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EFFECT OF POTASSIEN FERTILIZER ON QUALITY AND PRODUCTIVITY OF SUGAR BEET

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ABSTRACT

A field experiment was conducted in 2010/2011 and 2011/2012 seasons at Sakha Agricultural Research Station, Kafer El-Sheikh Governorate to study the effect of Potaissien-N and/or -P fertilizers (1 litter/300 litter water/fed) as a foliar application and three potassium fertilizer rates (12,24 and 48kg K_2O /fed) as soil application on quality and productivity of sugar beet (Desperes poly N variety). A split plot design with three replications was used, where potassien-N and/or -P were arranged in the main plots and the three potassium rates were allocated in the sub plots.

The results showed that foliar applications with potassien significantly affected yields of root and sugar (ton/ fed), and α-amino-N % in the 1st season, Na, K and purity percentages in the 2nd season, as well as sucrose % in both seasons. Potassien-N gave the highest root and sugar yields (ton/ fed) and sucrose % in the 1st season, and purity% in the 2nd season. On the contrary, it gave lowest Na% in the 2nd season. Potassium as soil application, significantly affected sugar yield (ton/ fed) and α-amino-N % in the 1st season; sucrose, sugar extractable and extractability percentages in the 2nd season, as well as Na and purity in both seasons. It is worth mentioning that sugar beet plants fertilized with 24 kg K_2O/fed maximized sugar yield in first season, and sucrose, purity, extractable sugar and extractability percentages, while Na% significantly decreased in the second season. Foliar application with potassien- N and fertilized with potassium at rate 24 kg K_2O/fed increased root yield, sugar yield, extractable sugar and extractability percentages by 30.72,43.23, 16.75 and 20.85%, respectively, compared to using 48 kg K_2O /fed (recommended rate).

Key words: *potassium fertilizer, potassien , productivity, quality, sugar beet*

1. INTRODUCTION

In Egypt, sugar production is still insufficient for local consumption. Therefore, many attempts were devoted to improve quality and quantity of sugar beet plants, which may be done through plant fertilization. Foliar application of nutrients is one of the most important methods to substitute soil application of fertilizers, where it saves a considerable amount of nutrients lost by fixation and reduces the environmental pollution. Potassium is known for its role in sucrose transportation and accumulation in storage tissues of plants. It is one of the major elements needed for vegetative growth and sugar synthesis.

K^+ is considered to be the most important cation not only for its relative amounts but also for its physiological and chemical functions. This could be because K^+ is usually absorbed as a single charge cation by an active mechanism and it canbe translocated along electrochemical potential gradient (Roghieh and Arshad, 2009).

El-Shafai (2000) obtained significant increase in root fresh weight/plant, sugar yield and sucrose percentage as K^+level was increased from zero to 48 kg K_2O/fed, while root yield was insignificantly increased. Purity percentage was not significantly affected by K^+ fertilizer level. Ismail, *et al.* (2002) obtained a significant increase in root fresh weight/plant, purity%, and root and sugar yields. Sucrose, sugar extractable and extractability % significantly increased with application of 24 kg K_2O/fed and one spray of potassien nutrient solution. Ismail and Abo El-Ghait (2004) obtained highly root length, sucrose %, root yield and sugar yield from increasing K^+ levels up to 48 kg K_2O/fed. Hilal (2005) reported that root fresh weight, sucrose percentage, root and sugar yields (t/fed) increased significantly with increasing potassium fertilizer rates. Moustafa *et al*. (2006) found that decreasing soil application of potassium fertilizer from 24 to 12 kg K_2O/fed gave an obvious reduction in root diameter, length, fresh weight, yields of root and sugar as well as root impurities content (K^+ and alpha amino-N percentages) and some technological parameters (sugar loss to molasses and extractable sugar percentages), while purity % increased. Moustafa and El-Masry (2006) obtained high root and sugar yields/fed as well as sucrose %, purity %, and impurities content (α-amino-N, Na^+ and K^+) from increasing potassium level up to 48 kg k_2O/fed. Enan (2011) found that the application of 24 kg K_2O/fed + two sprays of potassein gave the highest values of root length, root diameter, root and top fresh weight (g/plant), as well as root, top and sugar yields/fed, purity % and sucrose % in both seasons. Soudi *et al*. (2012) studied the effect of different levels of Potassien-P as foliar application and 24 kg K_2O/fed to soil as a starter dose in sugar cane, they found that Potassien-P gave the highest values of purity and sugar yield (t. /fed).

