PRODUCTIVITY AND NPK UPTAKE OF SUGAR BEET AS INFLUENCED BY N, B AND Mn FERTILIZATION

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Sugar beet (*Beta vulgaris* L. var. Trible) was cultivated in Sakha Res. St., Kafr El-Sheikh Governorate during two successive seasons (1997/1998 and 1998/1999) to study the effect of boron and manganese foliar application under three levels of nitrogen fertilizer on the root and sugar yields as well as N, P and K uptake by sugar beet plant.

The obtained results showed a significant increase in root, sugar yields, and NPK uptake with increasing applied N up to 80 kg N fed^{-1} except the uptake of P by root was increased only up to 40 kg N fed^{-1} application.

Concerning the foliar application of boron data indicated that boron at 100 ppm increased sugar yield in 1st season whereas at 200 ppm had no significant effect on root, sugar yields in both season whereas it increased significantly N, P and K uptake in two seasons except K uptake in the second season.

Data also showed that manganese applied at 2000 ppm had significant effect on root and sugar yields as well as N, P and K uptake by plant in both season.

The positive effects of interaction between N, B and Mn on the studied variables were also discussed.

تــأثير النيتــروجين والبــورون والمنجنيــز علــى إنتاجيــة وإمتصــاص النيتــروجين والفوسفور والبوتاسيوم لبنجر السكر

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أقيمت تجربة حقلية بمحطة البحوث الزراعية بسخا خلال موسم ١٩٩٧/١٩٩٨م ، وأخرى خلال ١٩٩٨/١٩٩٩م لدراسة تأثير إضافة البورون والمنجنيز بالرش تحت ثلاث مستويات للتسميد بالنيتروجين على محصول الجذور والسكر لبنجر السكر وكذلك إمتصاص النيتروجين والفوسفور والبوتاسيوم. وتتلخص أهم النتائج فى الآتى:

أدت زيادة إضافة النيتروجين حتى ٨٠كجم/للفدان إلى زيادة فى محصول الجذور والسكر وكذلك زيادة إمتصاص العناصر الغذائية النيتروجين والفوسفور والبوتاسيوم ما عدا إمتصاص الفوسفور كانت الزيادة إيجابية حتى ٤٠كجم/فدان ثم إنخفضت بعد ذلك.

أدت إضافة البورون بمعدل ٢٠٠ جزء فى المليون إلى زيادة إمتصاص عناصر النيتروجين والفوسفور والبوتاسيوم لبنجر السكر ما عدا امتصاص البوتاسيوم فى الموسم الثانى بينما لم يتاثر محصول الجذور والسكر بهذه الاضافة فى الموسم الثانى وزاد محصول السكر بالموسم الاول عند تركيز ١٠٠ جزء فى المليون.

تأثر محصول الجذور والسكر وكذلك إمتصاص بنجر السكر لعناصر النيتروجين والفوسفور والبوتاسيوم خلال موسمى الزراعة بإضافة المنجنيز حتى ٢٠٠٠جزء/مليون كتسميد ورقى.

تمت مناقشة التأثيرالإيجابى التسميد المشترك من هذه العناصر الثلاثة النيتروجين والبورون والمنجنيز على المحصول وامتصاص النبات للعناصر الغذائية النيتروجين والفوسفور والبوتاسيوم.

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is the second important crop for sugar production in Egypt.

Attempts are presently made to determine its nutritional requirements under the Egyptian soil conditions. Nitrogen is in short supply in nearly all arable soils and it is the most important element for sugar beet fertilization, wherever the crop is grown (Draycott, 1972). Application of N fertilizer increased the root yield of sugar beet (Sobh, 1985; Abou-Amou *et al.*, 1996; and Samia *et al.* (1998). Contrarily, Madge (1981), and Mostafa (1996) indicated that N rates added to the soil had no significant effect on sugar yield.

