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PHYSIOLOGICAL ROLE OF SOME NUTRIENTS AND CITRIC ACID ON GROWTH AND YIELD QUALITY OF SUGAR BEET (*Beta vulgaris.* L).

BY

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ABSTRACT

Two field experiments were conducted at the Sakha Agricultural Research Station, Khafer El-Sheik Governorate, Agricultural Research Center, during two successive seasons of 2006 and 2007, to study the effect of foliar spraying with potassium (K) at 500-1000, iron (Fe) at 200-400, boron (B) at 20-40 and 500-1000 ppm of citric acid (CA) at 80,100 and 120 days after sowing on some morphological characteristics of root and leaves, photosynthetic pigments and chemical composition of leaves as well as root yield and quality of sugar beet.

Results revealed that, foliar spraying with different treatments were significantly increased leaf characteristics (i.e. number of leaves, leaf area and leaves dry weight per plant) and root characteristics (length, diameter and fresh weight) as well as root quality (sucrose, total soluble solids (T.S.S) and juice purity%), at different growth stages in both seasons.

Besides, the foliar application with K at 1000 ppm and boron at 40ppm obviously increased photosynthetic pigments, minerals content (N, P, K, Fe and B), total sugars and carbohydrates as well as crude protein in leaves at 100 and 120 days after sowing during 2007 season.

In addition, root yield and quality of sugar beet (length, diameter, fresh weight, sucrose, T.S.S and juice purity %) at harvest (200 days after sowing) were significantly increased by foliar application with K at 1000 and B at 40 ppm in both seasons. Generally, it could be concluded that, foliar application with K and B play an important role for increasing root yield and sucrose percentage of sugar beet plants.

Key words: Potassium,, iron, boron, citric acid, photosynthetic pigments, root yield, sugar beet .

INTRODUCTION

It has been established that sugar beet (*Beta vulgaris* L) is an important sugar crop not only in Egypt, but also in many different countries of the world. Production of sugar was depend mainly on sugar cane from long time ago. After introducing sugar beet in Egypt and its success as another source of sugar production as well its more adaptability to our environmental factors, it became the second source for sugar industry. Recently production of sugar is not adequate enough to our consumption. Therefore, more attention has been given to grow and development of sugar beet crop to overlap the gab between consumption and production, especially its suitability to grow well in new reclaimed soils as well as tolerant to stresses El-Harriri and Mirvat (2001) and Nemeat-Alla and Samia (2005) .The Egyptian Government is pushing hard to built new factories in these new areas i.e. at Noubaria and El-Fayoum to raise production of sugar in suitable sites.

Two important aspects of a plant productivity are:(a) Its ability to produce large amounts of photosynthates, and (b) its ability to transport and partition a great part of these photosynthates to appropriate sinks areas. In sugar beet, large quantities of photosynthate (sucrose) are translocated and stored in the vacuole of parenchyma cells in the root sink (Wyse,1979; Saftner and Wyse 1984 and Bondok,1996).

Moreover, yield of sugar beet and its technological properties is highly affected by nutrient elements. Foliar application with minerals as a method of supplying nutrients to higher plants was more rapidly effective than other methods including soil application (Marschner,1995). The positive effect of minerals as a foliar application on yield and sugar percentage of sugar beet was reported by Abdel-Aal (1990), Ibrahiam and Attia (1990), Osman (1997), Saif (2000) and Esmail and Abo El-Hamd (2007).

In this regard, potassium (K) is major plant nutrient needed in sugar beet production. Average of root length, sucrose percentage and root yield of sugar beet were significantly increased with increasing potassium fertilizer rates (Ghaly *et al.*,1984 and El-Hawary 1994 and 1999). In addition various studies provide evidence that K promotes the translocation of products of photosynthesis in plants Doman and Geiger (1979) and Geiger and Giaquinta (1982). This promotion will take place if a higher level of K nutrition causes one or more of the following to increase: (a) phloem loading, (b) velocity of transport into cells of sinks, and (c) metabolic conversion of sucrose in sink tissues Terrance and Geiger (1982).

Also, boron (B) plays a key role in higher plants by facilitating the short- and long- distance transport of sugar via the formation of borate- sugar complexes (Dugger, 1983). However, such a proposal is unacceptable because, the prevalent sugar transport in the phloem forms only weak complexes with boron, and in the mechanisms of phloem loading of sucrose boron is not involved Marschner (1995).

In addition, iron (Fe) is requirement for the structural and functional integrity of the thylakoid membrane and the biosynthesis of chlorophyll .Also, it is directly involved in the electron transport chain per unit of PSII and PSI Terry and Abadia (1986) and Rutherford (1989).