This study was carried out to define the optimal rate of potassium with Potassien to reduce the pollution and achieve the highest quality and productivity of sugar beet plants under (North Delta conditions)Sakha Agricultural Experimental Research Station, Kafr El-Sheikh Governorate.

2. MATERIALS AND METHODS

The field experiment was conducted at Sakha Agricultural Experimental Research Station, Kafr El-Sheikh Governorate, Egypt , during 2010/2011 and 2011/2012 seasons to study the effect of potassium fertilizer as soil application and Potassien-N and/or Potassien-P as foliar application on quality and yields of sugar beet.

Soil samples were randomly taken from the experimental sites at a depth of 30 cm from soil surface and were prepared for both mechanical and chemical properties analyses (mean of two seasons).

The mechanical analysis was (Coarse Sand 4.95%, Fine sand 17.75%, Silt 31.1% and Clay 46.2%). The soil type was silty clay. The chemical analysis was ($CaCo_3$ 2.67 %, E.C (1:5d sm^{-1}) 3.14, pH 8.14, Organic Matter 1.81% and (available nutrients (ppm) were Na 28.7, P 8.98 and K 38.7). The soil tests indicated that available K^+ is below the optimum levels (60-120 ppm) of the amount of potassium, where the recorded K^+ was 38.7 ppm.

Soil was fertilized with 30 kg P_2O_5 / fed in the form of calcium super phosphate (15.5% P_2O_5) during soil preparation, 90 kg N/fed in the form of urea (46.5%N) was applied in two equal doses, after thinning and month later.

The preceding summer crop was corn in both seasons. Sugar beet was sown on 15 and 20 October 2010 and 2011, respectively.

Seeds were planted by hand in hills approximately 3-4 seed balls / hill. Plants were thinned to one plant / hill, spacing between hills was 20 cm after 45 days from sowing. Other cultural practices were done as recommended, in sugar beet fields.

A split plot design with three replications was used, where the potassien foliar application control (without potassium), potassien-N (30 % K^+, 8 % N) and potassien–P (30 % K^+, 10 % P) at rate 1 litter/ 300 litter water/fed three times, the first after 8 weeks, the second after 10 weeks and the third one after 12 weeks age were arranged in the main plots. the three potassium rates as soil application 48 (recommended rate), 24 and 12 kg K_2O/fed were allocated in the sub plots. Potassium fertilizer was applied in two equal doses the 1*st* one was applied before sowing and the 2*nd* dose after 20 days. The sub plot area was 21 m^2 consisting of 5 ridges, 7 m along and 60 cm apart. Harvest of sugar beet plants took place after 210 days from sowing in both seasons.

At harvest two guarded rows of each plot were harvested, topped and the following data were taken:

2.1. Juice quality

At harvest a random sample of five roots from each plot was taken and the following traits were determined.

1- Sucrose percentage (Pol %).
2- Purity %
3- Alkalinity Coefficient (AC %).
4- Impurities (Na^+, K^+ and α-amino-N %).
5- Sugar extractable percentage.
6- Extractability percentage
7- Sugar loss to molasses percentage(SLM %).

2.2. Yields

1. Root fresh weight (kg)
2. Root yield (tons/fed).
3. Sugar yield (tons/fed)= Root yield (tons/fed) X sugar extraction percentage.

Sucrose percentage (Pol %) was polarimetrically determined on a lead acetate extract of fresh macerated root according to the method of Le-Docte (1927). Meantime, the extract was used to determine beet impurities, sodium and potassium using Flame Photometry while α-amino-N % determined by Hydrindnation method according to Carruthers *et al*.(1962).

