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EFFECT OF INJECTED AMMONIA GAS AND APPLIED POTASSIUM RATES WITH OR WITHOUT SOME MICRONUTRIENTS ON SUGAR BEET PRODUCTIVITY

BY

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ABSTRACT

In 2004/2005 and 2005/2006 seasons, two field trials were conducted in the farm of Sids Agriculture Research Station at Beni Suaif governorate to study the effect of ammonia gas injection and potassium at different rates with or without some micronutrients (Zn, Mn, and Fe) mixture on sugar beet growth, quality and yield.

Analysis of variance revealed that N fertilizer at the rate of 40 and 120 kg/fed significantly decreased root diameter, elemental roots uptake i.e. N, K, Zn, Mn and Fe, juice quality (sucrose and purity) percentages and roots and sugar yields. The decreases in these traits were significant at 40 kg N/fed. While number of leaves, top dry weight, elemental tops uptake (N, K, Mn and Fe) increased gradually by the increase in N rate up to 120 kg/fed.

The increase in K rate from 12 to 48 K_2O/fed. increased significantly root diameter, number of leaves, top and root dry weights. Elemental tops and roots uptake were also increased by increasing K rates. In addition, K fertilizer at different rates increased significantly tops, roots and sugar yields especially under the highest rate.

Foliar spray with micronutrients in mixture (Zn, Mn and Fe) increased significantly most above mentioned traits.

N x K interaction at the recommended rates was the best effect as compared with the other interactions which showed significant effects on all traits under study except juice quality.

INTRODUCTION

In the recent years, Sugar beet is ranked as the second crop after sugar cane to produce sugar yield. In Egypt, sugar production is still insufficient for local consumption, therefore, many devoted attempts have been exerted to improve beet quality and yield.

Sugar beet nutrition had a great effect on beet productivity. Nitrogen and potassium management are the important keys to accomplish this goal. Nitrogen supply is the most essential factor in plant nutrition. One of the used N fertilizer form is anhydrous ammonia, which represents a source of the highest N content (about

82% N). Any increase in the N efficiency will increase the agronomic and economic values of the fertilizer via the increase in crop production. Moustafa and Darwish (2001) found that anhydrous ammonia gave higher results on most traits of sugar beet plants than urea Franzen (2003) found that N deficiency led to poor leaf canopies, premature yellowing and low tonnage yields. While overrated N application of decreased technological value, sucrose content and higher impurity. Kozicka, (2005) showed that insufficient N fertilization had a negative effect on yields. Good nitrogen management is necessary not only in the year in which beets are grown, but also in the rest of the rotation, so that soil N levels that not excessive are going into the beet year. This trend proved by Moustafa *et al.*, (2000) who found that increasing fertilization level up to 110 Kg N/fed. increased yield components, fresh and dry weights of root and top/plant , roots, tops and sugar yields in sugar beet plants.

In addition, potassium is considered as one of the macro essential nutrients which affected greatly sugar production, due to its influences on various biochemical processes, enzyme systems and hence sugar translocation and accumulation in beet roots. Kandil *et al.* (1993) found that K fertilization exhibited an increase in root length, root diameter and weight of leaves/plant and blade leaf area. Kristek *et al.* (1996) found that increasing K fertilizer increased root, top and sugar yields. El-Maghraby *et al.* (1998) showed that the application of K fertilizer up to 48 Kg K_2O/fed caused significant decrease in sugar beet purity. Khalil *et al.* (2001) found that application with potassium fertilizer increased sucrose, total soluble solids and purity of sugar beet plants. In addition, Orlovius (2002) showed that with the same amount of N, the sugar beet yield could be doubled with adequate potash. With an insufficient K-supply the efficiency of the other production factors (e.g. N fertilization) is also reduced. The content of noxious N in beets with adequate potash supply is also lower than that in beets plants receiving inadequate potash because potassium also improves N metabolism (Krauss, 2000).

Micronutrients as foliar application are particularly useful under Egyptian conditions where their uptake from the soil is restricted. This case in alkali soil (pH>7.0), where Zn, Mn and Fe are frequently fixed and becomes scarcely available to plant roots (Shalaby, 1998). Application of foliar Fe combined with Zn and Mn was very effective in increasing root yield of sugar beet, sugar content and sugar yield as well as juice purity, which, in turn improved sugar extractability (Shalaby, 1998 and Osman *et al.*, 2003).

The aim of the present study is to determine the effect of different rates of N (anhydrous ammonia form) and K fertilization with or without some micronutrients in mixture (Zn, Mn and Fe) on the productivity and quality of sugar beet plants.

