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Effect Concentration and Spraying Time of Boron on Yield and Quality Traits of Sugar Beet Grown in Newly Reclaimed Soil Conditions

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Abstract:

Experimental work was done in Al-Wady El-Assiuty, Expt. Farm of Assiut University, Assiut, Egypt during 2010/2011 and 2011/2012 seasons to investigate the effect of boron concentration (zero, 50 and 100 ppm) and different application time (35, 70 and 105 days after planting, DAP) on yield and quality traits of sugar beet plant grown in newly reclaimed soil conditions. Randomized complete block design (RCBD) using split-plot with three replications was used. The obtained results revealed that:

-Yield and quality traits of sugar beet i.e., top and root fresh and dry weights, sucrose %, sugar recovery % and K concentration in root were significantly increased by high boron concentration compared with control in both seasons.

-Boron spraying time had a significantly positive effect on yield and quality traits of sugar beet, however it's had any considerable effect on tops dry weight (ton fed.$^{-1}$), sugar loss %, sugar loss yield (ton fed.$^{-1}$) and some impurities components concentration in both seasons.

-There were significantly effects due to the interaction between concentration and spray time of boron on yield and quality traits of sugar beet crop except for sugar loss %, sugar loss yield (ton fed.$^{-1}$), α-amino-N and Na concentration of root in both seasons.

It could be concluded that the highest sugar yield and the best technological quality of sugar beet were obtaining by using 100 ppm boron concentration and spraying after 70 days after planting under newly reclaimed soil conditions.

Key words: *sugar beet, boron, spraying time and newly reclaimed soil*

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Introduction:

Sugar beet (*Beta vulgaris*, L.) is responsible for one-third of the world sugar production. In Egypt, sugar beet is the second source for sugar production after sugarcane. The importance of this crop comes from its ability to grow in the new reclaimed soils, and provides the growers under low soils fertility profitable income. Micronutrients deficiency is one of the most important a biotic stresses in plants grown on calcareous soils (Xudan, 1986). It is well known that newly reclaimed soil is often very poor in macro and micro nutrient elements. The strategy of sugar production is to expand sugar beet cultivation in the newly reclaimed soils where some nutrients especially micronutrients are short in supply for normal growth and high yield of root and sugar.

In sugar beet, large quantities of phytosynthate (sucrose) are translocated and stored in the vacuole of parenchymal cells in the root sink without hydrolysis. In this regard, boron plays 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. Boron increase root weight and diameter enhance dry matter accumulation and improve quality of roots that increase sugar yield of sugar beet (Eweida *et al*., 1994). On the other hand, boron deficiency is associated with a disturbance in synthesis of plant hormones and nucleic acid metabolism. Deficiency of boron leads to depression in cytokinin biosynthesis. Despite the important role of micronutrient at higher yield or quality of sugar beet, there is still a lack of information regarding the role of boron application on sugar beet particularly in the context of Egypt.

Boron is involved in numerous important processes. It is known to play role in cell division, protein synthesis, water relations, respiration, RNA, IAA and carbohydrate metabolism, translocation of sugars, fruit and seed development and its deficiency may effect on all these processes (Marschner, 1995). Moreover, functions of boron are related to cell wall synthesis and cell wall structure by cross-linking of cell wall polysaccharides as well as the structural integrity of biomembranes. It increases the transport of chlorine and phosphorus as a result of plasmalemma ATPase induction. Other investigations have shown that boron can stimulate proton pumping that causes hyperpolarization of the membrane potential. More than 90% of the boron in plants is found in cell walls, and rhamnogalacturonan. Since all these functions are fundamental to meristematic tissues, boron deficiency is predominantly damaging actively growing organs such as shoot and root tips so that the whole plant may be stunted (rosetting). The aim of this work was to study the effect of boron concentration and spraying time on yield and quality traits of sugar beet plant grown in newly reclaimed soil conditions.

Materials and Methods

Two field experiments were conducted at Al-Wady El-Assiuty, Expt. Farm of Assiut University, Assiut, Egypt during 2010/2011 and 2011/2012 seasons to investigate the effect of boron concentration and spring time on yield and quality of sugar beet plant grown in newly reclaimed soil conditions. Some physical and chemical properties of the experimental soil were determined before sowing and presented in Table 1, according to the methods described by Jackson (1967).