Increasing increments of nitrogen fertilizer increased the amount of gross sugar yield produced by the crop Sobh (1985), Sharif and Eghbal (1994) and Samia *et al.* (1998). Kochl (1978), Sobh (1985), El-Kassaby and Leilah (1992), and Moustafa *et al.* (2000) reported that N, P and K uptake by sugar beet crop increased as a result of application of N fertilizer. With regard to micronutrients, it was found that boron fertilization increased root yield and sugar content, Kalimeri and Pellumbi (1982), Hegazy *et al.* (1992) and Ebrahim (1995). El-Kobbia *et al.* (1971), Genaidy (1988). Also, El-Kobbia *et al.* (1971) and Abou El-Soud *et al.* (1990) revealed that B application to the soil or as foliar spraying resulted in pronounced positive effect on N, P and K uptake by sugar beet crop. On the other hand, some studies clarified that B application had no effect on sugar beet yield and NPK uptake Voth *et al.,* (1979). Compared with other crops, sugar beet is particularly sensitive to shortage of manganese. Mn application significantly showed clear positive effect on root and sugar production as well as N, P and K uptake (Lachowski, 1961 and Farley and Draycott, 1973 and Abou El-Soud *et al.* (1990). Badawi (1989) and Hegazy *et al.* (1992 reported that Mn fertilization gave pronounced synergistic effect on both root and gross sugar yields of sugar beet plants. On the other hand, Voth (1978) revealed that top dressing of Mn had no significant effect on root production of sugar beet plants. The interaction effect of N, B, and Mn fertilization gave greatest values of root and sugar content of sugar beet crop (Hegazy *et al.,* 1992).

The objective of this work is to study the effect of N, B and Mn fertilization on root and sugar production as well as N, P, and K uptake of sugar beet crop grown on the Northern Delta soils.

MATERIALS AND METHODS

Two field experiments were conducted at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during the two successive growing seasons of 1997/1998 and 1998/1999, to study the effect of N, B, and Mn fertilization on root and sugar production as well as N, P and K uptake by sugar beet crop.

Soil samples were taken from both experimental sites before planting for physical and chemical analyses according to Black (1982) and presented in Table (1).

Table (1): Some physical and chemical analyses of the studies soil.*

Particle size distribution				Soil texture	Chemical analysis								
Coarse sand	Fin. sand	Silt	Clay		*pH 1: 2.5	EC dSm^{-1}	O.M %	$CaCO_3$ %	Avail. N	Avail. P	Avail.K	Avail. B	Avail. Mn
7.21	17.78	25.85	49.81	Clayey	7.82	1.39	1.6	2.41	41	9.95	647	0.51	1.51

*** Methods**
Available N (ppm) - (K sulfate extract) **Available P (ppm) - by Olsen extract P**
Available K (ppm) -(ammonium acetate). **Available B (ppm) -(hot water extract)**
Available Mn (ppm) -(DTPA extract)

The effect of N, B and Mn fertilization was tested in a split split plot design of three levels of N (0, 40 and 80 kg N fed^{-1}) in main plots two levels of boron (B) in subplots (0, and 100 ppm) for the first season and 0 and 200 ppm for the second season and two levels of manganese (Mn) in sub-sub plots (0-1000 ppm for the 1st season and 0, 2000 ppm for the 2nd season), which were arranged in three randomized blocks. N-fertilizer as urea (46.5% N) was added in three doses (at planting, after thinning and one month after. P-fertilizer as superphosphate (15%P_2O_5) at a rate of 30 kg P_2O_5 fed^{-1} was banded adjacent to seed hills at planting whereas K fertilizer as potassium sulfate (48% K_2O) was used at a rate of 48 kg K_2O fed^{-1} as one dose at planting. Boron in the form of boric acid (17% B) was sprayed at rate of (200 L/fed) 2 times (45 and 60 days after sowing) while manganese sprayed as manganese sulfate (27% Mn) at a rate of 200 L/fed. for 3 times (45, 60, 75 days after sowing).

Sugar beet (*Beta vulgaris* L.) variety trible (Kawemira) was sown mid November in hills on rows spaced 20 and 60 cm apart respectively where plot area was 12 m^2 (3 x 4 m). Harvesting was done during the second weak of May.