MATERIALS AND METHODS

Two field experiments were carried out at Sids, Beni Suaif governorate during 2004/05 and 2005/06 to study the effect of nitrogen as anhydrous ammonia (82%N) and potassium at different rates with or without some micronutrients in mixture (Zn, Mn and Fe) on sugar beet yield and quality. Representative soil samples from the experimental site were taken to determine some physical and chemical properties of the soil according to Chapman and Pratt (1961). The obtained results are shown in Table (1):

Table (1): Physical and chemical properties of the tested soils.

Season	Sand %	Silt %	Clay %	Soil texture	pH	E.C (dSm^{-1})	O.M %	Macronutrients ($mg\ kg^{-1}$)			Micronutrients ($mg\ kg^{-1}$)		
								N	P	K	Fe	Mn	Zn
2004	18.25	35.84	45.91	Clay	8.3	1.43	2.11	111	13.9	280	10.3	6.7	3.5
2005	14.33	33.70	51.97	Clay	8.0	1.68	2.11	120	12.1	288	10.0	7.2	3.2

Multigerm sugar beet variety Kawetema was planted by hand on November 11th and 27th in 2004 and 2005 respectively. Plot size was 21 m^2, consists of 6 rows, 7 m long and 50 cm apart; spacing between hills was 20 cm. The experiment was conducted in a split-split plot design with three replicates. The experimental area was divided into three main plots, receiving 40, 80 (recommended rate) and 120 Kg N/fed as anhydrous ammonia. Each main plot was divided into two sub plots with and without micronutrients mixture (Zn, Mn and Fe). Each sub plot was divided into three sub- sub plots receiving 12, 24 and 48 Kg K_2O/fed. The anhydrous ammonia was injected directly into the moderately moister soil by a band applicator at 5 days before sowing. Anhydrous ammonia (82 % N) was chosen as a NH_3 source. K fertilizer was added in the form of potassium sulfate (48% K_2O) in one doze after thinning. Twice foliar sprays with micronutrients (Zn, Mn and Fe) as 0.15 g Zn chelate (14 % Zn), 0.15 g Mn chelate (13 % Mn) and 0.3 g/ liter Fe chelate (6 % Fe) were added after 60 and 75 days from sowing.

At 90 days from sowing (after 15 days from the second spray) and at harvest, (210 days from sowing), random samples of ten guarded roots were taken from three inner rows of each sub-sub plot to determine the following traits:

At 90 days from sowing

1- Average root diameter (cm)
2- Average number of leaves
3- Tops and roots dry weights (g/plant)
4- Contents of N, K, Zn, Mn and Fe in both plant tops and roots were determined according to A.O.A.C. (1990).

At harvest (210 days from sowing).

1- Root quality (sucrose, TSS and Purity percentages) were estimated where, sucrose percentage in fresh sugar beet roots was determined in the lead acetate extract using Succarometer apparatus, TSS % were determined by hand refractometer and purity was calculated from the following equation:
   Purity % = sucrose % x100/TSS %
2- Tops, roots and sugar yield (ton/fed).

Analysis of variance was computed for each trait according to Steel and Torrie (1980) based on combined analysis over two growing seasons and treatment means were compared using LSD at 5% level of probability.

RESULTS AND DISCUSSION

Effects on root diameter and number of leaves:

Pooled data in Table (2) show that after 90 days from sowing, both of the low N fertilizer rate at 40 kg N /fed or overrate N at 120 kg N /fed significantly decreased root diameter as compared to N at the recommended rate (RR), 80 kg N/fed. RR therefore gave the highest values of root diameter. While, number of leaves was increased by increasing N rate from 40 to 120 kg N /fed. The increase in number of leaves and the decrease in root diameter may be due to excess N availability and hence excessive vegetative growth resulted at the expense of photosynthate (sugar) used for growth instead of storing in roots. A similar trend was found by Szklarz *et al.* (1995) showed that the number of green leaves increased with increasing N rate while, root length and diameter were decreased. Basha, (1999) showed that large N dressing stimulates initiation of new leaves.

Data also, show that root diameter and number of leaves increased significantly as K rate increased from 12 to 48 kg K_2O/ fed. Similar results were obtained by Ying and Hong (1997) who found that K fertilizers increased the leaf number and leaf length.

In addition, application of foliar micronutrients mixture (Zn, Mn and Fe) increased significantly root diameter and number of leaves as compared with control (without micronutrients). Such effect may be due to the increasing effect of treatments with micronutrients on various biochemical processes in beet plant. These results are in line with those of Ziaeian and Malakouti (1998) who reported that the application of micronutrients increased sugar beet foliage.

Interactions :

All interactions significantly affected the root diameter and number of leaves except K x M interaction for root diameter. From these interactions, it is important to mention that the best treatment gave the highest root diameter values was the interaction between N at (RR) and K at highest rate (48 kg K_2O/fed) plus micronutrients as compared other interactions.