Purity, sugar loss to molasses percentage (SLM %), extractable sugar percentage, extractability percentage and Alkalinity coefficient were calculated according to the following formulas:

Purity % = 99.36-14.27(K^++ Na^+ + α-amino-N)/ Pol (Devillers, 1988).

Sugar loss to molasses percentage (SLM %) = 0.343(K^++Na^+)+0.094(α-amino-N)- 0.31 (Reinefeld *et al*, 1974).

Sugar extraction percentage = Pol – SLM – 0.6 (Dexter *et al.*, 1967).

Extractability percentage = Sugar extraction / Pol%.

Alkalinity coefficient (AC) = (K+ Na)/(α-amino-N)

The collected data were subjected to the proper statistical analysis of spilt plot design to compare treatments mean, LSD at 5% level significance was used according to Steel and Torrie (1980).

3. RESULTS AND DISCUSSION

3.1. Effect on sucrose, purity, sugar extraction, extractability and sugar loss to molasses percentages

The effect of potassien-N and or–P as foliar application, potassium fertilization rates as soil application and their interaction on purity, sugar extractable% and extractability and sugar loss to molasses% in 2010/2011 and 2011/ 2012 seasons are presented in Table 1. Data show that all mentioned traits were insignificantly affected by foliage spray sugar beet plant with potassien in both studied seasons, except sucrose % in both seasons and purity % in the 2nd season only. it is worth mentioning that there was no statistical difference between potassien-N and potassien-P on purity %. Potassium fertilization at rate of 12 kg K_2O/ fed significantly increased purity % in second season, while significantly increased extractable sugar % and extractability % in the 2nd season only. Using 24 kgK_2O/fed gave the highest values compared to the recommended rate (48 kgK_2O/fed), of purity, sugar extraction, extractability as 83.14, 14.04 and 72.59 in the 2nd season. The statistical difference between 24 kgK_2O/fed and 12 kgK_2O/fed did not reach the level of significance at 5% as shown in Table 1. Similar trend was found by Soudi *et al*. (2012) studying the effect of different levels of Potassien-P as foliar application and 24 kg K_2O/fed to soil as a starter dose in sugar cane, they found that Potassien-P gave the highest values of purity and sugar yield (tons /fed).

Data cleared that potassium rates had a significant effect on sucrose % in the second season (Table 1). Potassium fertilizer at a rate of 24 kg K_2O / fed gave the highest sucrose% in the 2nd seasons. The positive effect of potassium applications may be due to the fact that potassium has a prevalent action in plants and it is involved in maintenance of ionic balance in cell and binds ionically to enzyme pyruvate kinase which is essential in respiration and carbohydrate metabolism (Aisha *et al.*, 2007). The increases in sucrose content may be due to increasing photosynthesis and translocation as assimilates to storage root for K^+ on plant (Cooke and Scott, (1993). A similar trend was found by Moustafa *et al*. (2006) and Enan (2011).

The interaction between potassien and potassium applications significantly affected sucrose, purity, extractability and sugar loss to molasses percentages in the 2nd season only, as well as sugar extraction, in both seasons (Table 1). Potassien-P and 12 kgK_2O / fed recorded the highest sucrose, purity, extractable sugar % and extractability % and lowest sugar loss to molasses% compared with the other treatments.

3.2.Effect on impurities and alkalinity coefficient %

The sugar beet quality depends primarily on the content of soluble amino compounds, and minerals in particular potassium and sodium. The presence of soluble amino compounds and mineral disturbs crystallization during sugar processing and thus affects the sugar output and its purity. The non- sucrose components most relevant for "technical quality: of sugar beet are potassium, sodium and α-amino-N % (Europabio, 2003)

Data in Table (2) revealed that foliar application with potassien significantly affected α-amino-N % only in the 1st season, and Na^+ and K^+ percentages in the 2nd season.

Potassium fertilization as soil application significantly affected Na % in both seasons and α-amino-N % in the 1st season only. Reducing potassium fertilizer to 24 or 12 kg K_2O/fed significantly reduced Na% compared with 48 kg K_2O/fed (recommended rate) in the second season. The interaction between potassien as foliar application and potassium fertilizer as soil application significantly affected alkalinity coefficient (AC) and sodium (Na^+) percentages in the 1st and 2nd seasons, respectively**.**

The highest value of AC (3.19), and the lowest value of Na % (0.97) resulted from application of potassien P and 12 kg K_2O/fed.