Plant samples (roots and shoots) were taken and well prepared then digested as described by Peterburgski (1968). The digestate was analysis for total N using microkjeldahl). Total phosphorus was determined using the hydroquinone method which described by Snell and Snell (1967), and potassium using flame photometer according to Black (1982). Manganese and boron were determined by atomic absorption spectrophotometry according to Cottenie *et al.* (1982). Sucrose % was determined by sucrometer according to Le Docte (1927). Statistical analysis was carried out according to Snedecor and Cochran (1982).

RESULTS AND DISCUSSION

I. Effect of nitrogen fertilization on sugar beet yield as well as N, P and K uptake:

Root yield (ton fed^{-1}):

Data in Table (2) indicate that root yield significantly increased in both growing seasons as the N-application rate increased up to 80 kg N/fed. The increments were 5.02% and 8.91% over the control treatment of 22.86 ton $fed.^{-1}$ for the first season whereas the magnitudes of increase in the second season were 8.51% and 15.94% as compared to the check treatment of 22.33 ton fed^{-1}. These findings are in agree with those reported by Badawi (1989), Mahmoud *et al.* (1990); El-Kassaby *et al.* (1991), Sobh *et al.* (1992);Gobara (1993) and Moustafa *et al.* (2000). The positive effect of nitrogen application might be attributed to the increased efficiency of N-fertilization in building up metabolites which translocated from leaves to developing roots and then increasing dry matter accumulation (El-Kassaby and Leilah, 1992).

Gross sugar yield (tons fed^{-1}):

For gross sugar yield, Table (2) also, shows that application of N fertilizer had significant positive effect on sugar yield and the greatest value of 4.24 ton fed^{-1} was obtained at the mid dose (40 kg N fed^{-1}) in the 1st season whereas the high rate (80 kg N fed^{-1}) gave the greatest value of sugar yield 4.33 ton fed^{-1} in the second season. Such effect reflects the response of root yield and sugar percentage to N fertilizer levels. These results were similar with those obtained by Abd El-Ghafar *et al.* (1981), Zalat (1986), Follet (1991), Sobh *et al.* (1992), El-Kased *et al.* (1993). Besheit *et al.* (1995), Al-Labbody (1998) and Moustafa *et al.* (2000).

The effect of N-fertilizer on nitrogen, phosphorus and potassium uptake:

As concern N, P and K uptake by sugar beet, the results in Table (2s) show that the N content of the roots, shoots and whole plant was significantly increased when graded amounts of N fertilizer added to the soil up to 80 kg N fed^{-1} in both growing season. These results are in agreement with Draycott and Holliday (1970). Linden (1981) and Abou El-Soud *et al.* (1990), and Moustafa *et al.* (2000).

In regard to P uptake, data in Table (2, 3) clarify that the different applications of N resulted in increase in the P content of the plant parts over the control treatment. The increments were significant for both tops, roots and whole plants for two growing seasons but the roots were not significant in the second season only. The greatest values were obtained when the N fertilizer was added to the soil with the rate of 40 kg N fed^{-1}. These findings are in agreement with those obtained by Abo El-Soud *et al.* (1990) and Moustafa *et al.* (2000).

Table (2): Root and sugar yields (ton/fed) as well as N, P and K uptake (kg/fed) by sugar beet under different levels of N, B and Mn fertilizers.