Effects on average tops and roots dry weight/ plant.

Data in Table (2) show that top and root dry weight after 90 days from sowing significantly increased by increasing N fertilizer rate from 40 to 80 kg/ fed. Thereafter, excess N over (RR) 120 kg/fed. increased both top and root dry weight but the increase was significant for top dry weight only. Such results may be attributed to increasing N over RR may stimulate top growth at the expense of sugar that used for vegetative growth instead of in roots. In this connection, Kozicka (2005) found that increasing N rate from 90 to 180 Kg N/ha caused a significant increase in average root mass, leaves and dry matter yield.

Furthermore, increasing the rate of K fertilizer from 12 to 48 kg K_2O/ fed. exhibited a significant increase in top and root dry weights. Such effects could be attributed to the promotive effect of K on photosynthesis and growth, carbon assimilation and translocation in plants and effect of the rate of ATP and NADP production in beet chloroplasts (Conti and Gelge, 1982) and (Terry and Ulrich, 1973). Similar results were also recorded by Koch *et al.*, (1987) who stated that increasing K application rates to sugar beet increased root dry matter.

Table (2): Effect of nitrogen as ammonia gas (N) and potassium (K) with or without micronutrients (M) on growth. (combined analysis of two seasons).

Treatments (rate)		Growth traits/ plant											
		Root diameter (cm)			Leaves number			Average top dry weight			Average root dry weight		
N	K	-M	+M	Mean	-M	+M	Mean	-M	+M	Mean	-M	+M	Mean
40	12	3.44	3.56	**3.50**	10.48	10.71	**10.60**	17.56	18.69	**18.12**	22.28	23.58	**22.93**
	24	3.91	4.05	**3.98**	11.14	11.53	**11.33**	20.58	22.54	**21.56**	25.27	26.64	**25.95**
	48	4.31	4.47	**4.39**	12.35	14.17	**13.26**	23.95	26.44	**25.19**	28.17	30.34	**29.25**
Mean		**3.89**	**4.03**	**3.95**	**11.32**	**12.14**	**11.73**	**20.69**	**22.56**	**21.62**	**25.24**	**26.85**	**26.04**
80	12	4.19	4.43	**4.31**	14.75	15.13	**14.94**	31.00	32.14	**31.57**	25.21	27.39	**26.30**
	24	4.71	5.01	**4.86**	15.75	15.88	**15.82**	33.98	35.24	**34.61**	29.10	30.57	**29.83**
	48	5.20	5.35	**5.27**	16.32	16.57	**16.44**	36.47	37.05	**36.76**	33.07	34.75	**33.91**
Mean		**4.70**	**4.93**	**4.82**	**15.61**	**15.86**	**15.73**	**33.81**	**34.81**	**34.31**	**29.13**	**30.90**	**30.01**
120	12	3.97	4.09	**4.03**	15.77	16.00	**15.88**	37.04	37.86	**37.45**	27.41	28.42	**27.92**
	24	4.18	4.25	**4.22**	16.32	16.63	**16.48**	38.67	39.62	**39.15**	29.40	30.75	**30.08**
	48	4.39	4.57	**4.48**	16.97	17.27	**17.12**	40.31	41.21	**40.76**	32.30	33.36	**32.83**
Mean		**4.18**	**4.30**	**4.24**	**16.35**	**16.63**	**16.49**	**38.67**	**39.56**	**39.12**	**29.70**	**30.84**	**30.27**
Mean of K	12	3.87	4.03	**3.95**	13.00	13.28	**13.14**	28.53	29.56	**29.05**	24.97	26.46	**25.71**
	24	4.27	4.44	**4.35**	13.73	14.02	**13.87**	31.08	32.47	**31.77**	27.92	29.32	**28.62**
	48	4.63	4.79	**4.71**	14.54	15.33	**14.94**	33.57	34.90	**34.24**	31.18	32.81	**32.00**
Mean of M		**4.26**	**4.42**	**4.34**	**13.76**	**14.21**	**13.99**	**31.06**	**32.31**	**31.69**	**28.02**	**29.53**	**28.78**

LSD at 0.05%	Root diameter	Leaves number	Average top dry weight	Average root dry weight
N	0.30	0.30	3.09	1.07
K	0.11	0.08	0.61	0.35
M	0.03	0.03	0.28	0.16
NxK	0.19	0.13	1.07	0.61
NxM	0.05	0.05	N.S	N.S
KxM	N.S	0.05	N.S	N.S
NxKxM	0.05	0.09	N.S	N.S

Data also fount that foliar sprays with Zn, Mn, Fe mixture improved top and root weight/plant as compared with the control treatment (no micronutrients) The enhancing effect of micronutrients could be attributed to the vital role of micronutrients on protein synthesis which, lead to a better growth and dry matter accumulation (El-Kortoby, 1982).