3.3. Effect on root fresh weight, as well as root and sugar yields

Data in Table (3) show that foliar application with potassien exhibited significant increase in root and sugar yields (ton / fed) only in the first season. Such increase in root yield may be

Table (1): Effect of Potassein on sucrose, purity, sugar extraction (S Ex), extractability (Ex) and sugar loss to molasses (SLM) percentages in sugar beet plants in 2010/ 2011 and 2011/ 2012 seasons.

Treatments		2010/ 2011 season					2011/ 2012 season				
Foliar application (A)	Soil Application (B)	Sucrose %	Purity %	S Ex %	Ex %	SLM %	Sucrose %	Purity %	S Ex %	Ex %	SLM %
Control	48 kg $_2$O/fed	14.88	90.06	13.34	89.67	0.942	15.04	76.53	13.27	88.26	1.167
	24 kg $_2$O/fed	14.35	85.46	12.48	86.97	1.272	14.71	77.79	12.69	86.22	1.422
	12 kg $_2$O/fed	14.87	74.15	12.70	85.32	1.573	15.17	80.37	13.25	87.34	1.320
Mean		**14.70**	**83.22**	**12.84**	**87.30**	**1.262**	**14.97**	**78.23**	**13.07**	**87.28**	**1.303**
Potassein-N	48 kg $_2$O/fed	15.29	88.08	13.30	85.98	1.390	15.23	82.57	13.15	86.29	1.480
	24 kg $_2$O/fed	18.25	83.24	16.21	88.74	1.435	17.67	86.94	15.94	90.17	1.131
	12 kg $_2$O/fed	16.86	83.79	14.97	88.76	1.293	16.62	80.83	14.60	87.81	1.424
Mean		**16.80**	**85.04**	**14.83**	**88.16**	**1.373**	**16.51**	**83.45**	**14.56**	**88.09**	**1.345**
Potassein-P	48kgK$_2$O/fed	15.08	85.86	13.18	87.41	1.300	15.23	76.31	13.01	85.41	1.622
	24kgK$_2$O/fed	15.49	78.33	13.52	87.42	1.374	17.55	84.71	15.71	89.44	1.248
	12 kg $_2$O/fed	16.15	79.09	14.18	87.77	1.371	18.06	88.03	16.49	91.28	0.975
Mean		**15.58**	**81.10**	**13.63**	**87.44**	**1.348**	**16.95**	**83.02**	**15.07**	**88.01**	**1.281**
Mean Of Potassium	48 kg $_2$O/fed	15.08	88.00	13.27	88.00	1.210	15.17	78.47	13.15	86.65	1.423
	24kgK$_2$O/fed	16.03	82.34	14.07	87.65	1.360	16.64	83.14	14.78	88.61	1.267
	12 kg $_2$O/fed	15.96	79.01	13.95	87.28	1.412	16.62	83.08	14.78	88.81	1.240
L.S.D at 5% Foliar application (A)		**1.48**	**NS**	**NS**	**NS**	**NS**	**1.55**	**2.68**	**NS**	**NS**	**NS**
Soil application (B)		**NS**	**4.54**	**NS**	**NS**	**NS**	**0.87**	**3.39**	**0.80**	**1.02**	**NS**
(AxB)		**NS**	**NS**	**NS**	**2.65**	**NS**	**1.50**	**5.87**	**1.39**	**1.73**	**0.300**

Table (2): Effect of Potassien on alkalinity coefficient (AC) and impurities percentages in sugar beet plants in 2010/ 2011 and 2011/2012 seasons.