Citric acid is one of the organic acids presented in tri-carboxylic acid cycle and synthesized either from acetyl-CoA, glycine and α keto-glutaric or malic acid conversion to citric acid (Miernyk and Trelease,1981). Growth of cotton, corn, bean and sugar beet increased by foliar application with organic acids especially succinic, malic and citric acids (Malik and Singh, 1982 and Nofal *et al.*, 1990).

Therefore, this study was carried out to investigate the role of potassium, boron, iron and citric acid on growth and yield quality of sugar beet plant.

MATERIAL AND METHODS

Two field experiments were conducted at Sakha Agricultural Research Station, Agricultural Research Center Egypt during the two growing successive seasons of 2005/2006 and 2006/2007 to study the effect of potassium, iron, boron, and citric acid on some morphological and physiological characteristics as well as root yield and quality of sugar beet *(Beta vulgaris L.)*.Seeds of sugar beet cultivar *(Beta vulgaris var. vulgaris)* cv. Ras poly were obtained from field crop Research Institute, Agricultural Research centre.

Experimental design

Seeds of sugar beet were sown on 25th of September in both seasons .The experimental plot area was 3.0 x 3.5m (1/400 feddan) with six. rows in each plot and 30 cm apart between hills. The experimental plots in both seasons were fertilized with 150kg/fed. super phosphate (15.5%P_2O_5) and 24kg K_2O/fed. was applied before planting. While nitrogen at 50kg N/fed. was applied into two equal doses, the 1st after 40 days(after thinning) and the 2 nd dose after 80 days from sowing. Different recommended agricultural practices for this plant were followed by the Ministry of Agric., Egypt.

'The experiment included nine treatments, potassium(K) at 500 and 1000 ppm, iron(Fe) at 200 and 400ppm, boron (B) at 20 and 40 ppm and citric acid at 500 and 1000 ppm as well as control (distilled water). All treatments were added as a foliar application at 60, 80 and 100 days after sowing. The treatments were arranged in randomized complete block design (RCBD) in three replicates.

Sampling and collecting data:

a- Growth and yield characteristics

Nine plants from each treatment were randomly taken at 80, 100, 120 and at harvest (200) days after sowing in both seasons to estimate number of leaves/ plant, leaves dry weight(g)/ plant, total leaf area (cm^2) /plant using the disk method according to Derieux *et al* . (1973), root diameter (cm)/ plant, length (cm) /plant, fresh weight (g)/ plant.

Relative growth rate(RGR) is define as the increase of plant material per unit of time, according to Radford (1967).

RGR = Loge w2-Loge w1/ t2-t1 .

where: **w1** = dry weight at t1.

w2 = dry weight at t2.

b- Root quality

Sucrose % was determined according to Le Docte (1927), total soluble solids percentages (T.S.S %) was determined by using hand refractometer and Juice purity percentage was calculated according to Carruthers *et al.* (1962) as:

Juice purity % = (sucrose/ total soluble solids)×100

c- Photosynthetic pigments:

Chlorophyll a, b, and carotenoids were calorimetrically determined in fresh leaves of sugar beet plants according to the methods described by Wittesitn (1957) and calculated as mg/g fresh weight .

d- Chemical composition:

Samples from sugar beet leaves at 100 and 120 days after sowing were taken to determine Total nitrogen (Horneck and Miller, 1998), phosphorus (Sandell, 1950), potassium (Horneck and Hanson, 1998) and each of boron and iron (Black *et al.,* 1965). Also NPK uptake was calculated after determination of NPK according to Chapman and Pratt (1961). Total sugars and total carbohydrates were determined according to Thomas and Dutcher (1924) and Dubois *et al.*(1956), respectively. Crude protein was calculated according to the following equation:

Crude protein= Total nitrogen x 6.25 (A.O.A.C., 1990).

Statistical analysis:

Data of morphological and yield characteristics were statistically analysized and the means were compared using the least significant difference test (L.S.D) at 1% and 5% levels according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1- Growth:

a- Root characteristics:

Data of root characteristics expressed as root length, diameter and fresh weight per plant as affected by potassium, boron, iron and citric acid as a foliar nutrition during different periods of growth 80,100 and 120 days after sowing in the two seasons are shown in Table (1).