	First season										
	Yield		N uptake			P uptake			K uptake		
	Root	Sugar	Root	Shoot	Total	Root	Shoot	Total	Root	Shoot	Total
N_1	22.86	3.85	32.43	33.56	65.97	4.01	1.95	5.96	113.59	120.67	234.26
N_2	24.01	4.24	31.82	45.55	77.36	4.14	2.45	6.58	131.89	156.09	287.99
N_3	24.90	4.24	35.13	51.48	87.09	3.80	2.56	6.36	163.89	183.59	347.48
L.S.D	*	*	*	**	**	**	**	**s	**	**	**
B_0	23.68	3.97	30.62	42.23	72.89	2.95	2.19	5.40	13458	152.51	288.97
B_1	24.17	4.24	35.63	44.83	80.73	5.02	2.45	7.20	138.34	154.39	290.85
L.S.D.	n.s	*	**	*	**	**	**	**	**	n.s	n.s
Mn_0	22.82	3.96	38.93	41.84	80.77	3.18	1.98	5.16	132.92	144.67	277.59
Mn_1	25.03	4.25	27.32	45.22	72.85	4.78	2.66	7.44	140.0	162.22	302..23
L.S.D.	**	**	**	**	**	**	**	**	**	**	**

Second season											
	Yield		N uptake			P uptake			K uptake		
	Root	Sugar	Root	Shoot	Total	Root	Shoot	Total	Root	Shoot	Total
N_1	22.33	3.77	31.62	31.33	63.01	4.64	1.99	6.63	120.76	121.31	242.08
N_2	24.23	4.08	40.73	41.25	82.24	4.90	2.61	7.51	134.09	165.83	299.92
N_3	25.89	4.33	45.30	52.75	97.96	4.88	2.50	7.38	149.65	195.53	345.44
L.S.D	*	*	**	**	**	n.s	**	**	**	**	**
B_0	23.97	4.01	38.01	41.72	79.81	4.58	2.36	6.94	134.5	157.14	291.63
B_1	24.33	4.11	40.4	41.83	82.32	5.03	2.37	7.40	135.17	164.65	299.99
L.S.D.	n.s	n.s	*	n.s	n.s	*	n.s	**	n.s	n.s	n.s
Mn_0	24.02	4.05	42.11	39.89	81.95	3.55	2.11	5.66	133.79	156.95	292.84
Mn_1	24.66	4.18	36.39	43.67	80.18	6.07	2.61	8.68	135.88	164.83	298.78
L.S.D.	*	n.s	**	**	*	**	**	**	n.s	**	**

With respect to K uptake, the results reveal that all N fertilizer treatments markedly increased K content of roots, tops and the whole plants in both two seasons. The greatest values were recorded with the application of 80 kg N fed^{-1} rate and the percentages increase relative to the control were 44.3, 52.1 and 69.7% in the first season and 23.9, 61.2 and 42.7% in the second season (for roots, tops and whole plant, respectively).

The effect of nitrogen fertilizer on mineral composition i.e., N, P and K of beet leaves and roots may be due to that N dressing enhanced the uptake of other minerals which finally reflected in better growth of tops, roots and quality (Boyed *et al.,* 1970, and Milford *et al.,* 1985). The data also indicate that the K content of the tops seemed to be higher than of the roots, this may be due to the essentiality of K to improve efficiency of photosynthesis, furthermore K helps in maintaining a normal balance between carbohydrates and proteins (Lamp, 1967). These findings are in accordance with those of Puente *et al.* (1982) and Abou El-Soud *et al.* (1990) ands Moustafa *et al.* (2000).

Table (3): Nitrogen, boron and manganese interactionss.