Treatments		2010/ 2011 season				2011/ 2012 season			
Soil application (A)	Foliar application (B)	A.C %	Impurities %			A.C%	Impurities %		
			Na%	K%	α-amino-N %		Na%	K%	α-amino--N %
Control	**48 kg K_2O/fed**	3.31	0.83	2.52	1.07	3.37	1.76	2.13	1.52
	24 kg K_2O/fed	2.97	1.19	2.96	1.68	3.70	1.72	2.92	1.49
	12 kg K_2O/fed	4.82	1.99	3.14	1.29	3.79	1.53	2.79	1.57
Mean		**3.70**	**1.34**	**2.88**	**1.35**	**3.62**	**1.67**	**2.61**	**1.53**
Potassein-N	**48 kg K_2O/fed**	3.46	1.04	3.51	1.45	4.01	1.42	3.43	1.34
	24 kg K_2O/fed	3.17	1.36	3.23	1.79	4.58	1.08	2.89	0.84
	12 kg K_2O/fed	2.88	1.30	2.88	1.81	4.06	1.53	3.18	1.28
Mean		**3.17**	**1.24**	**3.21**	**1.69**	**4.22**	**1.34**	**3.17**	**1.15**
Potassein-P	**48 kgK_2O/fed**	2.83	1.17	3.02	1.82	4.55	1.86	3.41	1.32
	24 kgK_2O/fed	3.16	1.67	2.73	1.83	3.69	1.24	2.97	1.21
	12 kg K_2O/fed	3.19	1.62	2.79	1.79	3.75	0.97	2.51	0.96
Mean		**3.06**	**1.49**	**2.85**	**1.81**	**4.00**	**1.36**	**2.96**	**1.16**
Mean Of Potassium	**48 kg K_2O/fed**	3.20	1.01	3.02	1.45	3.98	1.68	2.99	1.39
	24 kgK_2O/fed	3.10	1.41	2.98	1.77	3.99	1.35	2.93	1.18
	12 kg K_2O/fed	3.83	1.64	2.94	1.63	3.87	1.34	2.83	1.27
L.S.D at 5%									
Foliar application (A)		NS	NS	NS	0.26	NS	0.19	0.39	NS
Soil application (B)		NS	0.33	NS	0.23	NS	0.23	NS	NS
(AxB)		0.89	NS	NS	NS	NS	0.39	NS	NS

Table (3): Effect of Potassien on root fresh weight (kg), root and sugar yields (tons/ fed) in sugar beet plants in 2010/ 2011 and 2011/2012 seasons.

Treatments		2010/ 2011 season			2011/ 2012 season		
Foliar Application (A)	Soil Application (B)	Root Fresh weight (kg)	Root yield ton/fed	Sugar yield ton/fed	Root Fresh weight (kg)	Root yield Ton/fed	Sugar yield ton/fed
Control	**48 kg K_2O/fed**	0.956	25.367	3.381	1.084	23.565	3.128
	24 kg K_2O/fed	1.176	22.954	2.855	1.128	24.939	3.168
	12 kg K_2O/fed	1.207	24.600	3.092	1.010	27.004	3.576
Mean		**1.113**	**24.304**	**3.109**	**1.074**	**25.169**	**3.291**
Potassein-N	**48 kg K_2O/fed**	1.264	24.783	3.297	1.122	27.587	3.632
	24 kg K_2O/fed	1.099	36.617	5.956	1.061	24.424	3.872
	12 kg K_2O/fed	0.974	36.167	5.435	1.164	21.672	3.156
Mean		**1.112**	**32.522**	**4.896**	**1.116**	**24.561**	**3.553**
Potassein-P	**48 kg K_2O/fed**	1.189	32.817	4.355	1.172	25.800	3.345
	24 kg K_2O/fed	1.345	36.747	4.954	1.151	25.456	3.997
	12 kg K_2O/fed	1.055	24.350	3.418	1.150	22.360	3.673
Mean		**1.196**	**31.304**	**4.242**	**1.157**	**24.539**	**3.672**
Mean Of Potassium	**48 kg K_2O/fed**	1.137	27.656	3.678	1.126	25.651	3.369
	24 kg K_2O/fed	1.206	32.103	4.588	1.113	24.940	3.679
	12 kg K_2O/fed	1.079	28.372	3.981	1.108	23.679	3.468
L.S.D at 5%							
Foliar application (A)		NS	4.895	0.930	NS	NS	NS
Soil application (B)		NS	NS	0.050	N.S	NS	NS
(AxB)		NS	7.875	1.225	NS	NS	NS

attributed to some extent to an increase in root fresh weight. Also the role of K could be explained through its need as cofactor (enzymes activator) for different enzymes. In addition, K^+ is needed for vital processes and its beneficial effect in translocation of carbohydrates to the storage organs. (Zengin *et al.*, 2009); Hassaanli *et al.*, 2010).