As for root characteristics, foliar application with two concentrations of potassium, boron, iron and citric acid caused a gradually significant increase in root diameter, length and fresh weight per plant compared with control during different periods of growth in the two seasons. In this respect, foliar spraying with K at 1000 ppm gave the highest values followed by B at 40 ppm and Fe at 400 ppm of root characteristics at120 days after sowing when compared with other treatments or control during the two seasons, respectively. Also nearly similar results were also obtained by El-Hawary (1999), Nemeat-Alla *et al.* (2002) and Haggag and El-Khair (2007). Such results could be attributed to the essentiality of K for photosynthates formation and translocation, activation of many enzymes and protein synthesis in meristematic tissues, which reflected on root diameter and fresh weight (Ismail and El-Ghait (2004); Hopkins (2005) and Osman (2006). Moreover, boron play a vital role during the development of sugar beet roots. The presence of boron in the plant is essential to facilitate sugar transport within plant (Pilbeam and Kirkby, 1983).

Table (1): Effect of foliar application with some nutrients and citric acid on root characteristics of sugar beet *(Beta vulgaris L.)* plants at 80, 100 and 120 days after sowing during 2006 and 2007 seasons.

Characteristics		Root								
		Diameter (cm)/ plant			Length (cm)/plant			Fresh weight (g)/plant		
		Days after sowing								
Treat-ments	ppm	80	100	120	80	100	120	80	100	120
		Season 2006								
Control	0.0	4.00	5.33	6.00	12.6	14.3	19.3	206.7	300.0	331.7
Boron	20	6.12	6.00	7.87	18.0	20.6	21.7	321.3	345.0	360.0
	40	6.43	7.27	8.97	19.3	21.6	24.6	348.3	361.7	421.7
Iron	200	5.40	6.67	7.57	18.6	19.1	22.0	318.3	337.3	350.3
	400	6.33	7.00	8.67	18.3	19.8	22.7	320.3	356.7	364.7
Pota-ssium	500	5.33	6.66	8.00	18.8	20.6	23.3	329.8	356.3	388.3
	1000	6.35	7.97	9.33	19.4	21.3	25.6	340.3	360.0	426.7
Citric acid	500	4.33	6.15	7.33	16.3	19.0	22.0	309.7	323.3	356.3
	1000	5.50	7.10	8.00	18.0	20.0	22.6	328.3	333.0	342.0
L.S.D.	5%	1.23	0.83	2.21	2.17	1.52	2.90	32.23	47.88	28.97
	1%	1.69	1.14	3.12	2.98	2.10	4.00	44.41	65.97	39.91
		Season 2007								
Control	0.0	4.32	6.33	7.67	13.6	16.0	18.9	287.7	310.0	331.7
Boron	20	6.33	7.33	8.27	178	20.3	224	330.0	335.0	356.7
	40	6.67	7.33	8.80	19.5	21.3	24.7	337.7	341.7	430.7
Iron	200	6.17	7.40	8.10	17.0	19.4	21.8	326.7	336.0	348.3
	400	6.13	7.22	8.55	17.3	20.0	22.0	323.3	334.3	353.7
Pota-ssium	500	6.67	7.00	8.22	19.6	22.0	25.6	336.7	355.0	442.8
	1000	7.33	7.67	910	20.1	23.2	25.7	372.3	362.0	451.3
Citric acid	500	5.00	6.67	6.67	15.6	18.0	20.6	319.7	3308.3	346.0
	1000	6.67	7.33	7.33	17.3	19.3	21.0	317.7	338.7	352.3
L.S.D.	5%	1.26	1.52	1.52	2.6	1.41	1.66	41.90	41.67	58.0
	1%	1.73	2.10	2.10	3.57	1.94	2.29	57.73	57.42	77.7

b-Leaf characteristics:

As shown in Table (2) it could be clearly noticed that leaves number, dry weight and total leaf area (cm^2) per plant were increased to reach the high level of significance with foliar application by K 1000 ppm and B 40 ppm at 120 days after sowing during 2006 and 2007 seasons. The only exception was that number of leaves insignificantly increased with citric acid at 500 ppm and 20 ppm of B at 120 days after sowing during 2006 and 2007 seasons. Also, in most cases leaf characteristics were gradually increased till the third sampling date (120) days after sowing during 2006 and 2007 seasons. Here, the enhancement of number of leaves and leaf area per plant are of great interest because that could be led to not only more efficiency of photosynthesis but also synthesizing more assimilates and high rates of their translocation specially toward sink sites (roots).In this respect nearly similar results were obtained by Besheit *et al.* (1992), Nemeat-Alla *et al.* (2002) and Osman (2006).

Table (2): Effect of foliar application with some nutrients and citric acid on leaf characteristics of sugar beet *(Beta vulgaris L.)* plants at 80, 100 and 120 days after sowing during 2006 and 2007 seasons.

