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Influence of Sulphur and Boron Levels on Productivity and Quality of Sugar Beet under Sandy Soil Conditions

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ABSTRACT

Two field trial were fulfillment at Kalabsho Experimental Farm (sandy soil) located at the longitude of 31.22° E and latitude of 31.14° N and 15 m above sea level in seasons of 2012/2013 and 2013/2014 to find out the influence levels of sulphur and boron fertilizers on sugar beet *cv.* Gloria yields and quality traits. A strip-plot by way of three replicates was done through together seasons. Sulphur fertilizer levels (50 , 100 and 150 kg S/fed) were added to the soil in the vertical-plots. While, levels of boron fertilizer (without, 5 and 10 %) as foliar application were devoted in the horizontal-plots. The obtained results showed that, in both seasons, fertilizing with 150 kg S/fed for sugar beet plants produced the greatest yields and its components and quality traits, followed by fertilizing with 100 kg S/fed and lastly fertilizing with 50 kg S/fed. Spraying sugar beet plants with solution of 10 % boron resulted in the maximum yields and its components and quality traits. Spraying sugar beet plants twice with boron (5 %) ranked secondly after boron (10 %) and followed by control treatment (without spraying plants with boron) through together seasons. It might be accomplished that fertilizing sugar beet plants through 150 kg S/fed and sprayed twice (after 50 and 70 days after sowing) with solution of 10% boron to maximizing yields and juice quality under the environmental conditions of sandy soil in Kalabsho region, Dakahlia Governorate, Egypt.

Keywords: Sugar beet, sulphur levels, boron levels, foliar, spraying, yields.

INTRODUCTION

Sugar beet (special type of *Beta vulgaris* L.), grown for production of edible sugar. In Egypt in addition to many countries all over the world, sugar beet is consider the main sugar crops alongside sugar cane.

Sugar beet importance in agriculture is not only restricted to production of sugar, but also, to generate many by-products. In recent times, sugar beet as winter crop has an imperative place in crop rotation not only in the fertile soils, but also in the poor, saline, alkaline and calcareous soils. So, it possibly will be expensively cultivated in newly reclaimed soils such as the Northern Egypt (Kalabsho region, Dakahlia Governorate) as one of the mainly charitable crops to salinity and broad range of climates.

Sulphur (S) is the 4th macro plant nutrient later than N, P and K due to its function in creation of amino acids (cystine and methionine), formation of chlorophylls and vitamins, enzyme systems activates (Marschner, 1995) and accordingly enhancement crop productivity. In Egypt, deficiency of S has been found in sandy soils of many districts of Egypt due to low native S content and soil conditions which favours leaching it from top layers of soil. Moreover, S deficiency may affect the amount of assimilates and thereby the sugar storage in roots by the drastic decrease of chlorophyll content of leaves (Kastori *et al.*, 2000). Thomas *et al.* (2003) pointed out that usage of sulphur (25 kg ha⁻¹) gave as increase of 25% in root

yield together with significant increases in root and shoot dry matter accumulation. Beet quality was also increased through a reduction in a-amino N concentration. Nemeat Alla (2005) reported that root dimensions and root yield per feddan were increased by application 300 kg sulphur fertilizer per feddan as compared with the other two levels (100 and 200 kg/fed). Seadh *et al.* (2007) reported that application of 72 kg potassium sulfate/fed (as a resource of K and S) significantly increased yields of sugar beet. Conversely, applying 48 kg potassium sulfate/fed gave the uppermost percentages of TSS and sucrose. Ferweez *et al.* (2011) deduced that sulphur fertilization level at 200 kg/fed had a significant increase on root diameter, purity % and sugar yield/fed. Awad *et al.* (2013) revealed that applying 250 kg S/fed for sugar beet is preferable to give the uppermost root in addition to recoverable sugar yields per feddan and quality.

Tawfic *et al.* (2014) established that the uppermost root dimensions, fresh weight of root per plant, yields of root and sugar, TSS, sucrose and purity and lowest values of impurities resulted from the addition 200 kg sulphur.