The effect of potassium fertilizer as soil application significantly increased sugar yield in the 1*st* season only. Potassium fertilizer at a rate of 24 kg K_2O/ fed gave the highest sugar yield (ton/fed). The interaction between foliar application and soil application was significant in the 1st season. Potassium fertilizer at rate 24 kg K_2O / fed and foliar application with potassien-N recorded the highest root and sugar yields (36.617and 4.894, respectively) in the 1st season. In this connection, Enan (2011) found that the application of 24 kg K_2O/fed + two sprays of potassein attained the highest values of root and sugar yields/ fed in both seasons.

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تأثير التسميد بالبوتاسين على جودة وإنتاجية بنجر السكر

خليل الشناوى محمد- سها رمضان خليل

معهد بحوث المحاصيل السكرية - مركز البحوث الزراعية – جيزة - مصر

ملخص

اجريت تجربة حقلية فى محطة البحوث الزراعية بسخا- محافظة كفر الشيخ خلال موسمى 2011/2010، 2012/2011 لدراسة تأثير الرش بمركب البوتاسين – ن أو-فو (بتركيز لتر/300 لتر ماء /فدان) مع التسميد الأرضى بثلاث معدلات من البوتاسى (48، 24، 12 كجم بو $_2$ أ /فدان) على جودة وانتاج بنجر السكر وتمت الزراعة بالصنف Desperes poly N وكان التصميم المستخدم القطع المنشقة مرة واحدة فى ثلاث مكررات حيث وضع الرش بالبوتاسين فى القطع الرئيسية ومعدلات التسميد البوتاسى فى القطع التحت شقية.

اظهرت النتائج ان الرش بالبوتاسين أثر تأثيراً معنوياً على محصولى الجذور والسكر (طن/فدان)، ايضا على نسبة ألفا أمينو نتروجين فى الموسم الاول، بينما تأثرت نسبة كلا من الصوديوم والبوتاسيوم والنقاوة فى الموسم الثانى، كذلك تأثرت نسبة السكر فى الموسمين. اعطى الرش بالبوتاسين-ن اعلى انتاجية من الجذور والسكر (طن/فدان) ونسبة السكر فى الموسم الاول وايضا نسبة النقاوة فى الموسم الثانى، بينما نتجت اقل نسبة من الصوديوم فى الموسم الثانى.

كان تأثير الاضافة الارضية للمعدلات المختلفة من البوتاسيوم تأثيرا معنويا على محصول السكر بالطن/فدان ونسبة ألفا أمينو نتروجين فى الموسم الاول، نسبة السكر المستخلص ونسبةالاستخلاص فى الموسم الثانى وكذلك على نسبتى الصوديوم والنقاوة فى كلا الموسمين. من الجدير بالذكر ان نباتات بنجر السكر التى تم تسميدها بمعدل 24كجم/بو$_2$ا/فدان أدت الى زيادة محصول السكر طن/فدان فى موسم 2011/2010، والنسبة المئوية لكل من السكر، النقاوة، السكر المستخلص والاستخلاص، بينما قلت نسبة الصوديوم معنويا فى موسم 2012/2011.

اعطت معاملة الرش بمركب البوتاسين-ن مع التسميد بمعدل 24 كجم بو $_2$ا/فدان اعلى انتاجية من محصول الجذور والسكر (طن/فدان)، نسبة كلا من السكر المستخلص والاستخلاص وكانت نسبة الزيادة 30.72، 43.23،16.75 و20.85 % على التوالى مقارنة بالتسميد بمعدل 48 كجم بو$_2$ا/فدان (المعدل الموصى به).

المجلة العلمية لكلية الزراعة – جامعة القاهرة – المجلد (64) العدد الأول (يناير 2013): 1-7.