Characteristics		Leaves										
		Number / plant			Dry weight (g)/plant			Total leaf area (cm^2)/plant			RGR1	RGR2
		Days after sowing									g/gm/ day	g/gm/ day
Treat-ments	ppm	80	100	120	80	100	120	80	100	120		
		Season 2006										
Control	0.0	19.6	22.3	23.3	4053	46.60	53.94	2946	3701	4283	0.70	0.85
Boron	20	20.8	24.0	26.2	43.00	54.78	57.26	3381	4178	4422	1.36	0.29
	40	23.6	26.9	28.6	45.93	56.91	60.61	3690	4330	4785	1.26	0.43
Iron	200	20.5	23.6	25.3	42.22	49.90	57.52	3400	3987	4592	0.88	0.88
	400	20.8	24.9	26.7	44.12	51.49	58.87	3574	4173	4699	0.85	0.85
Pota-ssium	500	24.0	26.0	29.0	45.89	53.63	59.91	3487	4194	4758	0.89	0.68
	1000	25.0	26.5	31.0	48.55	55.35	61.07	3813	4399	5048	0.87	0.66
Citric acid	500	23.3	25.0	25.6	42.96	48.36	56.26	3305	3603	4394	0.62	0.91
	1000	22.6	23.4	26.3	43.39	47.32	52.18	3519	3792	4321	0.68	0.80
L.S.D.	5%	1.96	1.42	2.56	6.37	5.10	4.64	583.2	501.2	670.6	-	-
	1%	2.12	2.06	3.52	8.78	7.02	6.39	802.5	690.5	867.2	-	-
		Season 2007										
Control	0.0	20.0	22.8	23.6	38.33	43.80	49.61	2773	3752	3943	0.63	0.67
Boron	20	21.6	24.3	26.0	43.34	50.44	53.61	3322	4102	4273	0.82	0.37
	40	22.8	26.0	29.3	46.02	55.42	58.56	3749	4325	4860	1.08	0.36
Iron	200	21.3	24.0	25.6	43.53	49.95	59.95	3176	3863	4669	0.74	1.15
	400	22.3	25.0	26.2	46.08	50.85	58.40	3431	4132	4519	0.66	0.87
Pota-ssium	500	24.0	25.3	28.6	47.50	55.87	60.45	3585	4299	4623	0.73	0.53
	1000	25.3	26.7	30.9	48.56	56.18	61.74	3826	4323	5167	0.76	0.64
Citric acid	500	23.0	25.4	26.6	40.46	46.03	52.48	3125	3733	4169	0.64	0.74
	1000	23.6	25.8	26.9	45.74	50.79	57.60	3422	4158	4521	0.70	0.78
L.S.D.	5%	2.00	3.11	2.56	8.03	6.81	5.15	807.4	681.7	530.8	-	-
	1%	2.95	4.30	3.52	11.07	9.38	7.09	1112	939.3	731.4	-	-

- RGR1: Relative growth rate (80-100) days after sowing.
- RGR2: Relative growth rate (100-120) days after sowing.

In addition, Bondok (1996) found that, different concentrations of boron reduced shoot fresh weight, these results may be due to the reduction of auxin levels and the high level of ABA in sugar beet shoots after boron application which led to a limitation of vegetative growth. The reduction of shoot weight may also due to the role of boron upon the translocation of carbohydrates from the leaves (source organs) to root (storage organs) as well as boron deficiency is associated with a disturbance in synthesis of plant hormones and nucleic acids metabolism. He also mentioned that, many symptoms of boron deficiency are very similar to symptoms of abnormally high concentrations of auxins.

Concerning the relative growth rate (RGR), foliar application with potassium, boron, iron and citric acid caused increase in the relative growth rate of leaves dry weight between (80-100) days after sowing meanwhile, RGR was decreased between (100-120) in both seasons. The plants sprayed with high concentrations of K and B exhibited the highest increase of root and leaves characteristics the same as RGR between 80-100 days after sowing in comparison with those sprayed with the low concentrations in both seasons. The results are in harmony with those reported by Saif (1991) and Abd El-Hamid *et al.* (1992).

c- Root quality:

Data in Table (3) clearly indicate that each of sucrose, juice purity and total soluble solids (TSS) % in root of sugar beet were increased to reach the high level of significance with different applied treatments during 2006 and 2007 seasons.

Concerning sucrose %, the only foliar spray with citric acid at 500 ppm increased this trait significantly at 5% during two seasons. Moreover, boron at 40ppm gave the highest values those reached 18.87 % and 18.58 % at 120 days after sowing during 2006 and 2007 seasons, respectively. Meanwhile values were 13.63 and 13.53% sucrose in case of control plants. The promotion effect of boron on sugar yield may be due to more quantities of photosynthates (sucrose) are being translocated and stored in the root. These results are in agreement with those of Bondok (1996); El-Hawary (1999); Saif (2000) and Hussein (2002).