Boron (B) is considered as micronutrient, and has requisite role for nitrogen metabolism, hormonal action and cell division and elongation in meristematic tissues (BARI, 2006). Boron deficiency causes inhibition of leaf expansion and reduction in photosynthesis (Dell and Haung, 1997). Also, boron is an important trace element

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needed by sugar beet. Meantime, sugar beet has a higher requirement for boron than many other crops. It is generally stated that not including an adequate boron provide, the yields and its quality is harshly decreased.

Moreover, B is necessary for arrangement of innovative cells in meristems. Additionally, it has a imperative responsibility in sugar translocation toward roots. Foliar spraying of boron increased root yield, seeing as roots absorbed boric acid and its uptake depends on soil pH and soil boron content due to chloroplast formation and sink limitations and changes in cell wall and led to secondary effects in plant metabolism, development and growth (Loomis and Durst, 1992). Gobarah and Mekki (2005) revealed that rising application of B rates (from 0 to 1.5 kg/acre) increased root length, diameter and yield. Moreover, increasing boron fertilizer up to 2.0 kg/acre resulting highest sugar yield. Also, adding higher boron concentration increased percentages of sucrose and juice purity. Kirstek *et al.* (2006) suggested that application of 1.0 kg B/ha increased root yield and the quality traits as contrasted to chick treatment. Knany *et al.* (2009) observed that B fertilization lead to increments in root, top yield and sugar yields additionally quality traits. Abido (2012) indicated that root yield and its attributes and root quality significantly improved by foliar application with 80 ppm B. Armin and Asgharipour (2012) indicated that spraying with boric acid (at 12%) gave the uppermost yields of root and sugar. Dewdar *et al.* (2015) cleared that sprayed plants of sugar beet with 0.25 g B/L produced maximum productivity (root, top and sugar yields) and quality traits. Mekdad (2015) revealed that the highest root yield and its components as well percentages of gross and white sugar resulted from application of 120 or 150 ppm boron. Abdel-Nasser and Ben-Abdalla (2019) found that sugar beet yields and its components were significantly affected B application as foliar.

Hence, this study designed to decide the influence levels of sulphur and boron fertilizers on sugar beet cv.

Gloria productivity and quality under sandy soil circumstances in Kalabsho region, Dakahlia Governorate, Egypt.

MATERIALS AND METHODS

This research was executed in Kalabsho Experimental Farm as sandy soil conditions, (located at the longitude of 31.22° E, latitude of 31.14° N and 15 m above sea level) Dakahlia Governorate, Sugar Crops Research Institute, Agricultural Research Center, Egypt, through seasons of 2012/2013 and 2013/2014 to determine the influence of levels of sulphur and boron fertilizers on productivity and quality traits of sugar beet cv. Gloria.

In every season, trial was set in design of strip-plot by way of 3 replicates. Sulphur fertilizer levels *i.e.* 50, 100 and 150 kg S/fed were placed in the vertical-plots. Sulphur fertilizer levels were applied in the form of agricultural sulfur (18 % S) as soil application in one dose during soil preparation. Horizontal plots were billed with 3 levels of boron fertilizer (without, 5 and 10 %) applied as a boric acid solution on plant tops two times (50 and

70 days from sowing "DFS"). The foliar solutions volume was 200 L/fed carried out by hand sprayer.

Each investigational plot (10.5 m²) contains of 5 ridges (60 cm width and 3.5 length). Samples of soil surface (0-30 cm depth) were taken to determine physical and chemical properties (Table 1).

Table 1. Mechanical and chemical properties of soil at the investigational site in growing seasons.

Variables	2012/2013	2013/2014
A: Mechanical analysis		
Sand (%)	92.10	91.80
Silt (%)	4.55	4.75
Clay (%)	3.35	3.45
Soil texture class	Sandy	Sandy
B: Chemical analysis		
Soil reaction pH	7.77	7.81
EC (dS m ⁻¹) in soil water extraction (1:5) at 25°C	2.83	2.87
Organic matter (%)	0.170	0.175
CaCO ₃ (%)	0.77	0.73
Available B (mg kg ⁻¹)	0.22	0.26
Soluble so ₄ ²⁻ (meq L ⁻¹)	3.00	3.60
Macronutrients (ppm)	Total N	17.50
	Available P	2.75
	Available K	75.00
Soluble cations (meq L ⁻¹)	Ca ⁺⁺	1.11
	Mg ⁺⁺	0.45
	Na ⁺	2.33
	K ⁺	0.15
Soluble anions (meq L ⁻¹)	CO ₃ ⁻	0.00
	HCO ₃ ⁻	1.13
	SO ₄ ⁻	0.77
	Cl ⁻	1.85

During soil preparation, calcium superphosphate (15.0 % P₂O₅) was added (200 kg/fed).