First season													
B	Mn	Root yield			Sugar yield			N-Root uptake			N- shoot sUptake .		
		N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
B_0	Mn_0	20.48	21.06	25.02	3.53	3.58	4.09	37.58	45.80	48.68	28.34	37.14	52.44
	M_1	4.29	25.59	25.65	3.88	4.45	4.32	27.81	29.86	24.02	43.70	54.20	53.18
	L.S.D.	**	**	n.s	n.s	**	n.s	**	**	**	**	**	n.s
B_1	Mn_0	24.49	23.69	22.15	4.16	4.41	4.03	40.2	25.30	36.04	35.62	44.68	52.84
	M_1	22.19	25.69	26.78	3.84	4.52	4.50	24.12	26.31	31.77	26.60	46.15	47.46
	L.S.D.	*	*	**	n.s	n.s	*	**	n.s	*	**	n.s	**
Second season													
B_0	Mn_0	21.47	22.91	237.01	3.79	3.84	4.38	34.20	48.90	54.41	29.33	39.67	57.33
	Mn_1	24.10	25.14	22.43	4.30	4.47	3.69	33.54	25.56	31.99	30.33	45.00	49.33
	L.S.D.	*	*	**	n.s	n.s	n.s	n.s	**	**	n.s	**	**
B_1	Mn_0	23.75	23.64	24.81	3.69	4.10	4.487	21.90	49.93	43.31	28.00	39.00	46.00
	Mn_1	24.48	25.65	25.38	4.34	4.15	4.15	36.85	38.53	51.87	37.67	41.33	58.33
	L.S.D.	n.s	n.s	n.s	n.s	n.s	n.s	**	**	**	**	n.s	**
First season													
		P-root uptake			P-shoot uptake			K-root uptake			K-shoot uptake		
B_0	Mn_0	2.62	3.40	3.55	1.34	1.77	2.74	101.35	114.24	160.08	149.53	131.89	178.90
	M_1	3.01	2.60	2.50	3.03	3.41	2.43	119.06	149.20	163.56	141.46	185.32	191.22
	L.S.D.	*	**	**	**	**	*	**	**	n.s	**	**	n.s
B_1	Mn_0	4.02	2.44	3.05	2.06	1.93	2.05	112.46	146.93	162.43	141.54	142.85	175.33
	M_1	6.40	8.11	6.07	1.36	2.62	3.04	121.50	117.21	169.49	102.13	164.31	188.90

	L.S.D.	**	**	**	**	**	**	*	**	*	**	**	*
Second season)													
B_0	Mn_0	2.74	3.70	4.94	1.53	2.63	2.30	116.17	124.49	169.62	111.80	170.65	201.87
	Mn_1	4.52	6.51	5.05	2.50	2.90	2.31	13119	124.40	145.15	129.61	192.28	181.70
	L.S.D.	**	**	n.s	**	*	n.s	**	n.s	**	**	**	**
B_1	Mn_0	4.42	2.34	3.14	1.45	2.36	2.43	116.37	141.23	147.41	100.77	160.74	195.90
	Mn_1	6.87	7.05	6.39	2.49	2.59	2.95	119.31	146.23	136.43	149.07	139.66	202.67
	L.S.D.	**	**	**	**	n.s	**	n.s	n.s	**	**	**	*

II. Effect of Boron fertilization on sugar beet yield as well as N, P and K uptake:

Root and sugar yields (ton fed^{-1}):

Data in Table (2) show that both root and sugar yields responded to B as foliar spray whether used with the rate of 100 ppm in the first season or 200 ppm in the second one.

The values were not significant except for sugar yield in the first season (that receive 100 ppm B as foliar spray) which gave the greatest value of 4.24 ton fed^{-1}, with increment of 6.77% relative to the control treatment. The positive effect on root yield and the gross sugar yields may be due to the adequate growth of beet plants which was reflected on roots yield per unit area.

From the point of view of Chelobmiko (1970) foliar nutrition with boric acid applied to sugar beet at 6 to 8 leaf age increased the photosynthetic and enzymes activity in leaves, translocation of sugar to the root and sugar content.

Gauch and Dugger (1954), emphasized that increasing B concentration in plant cell give more facilities to sugar movement from the leaves to roots. These results are in accordance with those obtained by Kurbel (1976), Eweida *et al.* (1994) and Ebrahim (1995). On the other hand, Katimeri and Pellumbi (1982) found that foliar application of (Zn, Mg and B) did not affect the yield.

The response seemed to be more markedly pronounced with 100 ppm B treatment than with 200 ppm. Also, the result show that the tops contained higher N and K values than the roots whereas the reverse was found with the P content such results are in agreement with those reported by El-Kobbia *et al.* (1971), Draycott (1972) and Abd El-Aziz *et al.* (1992).