Regarding total soluble solids (TSS) and purity % in root of sugar beet were behaved as the same as the above mentioned characteristics. Since, all applied treatments showed their high significant increase but their maximum were also, obtained with the foliar application with K at 1000 ppm and B at 40 ppm treatments compared with control one.

The highest values of juice purity in root of sugar beet obtained with foliar application by K at 1000 ppm and boron at 40 ppm at 120 days after sowing during two seasons since values were 75.05%, 72.39 % and 72.25 %, 71.46 %, respectively. Nearly similar findings were obtained by Saif (1991) and Haggag and El-Khair (2007).

In this respect, boron increased dramatically cytokinin levels in treated roots, which lead to accelerate cambial activity and cell division which reflects upon root quality and increased storage cells (Dizengremel *et al.*, 1982). So increasing of root fresh weight and quality due to the high content of cytokinins in roots (Bondok, 1996).

Chemical composition:

a- Photosynthetic pigments:

Data in Table (4) indicate that different photosynthetic pigments as chlorophyll a, b and carotenoids were positively responded to the different applied treatments during 2007 season. Also, potassium at 1000 ppm and boron at 40 ppm gave the highest values at 80 and 100 days after sowing meanwhile citric acid ranked the first at 120 days after sowing during 2007 season when compared with other treatments or control one. Increasing of chlorophylls and carotenoids concentration were enhanced photosynthesis efficiency and increased dry matter production. Also, the stimulation of photosynthetic pigments formation could be attributed to the vigorous growth obtained in Tables (1& 2). Nearly similar results were reported by Bondok (1996), Abd-El-Hamid (1997). Increment of photosynthesis pigments in response to citric acid might be due to its action as a antioxidants for protecting chloroplasts from oxidative damage by free radicals. (Ghourab, 2000 and Haggag and El-Khair 2007).

Table (3): Effect of foliar application with some nutrients and citric acid on root quality of sugar beet *(Beta vulgaris L.)* plants at 80, 100 and 120 days after sowing during 2006 and 2007 seasons.

Characteristics		Root								
		Sucrose %			Total soluble solid (TSS) %			Purity %		
		Days after sowing								
Treat-ments	ppm	80	100	120	80	100	120	80	100	120
		Season 2006								
Control	0.0	8.47	11.20	13.63	17.00	18.33	21.67	46.20	61.10	62.89
Boron	20	16.20	16.50	16.50	22.50	23.67	24.33	59.00	66.70	67.81
	40	16.17	17.33	18.87	23.00	24.00	26.10	65.60	72.20	72.39
Iron	200	12.96	15.93	16.36	21.17	22.00	22.33	61.21	64.40	65.04
	400	15.66	16.07	17.33	21.33	23.00	25.31	63.41	67.86	68.41
Pota-ssium	500	13.36	15.73	17.75	22.47	24.00	25.67	66.45	62.92	62.80
	1000	15.95	16.70	17.91	22.47	25.00	26.33	70.90	68.58	75.05
Citric acid	500	10.72	12.47	14.48	20.47	21.00	21.32	52.36	59.38	67.88
	1000	9.03	14.63	15.48	18.00	20.67	23.00	50.16	63.60	68.89
L.S.D.	5%	2.49	1.14	0.65	1.16	1.20	1.01	4.08	7.09	3.70
	1%	3.44	1.58	0.92	1.60	1.66	1.40	5.62	9.77	5.10
		Season 2007								
Control	0.0	9.27	12.87	13.53	17.67	18.67	21.67	52.46	58.46	62.44
Boron	20	15.38	17.27	1850	23.33	24.57	26.12	65.92	66.00	68.07
	40	16.48	17.80	18.58	24.33	25.67	26.37	65.73	67.00	71.46
Iron	200	14.29	15.93	17.50	20.00	21.00	23.33	62.13	64.91	66.46
	400	15.57	16.43	17.37	22.67	23.67	24.00	63.11	66.59	69.48
Pota-ssium	500	16.45	1790	18.55	23.00	24.33	25.67	62.82	63.86	70.16
	1000	15.85	17.95	1876	23.33	25.00	26.33	67.93	69.53	72.25
Citric acid	500	10.32	14.03	15.62	18.33	22.00	23.33	56.30	63.77	66.95
	1000	12.68	14.83	16.58	20.67	23.33	23.67	61.34	63.56	70.04
L.S.D.	5%	0.92	0.74	2.54	0.99	1.42	1.30	4.83	5.15	3.91
	1%	1.27	1.02	3.50	1.37	1.96	1.80	6.65	7.10	5.38