Seeds (balls) of sugar beet were sown at the 1st week of November using method of hand dry sowing (3-5 seeds/hill) on individual side of the ridge (20 cm between hills) in both growing seasons. Nitrogen fertilizer (urea "46.5%" form) was applied (100 kg N/fed) in 3 equivalent dosages *e.g.* subsequent to thinning (after 30 days from sowing), before the third and fourth irrigation. Before the 2nd irrigation, the potassium sulphate fertilizer (48 % K₂O) was applied (100 kg/fed). The other agricultural practices were completed as suggested by Sugar Crops Research Institute, ARC, Egypt.

The studied characters:

At harvest time (about 210 days from sowing), 5 plants were randomly chosen (from the outer ridges of each plot) to decide the subsequent traits;

1. Root fresh weight (g).
2. Foliage fresh weight (g).
3. Root dry weight (g).
4. Foliage dry weight (g).

To verify root and foliage dry weights, fractions of all plant were air-dried, after that oven-dried at 105 °C till steady weight.

5. Length of the roots (cm).
6. Diameter of the root (cm).
7. Sucrose percentage (%). It was determined according to Carruthers and Oldfield (1960) polarimetric method
8. Apparent purity percentage (%). It was calculated seeing that ratio between sucrose % and total soluble solids (TSS %) in roots as method of Carruthers and Oldfield (1960).

Also, at harvesting time, plants resulted from 2 inner ridges of every plot were collected and cleaned. The roots and tops were divided and weighed in kilograms.

Subsequently, it was transformed to calculate yields of root and top in tons per feddan. Theoretical

sugar yield per feddan was calculated through multiplying root yield by sucrose percentage.

In the strip-plot design, all obtained data were statistically analyzed according to Gomez and Gomez (1984), by means of MSTAT statistical package. The differences among means of the studied treatments were evaluated by least significant difference (LSD) method (at 5 % level of probability) according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1. Effect of sulphur levels:

Yield components and quality traits (fresh and dry root and foliage weights per the plant, dimensions of

roots, percentages of sucrose and apparent purity) were significantly influenced by the studied sulphur fertilizer *i.e.* 50 , 100 and 150 kg S/fed in either seasons (Tables 2 and 3). The greatest averages sugar beet yield components and quality traits were produced by applying the highest level of sulphur fertilizer (150 kg S/fed) through together seasons. However, fertilizing with 100 kg S/fed was the second best S levels concerning its effect on yield components and quality traits through together seasons. In opposition, the lowest sulphur fertilizer level (50 kg S/fed) resulted in the lowest means of yield components and quality traits in every season of this study.

Table 2. Means of root and foliage fresh and dry weights/plant of sugar beet as affected by sulphur and boron fertilization levels as well as their interaction in 2012/2013 and 2013/2014 seasons.