III. Effect of manganese fertilization on sugar beet yield as well as N, P and K uptake:

A. Sugar beet yield:

Data on root and sugar yields (Table 2) show that spraying the leaves with manganese sulfate solution with the rates of 1000 and 2000 ppm Mn in both first and second season, respectively had considerable positive effect on root and gross sugar yields except for sugar yield in the second season where the increase was not significant.

The greater response was produced by using the concentration of 1000 ppm Mn so the magnitudes of increase were 7.68 and 7.32% for root and sugar yields, respectively compared with 2.66 and 3.21% for 2000 ppm Mn treatment over the control treatment. These results are in accordance with those of Hegazy *et al.* (1992).

B. N, P and K uptake:

Data in Table (3) indicate that the application of Mn as foliar spray at 2000 ppm had significant effect on N, P or K uptake (kg fed^{-1}) by sugar beet plant (roots and shoots) in the two growing seasonss. Results showed that foliar application of Mn sulfate solution increased N-uptake by shoots, and P, or K uptake by roots, shoos, and whole plants, whereas decreased N-uptake by roots and whole plant in two seasons. These results are in agreement with those reported by Fuehring and Finkner (1973), and Chernova (1974).

IV. Interaction effects:

A. First order interaction effect:

Statistical analysis in Table (2, 3) showed that pair wise (N x B, N x Mn, and B x Mn) interactions were significant for roots yield in first season while N x Mn had significant effect on root and sugar yields in the second one.

Concerning the N, P or K uptake by roots, shoots, and whole plants, those were significantly affected by the first order interaction in both seasons.**B. Second order interaction effect:**

Data in Table (2, 3) revealed that root and gross sugar yields were significantly affected by (N x B x Mn) interaction in two sowing seasons as well as nutrients (N, P and K) uptake except for P uptake by root in the second season.

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تــأثير النيتــروجين والبــورون والمنجنيــز علـــى إنتاجيـــة وإمتصـــاص النيتــروجين والفوسفور والبوتاسيوم لبنجر السكر

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أقيمـت تجربـة حقليـة بمحطـة البحـوث الزراعيـة بسـخا خـلال موسـم ١٩٩٨/١٩٩٧م ، وأخـرى خـلال ١٩٩٩/١٩٩٨م لدراسة تأثير إضافة البورون والمنجنيز بـالرش تحت ثلاث مستويات للتسميد بـالنيتروجين علـى محصـول الجـذور والسـكر لبنجـر السكر وكـذلك إمتصــاص النيتـروجين والفوسـفور والبوتـاسيوم. وتـتلخص أهـم النتائج فى الآتى:
أدت زيادة إضافة النيتروجين حتى ٨٠كجم/للفدان إلـى زيـادة فـى محصـول الجذور والسكر وكذلك زيـادة إمتصـاص العناصر الغذائية النيتروجين والفوسفور والبوتاسيوم ما عدا إمتصاص الفوسفور كانـت الزيـادة إيجابيـة حتى ٤٠كجم/فدان ثم إنخفضت بعد ذلك.
أدت إضـافة البورون بمعدل ٢٠٠ جزء فـى المليـون إلـى زيـادة إمتصـاص عناصـر النيتـروجين والفوسـفور والبوتـاسيوم لبنجر السكر ما عدا امتصاص البوتاسيوم فى الموسم الثانى بينمـا لـم يتـاثر محصـول الجذور والسكر بهذه الاضافة فى الموسم الثانى وزاد محصول السكر بالموسم الاول عند تركيز ١٠٠ جزء فى المليون.
تأثر محصـول الجذور والسكر وكذلك إمتصاص بنجر السكر لعناصـر النيتـروجين والفوسـفور والبوتـاسيوم خلال موسمى الزراعة بإضافة المنجنيز حتى ٢٠٠٠جزء/مليون كتسميد ورقى.
تمت مناقشـة التأثيرالإيجـابى التسميد المشترك من هذه العناصـر الثلاثـة النيتـروجين والبـورون والمنجنيـز علـى المحصول وامتصاص النبات للعناصر الغذائية النيتروجين والفوسفور والبوتاسيوم.