In this respect, it could be suggested that, the enhancement effect of K, Fe, B and citric acid on increasing plant pigment concentration could be attributed to the favorable effect of these nutrients to increase biosynthesis of chlorophylls through improving the absorption of N and Fe ions which are involved in chloroplast formation, which might be expected as a reason for chlorophyll increases in sugar beet leaves(Abd El-Hamid *et al.*, 1992; Marschner 1995 and Bondok 1996).

b- Minerals content in leaves:

Data in Tables (5) indicate that all foliar sprayed treatments increased N, P, K, Fe and B concentrations and contents in leaves of sugar beet plants at 100 and 120 days after sowing during 2007 season. Also, foliar spray with potassium at 1000 ppm gave the highest increase in N and P meanwhile, citric acid at 1000 ppm gave the highest increase in K during 2007 season. Also, Fe and B were increased to reach their maximum with boron at 40 ppm treatment compared with control plants and other treatments. This result are in agreement with those obtained by Negm and Hassan (1998), El-Nour *et al.* (2000) and Koriem *et al* (2002).

Also, Ghourab (2000) mentioned that foliar spraying with potassium and boron were associated with enhancement of vegetative growth and increase NPK concentration and content in leaves of sugar beet plants.

Table (4): Effect of foliar application with some nutrients and citric acid on photosynthetic pigments of sugar beet *(Beta vulgaris L.)* leaves at 80, 100 and 120 days after sowing during 2007 season.

Characteristics		Chlorophyll (mg/g F.W.)									Carotenoids (mg/g F.W.)			Total pigments (mg/g F.W.)		
		a			b			a+b								
		Days after sowing														
Treat-ments	ppm	80	100	120	80	100	120	80	100	120	80	100	120	80	100	120
Control	0.0	0.29	0.30	0.31	0.16	0.12	0.11	0.45	0.42	0.42	0.17	0.19	0.20	0.62	0.61	0.62
Boron	20	0.33	0.46	0.54	0.18	0.15	0.27	051	0.61	0.81	0.24	0.23	0.23	0.75	0.84	1.04
	40	0.37	0.49	0.54	0.18	0.16	0.28	0.55	0.65	0.82	0.19	0.22	0.24	0.74	0.87	1.06
Iron	200	0.34	0.42	0.45	0.20	0.17	0.21	0.54	0.59	0.66	0.13	0.23	0.23	0.67	0.82	0.89
	400	0.35	0.48	0.50	0.21	0.19	0.22	0.56	0.67	0.72	0.19	0.24	0.22	0.75	0.91	0.94
Potassium	500	0.36	0.47	0.50	0.19	0.20	0.29	0.55	0.67	0.79	0.25	0.23	0.23	0.80	0.90	1.02
	1000	0.34	0.48	0.57	0.18	0.21	0.26	0.52	0.69	0.83	0.20	0.27	0.21	0.72	0.89	1.04
Citric acid	500	0.33	0.44	0.51	0.16	0.17	0.27	0.49	0.61	0.78	0.21	0.20	0.23	0.70	0.81	1.01
	1000	0.35	0.45	0.65	0.17	0.18	0.29	0.52	0.63	0.94	0.22	0.22	0.22	0.74	0.85	1.16

Table (5): Effect of foliar application with some nutrients and citric acid on minerals content of sugar beet *(Beta vulgaris L.)* leaves at 100 and120 days after sowing during 2007 season

Characteristics		Nitrogen				Phosphorus				Potassium				Iron		Boron	
		mg/g DW		uptake		mg/g DW		uptake		mg/g DW		uptake		ppm		ppm	
		Days after sowing															
Treatments	**ppm**	**100**	**120**	**100**	**120**	**100**	**120**	**100**	**120**	**100**	**120**	**100**	**120**	**100**	**120**	**100**	**120**
Control	**0.0**	21.6	21.7	946.1	1076.5	1.70	1.87	74.46	92.77	31.0	33.0	1357.8	1637.1	2.40	2.33	0.097	0.100
Boron	**20**	34.0	34.5	1718.7	1849.6	2.25	2.30	113.49	123.30	42.5	43.8	2143.7	2348.1	4.36	4.69	0.154	0.176
	40	39.1	38.0	2166.9	2225.3	2.40	2.50	133.01	146.4	43.7	44.0	2421.6	2576.6	5.23	5.45	0.169	0.193
Iron	**200**	31.5	34.6	1573.4	2074.3	2.60	2.82	129.87	169.06	44.0	45.0	2197.8	2697.8	5.15	4.87	0.119	0.120
	400	36.4	38.2	1850.9	2230.9	2.71	2.86	137.80	167.02	45.0	45.5	2288.3	2657.2	5.47	5.46	0.106	0.133
Potassium	**500**	34.0	34.5	1899.6	2085.5	2.73	3.10	152.53	187.40	46.0	50.0	2570.0	3022.5	3.62	4.31	0.158	0.136
	1000	39.1	38.6	2196.6	2363.9	2.90	3.75	162.92	231.53	47.0	51.0	2640.5	3148.8	5.17	5.34	0.139	0.139
Citric acid	**500**	31.2	33.5	1436.1	1758.1	3.20	3.30	147.30	173.18	48.0	48.5	2209.4	2545.3	5.11	5.60	0.123	0.119
	1000	36.2	35.6	1838.6	2050.6	3.30	3.40	167.61	195.84	49.0	52.0	2488.7	2995.2	4.88	5.90	0.155	0.163