Characters Treatments Seasons		Root fresh weight (g/plant)		Root dry weight (g/plant)		Foliage fresh weight (g/plant)		Foliage dry weight (g/plant)	
		2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014
A. Sulphur levels:									
50 kg/fed		583.0	527.5	123.4	116.0	250.7	220.5	52.6	48.5
100 kg/fed		742.2	700.1	152.3	154.0	318.4	260.0	67.2	57.2
150 kg/fed		915.1	865.1	202.5	190.3	393.5	364.3	82.6	80.1
LSD at 5% level		43.9	45.1	2.4	3.9	18.4	21.5	3.9	4.3
B. Boron levels:									
Without		729.5	673.5	147.5	148.1	313.7	248.6	66.2	54.6
5 %		745.6	699.1	162.0	153.7	320.6	293.8	67.3	64.6
10 %		765.1	720.2	168.7	158.4	328.3	302.4	68.9	66.5
LSD at 5% level		25.8	23.3	1.3	2.1	10.7	16.4	NS	3.0
C. Interaction:									
50 kg S/fed	Without	562.0	495.4	108.0	109.0	241.6	207.3	50.7	45.6
	5 % B	583.7	533.6	129.0	117.3	250.9	222.0	52.7	48.8
	10 % B	603.5	553.5	133.0	121.7	259.5	232.4	54.4	51.1
100 kg S/fed	Without	728.3	676.8	137.5	148.9	313.1	182.2	66.7	40.1
	5 % B	736.6	696.9	152.8	153.3	316.7	292.7	66.5	64.3
	10 % B	761.6	726.7	166.7	159.8	325.4	305.2	68.3	67.1
150 kg S/fed	Without	898.3	848.3	197.2	186.6	386.2	356.3	81.1	78.3
	5 % B	916.7	866.7	204.1	190.6	394.2	366.8	82.7	80.7
	10 % B	930.3	880.4	206.2	193.6	400.0	369.7	84.0	81.3
LSD at 5% level		36.9	40.3	3.8	4.8	16.9	18.1	NS	6.5

Table 3. sugar beet roots as affected by sulphur and boron fertilization levels as well as their interaction in 2012/2013 and 2013/2014 seasons.

Characters Treatments Seasons	Root length (cm)		Root diameter (cm)		Sucrose (%)		Apparent purity (%)		
	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014	
A. Sulphur levels:									
50 kg/fed	24.36	24.54	13.59	12.33	16.41	15.41	71.00	70.64	
100 kg/fed	27.00	26.54	14.78	14.05	17.74	16.74	79.19	77.84	
150 kg/fed	30.54	30.40	16.71	16.23	19.14	18.27	84.93	83.83	
LSD at 5% level	0.37	0.39	0.23	0.16	0.19	0.22	0.92	0.95	
B. Boron levels:									
Without	26.56	26.04	14.71	13.67	15.88	14.91	74.13	73.43	
5 %	27.57	27.38	15.06	14.35	18.28	17.40	79.52	78.63	
10 %	27.76	28.05	15.31	14.60	19.12	18.12	81.47	80.26	
LSD at 5% level	0.29	0.24	0.12	0.25	0.56	0.58	0.31	0.39	
C. Interaction:									
50 kg S/fed	Without	24.21	23.80	13.37	12.05	15.86	14.86	69.31	69.36
	5 % B	24.61	24.66	13.63	12.43	16.50	15.50	70.26	69.66
	10 % B	24.26	25.16	13.78	12.53	16.86	15.86	73.43	72.90
100 kg S/fed	Without	26.18	26.00	14.55	13.70	15.73	14.73	73.66	72.56
	5 % B	27.35	26.35	14.73	14.06	18.50	17.50	80.75	79.72
	10 % B	27.46	27.28	15.06	14.38	19.00	18.00	83.16	81.25
150 kg S/fed	Without	29.30	28.33	16.21	15.26	16.06	15.13	79.43	78.36
	5 % B	30.76	31.15	16.83	16.55	19.86	19.20	87.56	86.50
	10 % B	31.56	31.71	17.09	16.90	21.50	20.50	87.81	86.64
LSD at 5% level	0.51	0.44	NS	0.40	0.49	0.58	2.03	1.82	

The levels of sulphur fertilizer (50 , 100 and 150 kg S/fed) significantly affected sugar beet yields (root, top and sugar yields/fed) through together seasons (Table 4). The uppermost yields of sugar beet were formed from

soil fertilizing plants through 150 kg S/fed during the either seasons. Although, soil fertilizing plants through 100 kg S/fed ranked secondly after the utmost level of sulphur fertilizer concerning its effect on yields through

together seasons. On the contrary, the lowest means of yields were resulted from soil fertilizing plants with 50 kg S/fed in every season. It could be notice that soil fertilizing plants with 150 kg S/fed caused increases amounted with 27.31 and 43.84 % in root yield/fed, 26.63

and 46.01 % in top yield/fed and 39.00 and 70.73 % in sugar yield/fed as compared with soil fertilizing plants with 100 and 50 kg S/fed over together seasons, respectively.