Interactions

N x K interaction only affected top and root dry weight significantly after 90 days from sowing. The highest root dry weight was obtained by N injection at RR combined with K at the highest rate and the same trend for tops dry weight was also detected when both N and K were at their highest rates

Effects on tops uptake:

From Table (3) it is seen that there were significant increase in tops uptake of N, K (g/plant), Zn, Mn and Fe (mg/plant) after 90 days from sowing by the increase in the N fertilization rate from 40 to 80 Kg /fed. Thereafter, increasing N rate up to 120 Kg/fed increased insignificantly K, Mn and Fe and N content significantly while Zn gave a vice versa trend.

Increasing K rates up to 48 Kg K_2O/ fed. increased gradually and significantly the uptake of N, K, Zn, Mn and Fe (Table 3).

Foliar application of micronutrients increased significantly N, K, Zn, Mn and Fe uptake in leaves of sugar beet plants as compared with the control treatment (without micronutrients).

Interactions

Regarding, N x K interactions, data in Table (3) cleared that there was significant effect among different N and K rates on all elemental uptake, where, N at 120 Kg /fed. with K at 48 Kg/fed. gave the highest N and K as compared with other concentrations of N x K combination. Whereas, the highest values of micronutrients (Zn, Mn and Fe) were obtained by using N at the recommended rate with K at 48 Kg/fed. Generally, the other interactions were of no significant increase in most above elements.

Effects on roots uptake:

Injection of N gas with the rate of 40 or 120 Kg/fed decreased significantly the uptake of N, K, Zn, Mn and Fe in beet roots, as compared with N at the recommended rate (80 kg/fed). Therefore, RR was the best treatment which gave the highest element uptake. Furthermore, nitrogen rate at 120 kg/fed had less effect than 40 kg/fed (Table, 4). Such effect may be because N enhanced the uptake of other minerals, which finally was reflected in better growth (Milford *et al.* 1985). In this connection Moustafa *et al.* (2000) cleared that N, P, K uptake increased with the increase in N rates.

Data also reveal that, uptake of macro and micronutrients; N, K, Zn, Mn and Fe were increased by increasing the rate of K fertilizer from 12 to 48 kg K_2o /fed. (Table, 4). These may be attributed to that K enhances NH_4^+, NO_3^- and Mn contents in plant tissue

Table (3): Effect of nitrogen as ammonia gas (N) and potassium (K) with or without micronutrients (M) on tops uptake. (combined analysis of two seasons).

Treatments (rate)		Elemental to uptake														
		N (g/ plant)			K(g/ plant)			Zn(mg/ plant)			Mn(mg/ plant)			Fe(mg/ plant)		
N	K	-M	+M	Mean	-M	+M	Mean	-M	+M	Mean	-M	+M	Mean	-M	+M	Mean
40	12	0.723	0.778	**0.750**	0.633	0.691	**0.662**	0.377	0.439	**0.408**	0.658	0.726	**0.692**	1.925	2.157	**2.041**
	24	0.882	0.980	**0.931**	0.789	0.893	**0.841**	0.541	0.640	**0.590**	0.821	0.926	**0.874**	2.555	2.977	**2.766**
	48	1.055	1.174	**1.115**	0.972	1.099	**1.035**	0.722	0.839	**0.780**	1.008	1.140	**1.074**	3.338	3.877	**3.608**
Mean		**0.887**	**0.977**	**0.932**	**0.798**	**0.894**	**0.846**	0.547	0.639	**0.593**	**0.829**	**0.931**	**0.880**	**2.606**	**3.003**	**2.805**
80	12	1.584	1.702	**1.643**	1.632	1.740	**1.686**	1.296	1.415	**1.355**	1.561	1.667	**1.614**	5.997	6.429	**6.213**
	24	1.839	1.949	**1.894**	1.886	2.022	**1.954**	1.585	1.732	**1.659**	1.807	1.944	**1.875**	6.972	7.571	**7.272**
	48	2.108	2.205	**2.156**	2.148	2.230	**2.189**	1.853	1.958	**1.906**	2.042	2.198	**2.120**	8.186	8.606	**8.396**
Mean		1.843	1.952	**1.898**	**1.889**	**1.997**	**1.943**	1.578	1.702	**1.640**	**1.803**	**1.936**	**1.870**	**7.052**	**7.536**	**7.294**
120	12	1.786	1.933	**1.860**	1.877	1.913	**1.895**	1.329	1.413	**1.371**	1.692	1.805	**1.748**	6.829	7.169	**6.998**
	24	2.006	2.084	**2.045**	1.991	2.090	**2.040**	1.494	1.603	**1.548**	1.889	2.028	**1.958**	7.465	7.788	**7.626**
	48	2.151	2.227	**2.189**	2.176	2.242	**2.209**	1.717	1.796	**1.757**	2.110	2.267	**2.189**	8.112	8.383	**8.248**
Mean		1.981	2.081	**2.031**	**2.015**	**2.081**	**2.048**	1.513	1.604	**1.559**	**1.897**	**2.033**	**1.965**	**7.468**	**7.780**	**7.624**
Mean of K	12	1.364	1.471	**1.418**	1.381	1.448	**1.414**	1.001	1.089	**1.045**	1.304	1.400	**1.352**	4.916	5.252	**5.084**
	24	1.576	1.671	**1.623**	1.555	1.668	**1.612**	1.207	1.325	**1.266**	1.506	1.633	**1.569**	5.664	6.112	**5.888**
	48	1.771	1.869	**1.820**	1.765	1.857	**1.811**	1.431	1.531	**1.481**	1.720	1.869	**1.794**	6.546	6.956	**6.751**
Mean		**1.571**	**1.670**	**1.620**	**1.567**	**1.658**	**1.612**	**1.213**	**1.315**	**1.264**	**1.510**	**1.634**	**1.572**	**5.709**	**6.106**	**5.907**