c- Sugars, carbohydrates and crude protein concentrations in leaves:

As shown in Table (6) it could be clearly noticed that total sugars, total carbohydrates and crude protein concentration in leaves were increased with different applied treatments at 100 and 120 days after sowing during 2007 season when compared with the control treatment. As for total sugars, boron at 40 ppm gave the highest values followed by potassium at 1000 ppm meanwhile, iron at 200 ppm gave the lowest values during 2007 season.

Concerning the total carbohydrates concentration it was behaved as the same as the total sugars. Also, it could be noticed that application with K at 1000 ppm gave the highest concentration of carbohydrates in leaves of sugar beet at 100 and 120 days after sowing during 2007 season. High concentration of total carbohydrates is a direct result for high rates of photosynthesis with its great efficiency. That was preceded with large photosynthetic area Table (2) and high concentration of photosynthetic pigments Table (4) as well under the treatment of various foliar sprayed but it reached its maximum with K followed by B.

This result are in agreement with those reported by Abd-El-Hamid *et al.* (1992) and (1997), they concluded that foliar applications of potassium alone or with micronutrients increased the amount of carbohydrates and crude protein in roots and leaves of fodder beet plants. Also, Marschner (1995) pointed out that K, Fe and B affect carbohydrates and protein metabolism through their role as an activator of several enzymes involved in metabolic reactions.

Table (6): Effect of foliar application with some nutrients and citric acid on total sugar, carbohydrates and crude protein content of sugar beet (Beta vulgaris L.) leaves at 100 and 120 days after sowing during 2007 season.

Characteristics		Total sugars mg/g FW		Total carbohydrates mg/g DW		Crude protein mg/g DW	
		Days after sowing					
Treatments	**ppm**	**100**	**120**	**100**	**120**	**100**	**120**
Control	0.0	16.23	19.45	319.4	367.9	135.0	135.6
Boron	20	26.56	32.54	521.8	568.5	181.3	198.8
	40	37.20	39.43	643.7	656.2	206.3	219.4
Iron	200	21.70	22.13	352.6	366.9	196.9	216.3
	400	23.65	24.41	377.8	390.5	227.5	238.8
Potassium	500	27.53	36.90	634.6	683.4	212.5	215.6
	1000	29 60	38.42	665.5	673.2	244.4	237.5
Citric acid	500	24.51	26.33	465.7	480.2	195.0	209.4
	1000	25.13	27.68	475.9	489.6	226.3	222.5

With regard to the protein concentration, it could be noticed that Fe at 400 ppm gave the highest increase in leaves of sugar beet plants at 100 and 120 days after sowing followed by potassium at 1000 ppm during 2007 season. In addition, these data being more evident when related to the control ones. The results are in agreement with those obtained by Abd-El-Hamid (1992) and Koriem *et al* (2002).

Hopkins (1995) attributed such increases in sugar beet plants as a result of foliar application with k may be due to one or more of the following physiological functions for k: a) carbohydrates metabolism and formation, breakdown and translocation of starch, b) control and regulation of activities of various essential elements and c) activation of various enzymes.

Root yield and quality at harvest (i.e. 200 days after sowing):

Data in Table (7) indicate the effect of K, B, Fe and citric acid on yield and quality of root of sugar beet plants at harvest during 2006 and 2007 seasons.

Table (7): Effect of foliar application with some nutrients and citric acid on root yield and quality of sugar beet *(Beta vulgaris L.)* plants at harvest during 2006 and 2007 seasons.