Table 4. Means of root, top and sugar yields/fed of sugar beet as affected by sulphur and boron fertilization levels as well as their interaction in 2012/2013 and 2013/2014 seasons.

Characters Treatments Seasons	Root yield (t/fed)		Top yield (t/fed)		Sugar yield (t/fed)	
	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014
A. Sulphur levels:						
50 kg/fed	17.765	17.195	7.595	7.487	2.917	2.651
100 kg/fed	20.014	19.484	8.948	8.442	3.564	3.275
150 kg/fed	25.408	24.878	11.242	10.779	4.911	4.595
LSD at 5% level	0.731	0.786	0.233	0.119	0.130	0.180
B. Boron levels:						
Without	19.708	19.138	8.604	8.295	3.134	2.857
5 %	21.203	20.673	9.515	8.960	3.925	3.650
10 %	22.276	21.746	9.666	9.454	4.333	4.014
LSD at 5% level	0.592	0.665	0.362	0.325	0.228	0.261
C. Interaction:						
50 kg S/fed	Without	17.493	16.843	7.342	7.304	2.774
	5 % B	17.605	17.075	7.742	7.409	2.907
	10 % B	18.197	17.667	7.701	7.748	3.069
100 kg S/fed	Without	18.887	18.357	8.499	7.961	2.972
	5 % B	19.974	19.444	8.989	8.417	3.695
	10 % B	21.181	20.651	9.355	8.949	4.025
150 kg S/fed	Without	22.745	22.215	9.972	9.619	3.656
	5 % B	26.028	25.498	11.813	11.053	5.174
	10 % B	27.452	26.922	11.941	11.666	5.904
LSD at 5% level	0.828	0.842	0.456	0.396	0.250	0.279

The increase in yield components, quality and yields as a result of the maximum level of sulphur fertilizer may be ascribed to the effect of S in increment availability of definite plant nutrient as P, Mg and Zn (Abd El-Fattah and Hilal, 1985). In addition, the essential role of sulphur in synthesis of amino acids that involved in chlorophyll production, vitamin-A and proteins, activates certain enzymes, plant function and structure (Marschner, 1995). These findings are in conformity with those stated by Thomas *et al.* (2003), Nemeat Alla (2005), Seadh *et al.* (2007), Ferweez *et al.* (2011), Awad *et al.* (2013) and Tawfic *et al.* (2014).

2. Effect of boron levels:

Studied boron fertilizer levels (without, 5 and 10 %) showed significant impact on yield components and quality traits (root and foliage fresh and dry weights/plant, root dimensions, sucrose and apparent purity percentages) through together seasons, with exception foliage dry weight in the first season only as shown in Tables 2 and 3. It can be notice that spraying sugar beet plants twice (50 and 70 days after sowing) with solution of boron at the rate of 10 % was more effective than other studied boron levels (without and 5 %) in increasing yield components and quality traits and gave the top values of them through together seasons. Foliar spraying sugar beet plants twice with boron at the rate of 5 % ranked secondly after boron at the rate of 10 % with regard in consequence on yield components and quality traits through together growing years. Whilst, control treatment (without spraying plants with boron) gave the lowest means of yield components and quality traits through together seasons.

Root, top and sugar yields/fed significantly influenced as a result of studied boron fertilizer levels as foliar application through together seasons (Table 4). Foliar spraying sugar beet plants twice with boron at the rate of 10 % produced the maximum root (22.276 and 21.746 t/fed), top yield (9.666 and 9.454 t/fed) and sugar yield (4.333 and 4.014 t/fed) in 1st and 2nd seasons, correspondingly. The second best level of B as foliar application was 5 % with regard in effect on yields through together seasons. Whilst, sugar beet plants grown without boron application (control treatment) gave the lowest means of yields through together seasons.