LSD at 0.05%	N	K	Zn	Mn	Fe
N	0.13	0.13	0.09	0.13	0.60
K	0.04	0.03	0.03	0.03	0.10
M	0.02	0.02	0.01	0.01	0.04
NxK	0.07	0.05	0.05	0.05	0.17
NxM	N.S	N.S	N.S	N.S	0.08
KxM	N.S	N.S	N.S	0.02	N.S
NxKxM	N.S	N.S	N.S	N.S	0.13

Table (4): Effect of nitrogen as ammonia gas (N) and potassium (K) with or without micronutrients (M) on roots uptake. (combined analysis of two seasons).

Treatments (rate)		Elemental root uptake														
		N (g/plant)			K(g/plant)			Zn(mg/plant)			Mn(mg/plant)			Fe(mg/plant)		
N	K	-M	+M	Mean	-M	+M	Mean	-M	+M	Mean	-M	+M	Mean	-M	+M	Mean
40	12	1.03	1.11	**1.07**	1.00	1.07	**1.04**	1.16	1.27	**1.22**	1.23	1.34	**1.29**	3.24	3.70	**3.47**
	24	1.02	1.29	**1.24**	1.16	1.24	**1.20**	1.40	1.56	**1.48**	1.46	1.62	**1.54**	4.14	4.63	**4.39**
	48	1.38	1.53	**1.46**	1.32	1.44	**1.38**	1.70	1.90	**1.80**	1.76	1.95	**1.85**	5.15	5.91	**5.53**
Mean		**1.20**	**1.31**	**1.26**	**1.16**	**1.25**	**1.21**	**1.42**	**1.58**	**1.50**	**1.48**	**1.64**	**1.56**	**4.18**	**4.75**	**4.46**
80	12	1.30	1.46	**1.38**	1.29	1.44	**1.36**	1.80	2.07	**1.93**	1.78	1.98	**1.88**	5.47	6.10	**5.78**
	24	1.60	1.75	**1.68**	1.58	1.73	**1.65**	2.25	2.43	**2.34**	2.14	2.30	**2.22**	6.85	7.63	**7.24**
	48	1.98	2.16	**2.07**	1.93	2.12	**2.03**	2.70	2.87	**2.79**	2.55	2.74	**2.65**	8.66	9.31	**8.98**
Mean		**1.63**	**1.79**	**1.71**	**1.60**	**1.76**	**1.68**	**2.25**	**2.46**	**2.35**	**2.16**	**2.34**	**2.25**	**6.99**	**7.68**	**7.34**
120	12	1.23	1.31	**1.27**	1.26	1.32	**1.29**	1.69	1.81	**1.75**	1.67	1.77	**1.72**	5.53	6.10	**5.82**
	24	1.39	1.50	**1.44**	1.38	1.46	**1.42**	1.90	2.15	**2.02**	1.86	2.01	**1.93**	6.55	7.15	**6.85**
	48	1.61	1.67	**1.64**	1.55	1.62	**1.59**	2.23	2.36	**2.30**	2.17	2.29	**2.23**	7.85	8.37	**8.11**
Mean		**1.41**	**1.50**	**1.45**	**1.40**	**1.47**	**1.43**	**1.94**	**2.10**	**2.02**	**1.90**	**2.02**	**1.96**	**6.65**	**7.21**	**6.93**
Mean of K	12	1.19	1.29	**1.24**	1.18	1.28	**1.23**	1.55	1.72	**1.63**	1.56	1.70	**1.63**	4.75	5.30	**5.02**
	24	1.40	1.51	**1.46**	1.37	1.48	**1.42**	1.83	2.05	**1.95**	1.82	1.98	**1.90**	5.85	6.47	**6.16**
	48	1.65	1.79	**1.72**	1.60	1.73	**1.66**	2.21	2.38	**2.29**	2.16	2.33	**2.24**	7.22	7.86	**7.54**
Mean		**1.41**	**1.53**	**1.47**	**1.39**	**1.49**	**1.44**	**1.87**	**2.05**	1.96	**1.85**	**2.00**	**1.92**	**5.94**	**6.54**	**6.24**

