 2007/2008 and 2008/2009 seasons

2007/2008						
Potassium fertilizer levels (K_2O/fed)	**Root length (cm)**	**Root diameter (cm)**	**Root fresh weight (g)**	**Total soluble solids (TSS%)**	**Sucrose %**	**Purity %**
0	24.59	13.09	981.67	18.30	14.77	80.71
18	27.47	15.66	1174.11	20.29	15.20	74.98
36	27.58	15.76	1181.56	20.36	15.73	77.45
F. Test	*	*	*	*	NS	NS
LSD at 5%	2.43	1.82	136.02	1.61	-	-
2008/2009						
0	24.89	15.75	1181.26	20.18	15.20	74.21
18	26.54	17.38	1303.76	21.31	15.79	75.38
36	27.01	17.73	1330.01	21.75	16.33	75.26
F. Test	*	*	*	*	NS	NS
LSD at 5%	1.72	1.53	114.70	1.02	-	-

D.2. Effect of potassium fertilizer levels (K_2O/fed) on root juice quality characters of sugar beet crop during 2007/2008 and 2008/2009 seasons:

Data in Table 5 indicate that the effect of potassium fertilizer levels on total soluble solids, sucrose and purity% of sugar beet roots. The increase was significant for TSS% in both seasons, the highest mean values were 20.36 and 21.75 in both seasons, respectively. It is also found that increased potassium fertilizer level from zero control treatment to 36 kg K_2O/fed did not cause any significant for sucrose and purity% in both seasons. Application of 36 kg K_2O/fed increased mean values of these traits in both seasons. These finding are in the same line with those observed by Ismail and Abo El-Ghait (2004), Shafika and El- Masry (2006) and Ismail and Allam (2007).

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تـأثير الكثافـة النباتيـة والتسـميد البوتاسـى علـى محصـول وجـودة بنجـر السـكر فـى الاراضى الرملية المستصلحة

عبد الله ابراهيم نافع ، عادل محمود حسن عثمان ومها محمد الزينى
قسم بحوث المعاملات - معهد بحوث المحاصيل السكرية – مركز البحوث الزراعية

أقيمت تجربتان حقليتان بمحطة بحوث كفر الحمام بمحافظة الشرقية خلال موسم ٢٠٠٨/٢٠٠٧ و ٢٠٠٩/٢٠٠٨ واشتملت الدراسة على ثلاثة كثافات نباتية ٤٢٠٠٠ و ٣٣٦٠٠ و ٢٨٠٠٠ نبات/فدان وذلك باخذ مسافات (٢٠ و ٢٥ و ٣٠ سم بين الجور على الترتيب) ، وثلاثة مستويات من التسميد البوتاسى (صفر و ١٨ و ٣٦ كجم بو٢أ/فدان). أستخدم تصميم القطع المنشقة مرة واحدة فى أربع مكررات وكان الصنف المستخدم فى التجربة سلطان

وقد أوضحت نتائج التجربة مايلى:

- ادت زيادة الكثافة النباتية من ٢٨ الى ٤٢ الف نبات للفدان الى زيادة معنوية لطول الجذر وقطر الجذر والوزن الطازج للجذر والنسبة المئوية للمواد الصلبة الذائبة الكلية والسكروز والنسبة المئوية للفوسفور فى الجذور وايضا محصول العرش والجذر والسكر طن/فدان فى كلا الموسمين على الترتيب. وتم الحصول على اعلى متوسط لمحصولى الجذور والسكر ٣٥,٣٥ و ٥,٧٢ فى الموسم الاول وكذلك ٣٨,٥٣ و ٦,٤٠ فى الموسم الثانى على الترتيب.
- ادى زيادة التسميد البوتاسى من صفر حتى ٣٦ كجم بو٢أ للفدان الى زيادة معنوية لطول الجذر وقطر الجذر والوزن الطازج للجذر والنسبة المئوية للمواد الصلبة الذائبة الكلية ومحصول الجذور فى كلا الموسميين على الترتيب بينما زاد معنويا محصول السكر فى الموسم الاول فقط. وتم الحصول على اعلى متوسط لمحصولى الجذور والسكر ٣٥,٤٥ و ٥,٥٨ فى الموسم الاول وكذلك ٣٩,٩٠ و ٦,٥٣ فى الموسم الثانى على الترتيب.
- لم يكن للتفاعل بين الكثافة النباتية ومستويات التسميد البوتاسى اى تاثير معنويا على الصفات تحت الدراسة.

يوصى هذا البحث بزراعة تقاوى بنجر السكر بمعدل ٤٢٠٠٠ نبات/فدان مع التسميد البوتاسى بمعدل ٣٦ كجم بو٢أ /فدان للحصول على اعلى محصول جذور وسكر للفدان تحت ظروف هذا البحث.

قام بتحكيم البحث

أ.د / محسن عبد العزيز بدوي	**كلية الزراعة – جامعة المنصورة**
أ.د / زينب رمضان مصطفي	**مركز البحوث الزراعية**