This increase in sugar beet yield components, quality and yields by foliar spraying twice with boron may well be accredited to the role of boron in cell division and elongation in meristematic tissues, nitrogen metabolism and hormonal action (BARI, 2006), in addition boron had a imperative responsibility in sugar translocation to roots, therefore improve yields and quality of sugar beet. The obtained results are in harmony with those stated by Gobarah and Mekki (2005), Kirstek *et al.* (2006), Knany *et al.* (2009), Abido (2012), Dewdar *et al.* (2015) and Abdel-Nasser and Ben-Abdalla (2019).

3. Effect of interaction:

With regard to the influence of interact between both studied factors (sulphur and boron fertilizers levels), it was significant on all yield components, quality traits and yields in both seasons, excluding foliage dry weight and root diameter in the first season (Tables 2, 3 and 4). The uppermost means of these characters were obtained from soil fertilizing sugar beet through 150 kg S/fed and spraying twice (after 50 and 70 days from sowing) with

solution of boron at the rate of 10 % in the 2 growing years as illustrated in Tables 2, 3 and 4. The second best interaction treatment concerning all studied characters was fertilizing with 150 kg S/fed and spraying twice with boron (5 %) through together seasons. Meanwhile, soil fertilizing through 50 kg S/fed without spraying with boron fertilizer resulted in the lowest means of yield components, quality traits and yields in the 2 growing years.

CONCLUSION

It could be recommended that soil fertilizing with 150 kg S/fed and spraying twice sugar beet plants (after 50 and 70 days after sowing) with solution of boron at the rate of 10 % to maximize productivity and quality under the ecological circumstances of sandy soil in Kalabsho region, Dakahlia Governorate, Egypt.

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تأثير مستويات الكبريت والبورون على إنتاجية وجودة بنجر السكر تحت ظروف الأراضي الرملية

حازم محمود سرحان

معهد بحوث المحاصيل السكرية – مركز البحوث الزراعية – الجيزة - مصر.

أجريت تجربتان حقليتان بالمزرعة البحثية بمنطقة قلابشو ذات التربة الرملية، محافظة الدقهلية والتي تقع على خط طول ٣١,٢٢ شرقاً ودائرة عرض ٣١,١٤ شمالاً وترتفع عن سطح البحر بمقدار ١٥ م، خلال موسمي ٢٠١٣/٢٠١٢ و ٢٠١٤/٢٠١٣ لدراسة تأثير المعاملة بمستويات الكبريت والبورون على إنتاجية وجودة بنجر السكر (صنف جلوريا). تم تنفيذ التجريبتين في تصميم الشرائح المتعامدة في ثلاث مكررات خلال الموسمين. حيث وضعت مستويات الكبريت (٥٠ و ١٠٠ و ١٥٠ كجم كبريت/فدان) في الشرائح الرأسية، بينما تم تخصيص الشرائح الأفقية لمستويات البورون (بدون و ٥ و ١٠ ٪). كرش ورقي. أظهرت النتائج أن تسميد نباتات بنجر السكر بإضافة ١٥٠ كجم كبريت/فدان أنتج أعلى القيم لصفات الحاصل ومكوناته والجودة، يليها التسميد بمعدل ١٠٠ كجم كبريت/فدان ثم في المرتبة الأخيرة التسميد بـ ٥٠ كجم كبريت/فدان خلال الموسمين. أعطت نباتات بنجر سكر التي تم رشها مرتين بمحلول البورون بتركيز ١٠ ٪ أعلى القيم لصفات الحاصل ومكوناته والجودة. بينما جاء الرش الورقي مرتين لنباتات بنجر السكر بالبورون بمعدل ٥ ٪ في المرتبة الثانية، يليها معاملة المقارنة (بدون رش ورقي بالبورون) خلال موسمي الدراسة. من النتائج المتحصل عليها في هذه الدراسة يمكن تعظيم إنتاجية وجودة بنجر السكر من خلال تسميد النباتات بإضافة ١٥٠ كجم كبريت/فدان للتربة مع الرش الورقي مرتين (بعد ٥٠ و ٧٠ يوماً بعد الزراعة) بمحلول البورون (١٠ ٪) تحت الظروف البيئية للتربة الرملية بمنطقة قلابشو، محافظة الدقهلية، مصر.