LSD at 0.05%	N (g/plant)	K(g/plant)	Zn(mg/plant)	Mn(mg/plant)	Fe(mg/plant)
N	0.05	0.05	0.10	0.08	0.27
K	0.02	0.02	0.03	0.02	0.08
M	0.01	0.01	0.02	0.01	0.04
NxK	0.01	0.03	0.06	0.04	0.15
NxM	0.01	0.02	N.S	0.02	N.S
KxM	N.S	N.S	N.S	N.S	N.S
NxKxM	0.20	N.S	0.06	N.S	N.S

Spraying sugar beet leaves with the micronutrient mixture (Zn +Mn + Fe), increased significantly N, K, Zn, Mn and Fe uptake in sugar beet roots (Table, 4) Ziaeian and Malakouti (1998) proved that application of micronutrients increased their concentrations in leaves. Meantime, Fe is a component of proteins and enzymes and it is involved in N fixation.

Interactions

N x K interaction showed a significant effect on all the studied nutrient uptake. N fertilizer at RR in the presence of K at 48 kg/fed gave the highest N, K, Zn, Mn and Fe uptake as compared with other N x K concentrations. In addition, N fertilizer at RR combined with micronutrients gave the same previous trend. Furthermore, N x K x M interaction showed marked and positive effect on N and Zn only (Table, 4).

Effects on juice quality

Injection of ammonia gas with 40 Kg /fed significantly decreased sucrose, total soluble solids and purity percentages at harvest as compared with N at the recommended rate (80 Kg/fed). Increasing N rate up to 120 Kg/fed decreased sucrose % and purity %. Data also showed that the reduction in sucrose percentage compensated to the low N rate was more pronounced than that under the high N rate (Table 5).

Worthwhile to mention that the best N dose which maximized sucrose and purity percentages was N fertilizer at the recommended rate. The reduction in sucrose and purity percentages were detected from the exceeding N doze over the recommended rate may be due to the increase in non sugar contents such as α-amino nitrogen (α NH_2 –N), which affected sugar accumulation in roots and hence sugar extraction (Pootchi, 1997). Plants with excess N had a smaller proportion of their root dry weight as sugar because more was used in vegetative growth. This result coincides with that reported by Moustafa *et al.*, (2000) and Moustafa and Darwish (2001).

Data also showed that increasing K rate from 12 to 48 kg K_2O/fed increased significantly sucrose and purity percentages (Table 5). There are a variety of reasons explaining the effect of K application on sucrose content, one of them may be due to improve the functional quality of sugar beet which could be seen in stimulation of assimilation and translocation of sugar from leaves into the beet. K also prepares osmotically the beet cells to store large amounts of sugars (Krauss, 2000).

Regarding the foliar spray with micronutrient mixture (Zn + Mn +Fe), the results (Table 5) mentioned to significant improve in sucrose and total soluble solid percentages, however, purity insignificantly affected. Neveryanskaya *et al.* (1978) stated that treating sugar beet plants with trace elements had a considerable influence on the metabolic activities and in turn exerted an increase in its sugar content.

Table (5): Effect of nitrogen as ammonia gas (N) and potassium (K) with or without micronutrients (M) on root quality percentage. (combined analysis of two seasons).