Characteristics		Root											
		Yield				Quality							
		Fresh weight Kg/ plant		% relative to the control		Sucrose (%)		% relative to the control		Total soluble solid (%)		Juice purity (%)	
		seasons											
Treatments	ppm	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Control	0.0	1.55	1.58	100.00	100.00	16.70	16.89	100.00	100.00	24.00	24.26	69.58	69.63
Boron	20	2.44	2.62	157.41	165.82	18.11	18.21	108.44	107.81	25.00	25.05	72.44	72.69
	40	2.56	2.79	165.16	176.58	20.36	20.62	121.91	122.08	25.94	26.38	78.48	78.16
Iron	200	2.50	1.98	161.29	125.31	18.85	18.87	112.87	111.72	25.00	25.28	75.40	74.64
	400	2.61	2.71	168.38	171.51	19.69	19.60	117.90	116.04	25.48	26.45	77.27	74.10
Potassium	500	2.31	2.27	149.03	143.67	19.21	19.50	115.02	115.45	25.00	25.33	76.84	76.98
	1000	2.56	2.72	165.16	172.15	20.44	20.67	122.39	122.38	25.97	26.43	78.70	78.20
Citric acid	500	1.64	1.64	105.80	103.79	17.70	17.96	105.98	106.33	25.47	25.47	69.49	70.51
	1000	2.40	2.41	154.83	152.53	18.57	18.32	111.19	108.46	25.27	25.25	73.48	72.55
L.S.D.	5%	0.71	0.46	-	-	0.616	0.877	-	-	0.563	0.715	2.04	2.64
	1%	0.98	0.63	-	-	0.849	1.209	-	-	0.776	0.986	2.81	3.64

As for root fresh weight per plant, its significant increase existed with different applied treatments during the two seasons when compared with the control. Also it could be noticed that foliar application with boron at 40 ppm ranked the first followed by potassium at 1000 ppm, citric acid at 1000 ppm and iron at 400 ppm during the two seasons. Also, nearly similar results were reported by Bondok (1996), Abd-El-Hamid (1997).

With regard to root quality as expressed as sucrose, total soluble solids and juice purity percentages were significantly increased in root of sugar beet plants at harvest with different applied treatments during 2006 & 2007 season. The exception was only that significant increase at 5% level of significance with citric acid at 500ppm during 2007 season. This result are in agreement with those reported by Saif (2000) and Hussein (2002).

Generally, foliar spraying with K and B treatments of sugar beet plants gave not only the highest vigorous growth in the early stage but also increased root yields and the improvement of root quality.

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الدور الفسيولوجي لبعض العناصر الغذائية و حامض السيتريك علي النمو وجودة محصول بنجر السكر

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية بسخا- محافظة كفر الشيخ ــ مركز البحــوث الزراعية ــ خلال موسمي ٢٠٠٦ و ٢٠٠٧ م لدراسة تأثير الرش الورقي بالبوتاســيوم بتركيــز ٥٠٠ – ١٠٠٠ جزء في المليون ، الحديد بتركيز ٢٠٠ – ٤٠٠ جزء في المليون ، البــورون بتركيــز ٢٠ – ٤٠ جزء في المليون وحمض السيتريك بتركيز ٥٠٠–١٠٠٠ جزء في المليون عند ٨٠، ١٠٠ و ١٢٠ يوم من الزراعة على بعض الخصائص المورفولوجي والفسيولوجية للجذور والأوراق وصبغات البنــاء الضــوئي والمحتوى الكيماوي للأوراق وكذلك محصول الجذور وجودته لبنجر السكر . ومن النتائج المتحصل عليها:

- أدى الرش الورقي للمعاملات المختلفة إلى زيادة معنوية لخواص الورقة وهى عدد الأوراق، مساحة الأوراق والوزن الجاف للأوراق للنبات وأيضا لخواص الجذور وهى الطول والقطر والوزن الطازج للجذور وذلك خلال فترات النمو المختلفة خلال موسمي الدراسة .
- أظهرت معاملات الرش الورقي بالبوتاسيوم بتركيز ١٠٠٠ جزء في المليون والبورون بتركيز ٤٠ جزء في المليون زيادة ملحوظة في محتوى صبغات البناء الضوئي والعناصر المعدنية وهى النيتروجين والفوسفور والبوتاسيوم والحديد والبورون والسكريات الكلية والكربوهيدرات الكلية والبروتين الكلى في الأوراق عند ١٠٠، ١٢٠ يوم من الزراعة لنبات بنجر السكر .
- كذلك أعطى الرش الورقي بالبوتاسيوم بتركيز ١٠٠٠ جزء في المليون والبورون بتركيز ٤٠ جزء في المليون خلال موسمي الدراسة زيادة معنوية عند الحصاد في الطول والقطر والوزن الطازج وكذلك نسبة السكر والمواد الصلبة الكلية والنقاوة لجذور بنجر السكر .

على ضوء هذه الدراسة يمكن التوصية بالرش الورقي بعنصري البوتاسيوم والبورون نظرا للدور الهام لكلا منهما في زيادة محصول وجودة جذور بنجر السكر.