Treatments (rate)		Root quality (%)								
		Sucrose			T.S.S.			Purity		
N	K	-M	+M	Mean	-M	+M	Mean	-M	+M	Mean
40	12	14.79	15.60	15.20	18.08	18.25	18.17	81.87	85.54	83.70
	24	15.60	16.39	15.99	18.58	19.42	19.00	83.97	84.44	84.21
	48	16.74	16.92	16.83	20.00	20.42	20.21	83.84	82.83	83.34
Mean		15.71	16.30	16.00	18.89	19.36	19.13	83.23	84.27	83.75
80	12	15.11	16.48	15.79	18.17	19.08	18.63	83.34	86.39	84.87
	24	17.51	18.18	17.84	19.00	19.75	19.38	92.17	91.94	92.06
	48	17.02	17.55	17.28	20.33	21.33	20.83	83.75	82.23	82.99
Mean		16.55	17.40	16.97	19.17	20.06	19.61	86.42	86.85	86.64
120	12	15.32	16.16	15.74	19.53	20.08	19.83	78.10	80.44	79.27
	24	17.19	17.73	17.46	20.75	21.08	20.92	82.99	84.15	83.57
	48	16.88	17.38	17.13	21.25	22.50	21.88	79.39	77.23	78.31
Mean		16.46	17.09	16.78	20.53	21.22	20.88	80.16	80.61	80.38
Mean of K	12	15.07	16.08	15.58	18.61	19.14	18.88	81.10	84.12	82.61
	24	16.77	17.43	17.10	19.44	20.08	19.76	86.38	86.84	86.61
	48	16.88	17.28	17.08	20.53	21.42	20.97	82.33	80.76	81.54
Mean of M		16.24	16.93	16.58	19.53	20.21	19.87	83.27	83.91	83.59

LSD at 0.05%	Sucrose	T.S.S.	Purity
N	0.38	0.46	2.73
K	0.65	0.34	3.60
M	0.50	0.23	NS
NxK	NS	NS	NS
NxM	NS	NS	NS
KxM	NS	NS	NS
NxKxM	NS	NS	NS

Interactions:

All interactions between N, K and micronutrients in mixture had insignificant effect on sucrose %, total soluble solids % and purity % at harvest (Table 5).

Effects on tops, roots and sugar yields:

Tops, roots and sugar yields were increased significantly by increasing the rate of N from 40 to 80 kg/fed. (Table 6). Thereafter, increasing N rate up to 120 kg/fed. insignificantly decreased roots and sugar yields (ton/fed.). These results may be because at high N level, photosynthetic products are diverted from filling root tissue with sugar and to large extent utilized for the growth of new leaves and subsequently top yield increased otherwise, root and sugar yields decreased. In this connection, Jozefyova *et al.* (2004) proved that the highest white sugar yield was achieved from sugar beet fertilized at the rate of 50 Kg/ ha in the meantime, this rate was sufficient for high root yields as well as for high sugar content. Cai and Ge (2004) showed that with the high N dressing, the over ground grow too much and resulted in low yield of roots. Low N resulted in falling of leaves and low yield.

Table (6): Effect of nitrogen as ammonia gas (N) and potassium (K) with or without micronutrients (M) on yields (ton/fed). (combined analysis of two seasons).

Treatments (rate)		Yields (ton/fed)								
		Tops			Roots			Sugar		
N	K	-M	+M	Mean	-M	+M	Mean	-M	+M	Mean
40	24	6.78	6.89	**6.83**	17.13	18.40	**17.77**	2.54	2.87	**2.71**
	48	7.03	7.26	**7.14**	19.80	21.58	**20.69**	3.08	3.54	**3.31**
	72	7.44	7.55	**7.50**	22.32	23.35	**22.83**	3.74	3.96	**3.85**
Mean		**7.08**	**7.23**	**7.16**	**19.75**	**21.11**	**20.43**	**3.12**	**3.46**	**3.29**
80	24	7.63	7.95	**7.79**	27.67	29.05	**28.36**	4.18	4.77	**4.48**
	48	8.26	8.43	**8.34**	29.92	31.13	**30.53**	5.24	5.68	**5.46**
	72	8.60	8.80	**8.70**	31.68	32.80	**32.24**	5.42	5.76	**5.59**
Mean		**8.16**	**8.39**	**8.28**	**29.76**	**30.99**	**30.38**	**4.95**	**5.40**	**5.17**
120	24	9.23	9.42	**9.32**	27.10	26.20	**26.65**	4.15	4.25	**4.20**
	48	9.68	10.03	**9.86**	27.65	28.53	**28.09**	4.75	5.04	**4.89**
	72	10.32	10.56	**10.45**	29.82	31.32	**30.57**	5.04	5.45	**5.25**
Mean		**9.74**	**10.00**	**9.87**	**28.19**	**28.68**	**28.44**	**4.65**	**4.91**	**4.78**
Mean of K	24	7.88	8.09	**7.98**	23.97	24.55	**24.26**	3.62	3.96	**3.79**
	48	8.32	8.57	**8.45**	25.79	27.08	**26.44**	4.36	4.75	**4.55**
	72	8.79	8.97	**8.88**	27.94	29.16	**28.55**	4.73	5.06	**4.89**
Mean of M		**8.33**	**8.54**	**8.44**	**25.90**	**26.93**	**26.41**	**4.24**	**4.59**	**4.41**

LSD at 0.05%	Tops	Roots	Sugar
N	0.60	2.43	0.50
K	0.12	0.82	0.21
M	0.05	0.59	0.16
NxK	0.200	NS	NS
NxM	NS	NS	NS
KxM	NS	NS	NS
NxKxM	NS	NS	NS

Application of K fertilizer at different rates studied caused significant increase in tops, roots and sugar yields especially, at the highest rate (Table 6). As a result of improved top growth with the application of K, there was an increase in sugar beet root yield, sugar content and sugar yield (Ying and Hong, 1997).

Foliar spray with micronutrients increased significantly tops, roots and sugar yields as compared with control (untreated with micronutrients) (Table 6). Results are in harmony with those of Shalaby (1998) who found that Fe, Zn and Mn increased root yield, sugar concentration and yield of sugar beet plants.

Interactions:

Generally, various interactions degrees among the three factors did not show significant effect on yield traits (Table 6).

Years effect:

Data presented in Table (7) cleared that years had insignificant effect on most growth productivity and quality traits. On the other hand elements uptake for beet tops and roots were significant.

Table (7): Effect of nitrogen as ammonia gas (N) and potassium (K) with or without micronutrients (M) on growth, productivity and quality traits as well as elemental uptake during 2004, 2005 and 2005, 2006 seasons.

Traits	Year 1	Year 2	Significance		Traits	Year 1	Year 2	Significance
Root diameter (cm)	4.26	4.42	N.S	Topuptake	N (g/plant)	1.52	1.72	*
Number of leaves	13.77	14.20	N.S		K (g/plant)	1.58	1.64	N.S
Average top dry weight (g)	32.74	30.63	N.S		Zn(mg/plant)	1.18	1.34	*
Average root dry weight (g)	30.04	27.52	**		Mn(mg/plant)	1.45	1.69	*
Sucrose %	16.62	16.53	N.S		Fe(mg/plant)	5.42	6.40	*
Total soluble solids %	19.84	19.90	N.S	Roots uptake	N (g/plant)	1.42	1.54	*
Purity %	83.49	83.69	N.S		K (g/plant)	1.41	1.49	N.S
Tops yield (ton/fed)	7.93	8.94	*		Zn(mg/plant)	1.86	2.06	*
Roots yield (ton/fed)	26.32	26.50	N.S		Mn(mg/plant)	1.81	2.05	*
Sugar yield (ton/fed)	4.41	4.41	N.S		Fe (mg/plant)	5.93	6.55	*

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تأثير حقن الأمونيا الغازية ومعدلات مختلفة من البوتا سيوم مع أوبدون بعض العناصر الصغرى على إنتاجية بنجر السكر

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أقيمت تجربتان حقليتان في مزرعة محطة البحوث الزراعية بسدس في محافظة بني سويف في موسمي ٢٠٠٤/٢٠٠٥، ٢٠٠٥/٢٠٠٦ لدراسة تأثير حقن الأمونيا الغازية ومعدلات مختلفة من البوتاسيوم مع أو بدون مخلوط من بعض العناصر الصغرى (الزنك، المنجنيز والحديد) على نمو وجودة ومحصول بنجر السكر وقد أظهر تحليل التباين أن السماد النيتروجيني بمعدل ٤٠، ١٢٠ كجم/فدان قد ادى الى نقص معنوي في قطر الجذور ومحتوى العناصر الغذائية (النيتروجين والبوتاسيوم والزنك والمنجنيز والحديد) فى الجذور وجودة العصير (النسبة المئوية للسكروز والنقاوة) و كذا نقص في محصول الجذور ومحصول السكر وكان النقص في هاتين الصفتين معنويا عند معدل ٤٠ كجم ن/فدان بينما زاد عدد الأوراق والوزن الجاف للمجموع الخضري ومحتوى العناصر الغذائية (النيتروجين والبوتاسيوم والمنجنيز والحديد) في المجموع الخضري بزيادة معدل النيتروجين إلى ١٢٠/كجم/فدان .

زيادة معدل البوتاسيوم من ١٢ إلى ٤٨ كجم بو٢ا/فدان ادلى الى زياده معنويه بقطر الجذور وعدد الأوراق والوزن الجاف للمجموع الخضري والجذور. اضاف إلى ذلك أن زيادة فى إمتصاص العناصر الغذائية في المجموع الخضري والجذور.

إضافة البوتاسيوم بمعدلات مختلفة قد أدت الى زيادة معنوية في العرش ومحصول الجذور ومحصول السكر ولاسيما عند أعلى معدل.

رش الأوراق بمخلوط العناصر الصغرى (الزنك والمنجنيز والحديد) ادى الى زياده معنويه فى الصفات تحت الدراسه.

كان تفاعل النيتروجين × البوتاسيوم بالمعدلات الموصى بها أفضل تفاعل مقارنة بالتفاعلات الأخرى حيث أثر معنويا على كل الصفات باستثناء جودة العصير.