Table (1): Some physical and chemical properties of representative soil samples in the experimental site before sowing (0-30 cm depth) in 2010/2011 and 2011/2012 seasons

Soil property		2010/2011*	2011/2012*
Partice-size distribution			
Sand	(%)	84.4	86.5
Silt	(%)	8.7	7.3
Clay	(%)	6.9	6.2
Texture grade		Sand	Sand
EC (1:1 extract)	(dS m^{-1})	1.66	1.74
pH (1:1 suspension)		8.34	8.26
Total $CaCO_3$	(%)	20.26	19.85
Organic matter	(%)	0.097	0.095
Soluble ions			
Ca^{++}	(mmol l^{-1})	16.64	16.73
Mg^{++}	(mmol l^{-1})	7.36	6.95
Na^{+}	(mmol l^{-1})	1.86	1.75
K^{+}	(mmol l^{-1})	0.22	0.23
HCO_3^{-}	(mmol l^{-1})	7.65	8.29
Cl^{-}	(mmol l^{-1})	6.25	6.65
$SO_4^{=}$	(mmol l^{-1})	3.45	3.42
$NaHCO_3$-extractable P	(ppm)	5.54	6.64
NH_4OAC -extractable K	(ppm)	52.45	50.23
Total nitrogen	(%)	0.018	0.019
KCl-extractable N	(ppm)	28.26	30.64
DTPA-extractable Fe^{+2}	(ppm)	3.18	3.68
DTPA-extractable Zn	(ppm)	0.26	0.27
DTPA-extractable Mn	(ppm)	1.83	1.80
DTPA-extractable Cu	(ppm)	1.19	1.18
Hot water extractable B	(ppm)	0.06	0.05

*Each value represents the mean of three replications.

Randomized complete block design (RCBD) using a split-plot arrangement with three replications. The main plots were assigned to the three boron concentration levels (zero (as control), 50 and 100 ppm). Three spraying time of boron (35, 70 and 105 days after planting, DAP) were arranged randomly in the sub-plots at the rate of 200 l $fed.^{-1}$. Boron solution (15% concentration) was used. The preceding crop was wheat in both seasons.

The soil was treated with 31 kg P_2O_5 $fed.^{-1}$ in the form of calcium superphosphate (15.5% P_2O_5) during soil preparation. Nitrogen fertilizer was added at the rate of 100 kg fed.$^{-1}$ in the form of ammonium nitrate (33.5% N) in two equal doses. The first dose was applied after thinning and the second one was added 21 days later. Potassium fertilizer was applied at the rate of 50 kg fed.$^{-1}$ in the form of potassium sulphate (48% K_2O) after thinning. The area of each plot was 10.5 m^2 (3.5 m length x 3.0 m width), with 6 ridges 50 cm apart, 3.5 m in length. Sugar beet seed balls of multi-germ Top cv. were sown in hills 20 cm apart at a rate of 2-3 balls hill^{-1} on the 4th and 5th of October in the first and second seasons, respectively. The plants were thinned to one plant per hill at 4-6 leaf stage. All other cultural practices were done as recommended. Two weeks before harvest the irrigation of sugar beet was stopped in both seasons.

At maturity (190 days from sowing), sample of ten guarded plants from each sub- plot were taken at random to record the data of tops and roots fresh weight (g plant^{-1}). The tops and roots were separated, dried at 70 ^oC for 3 days and at 105 ^oC for two hours in air forced-draft oven, to determine their dry weight.

At harvest (195 days from planting), plants of each sub plot were harvested to determine roots and foliage yield (ton fed.$^{-1}$). A sample of 25 kg of roots were taken at random from each plot and sent to the Beet Laboratory at Abo-Korkas sugar factory, to determine root quality parameters including:

1- Alpha amino nitrogen (α-amino-N), sodium (Na) and potassium (K) concentrations were determined using auto analyzer as described by A.O.A.C., 1995. Results were calculated as mmol per 100 g beet paste.

2- Sucrose % was estimated in fresh samples of sugar beet root using Saccharometer according to the method described by Le-Docte 1927.

3- Sugar loss % was calculated using the following formula according to Reinefeld *et al*. (1974):

Sugar loss % = 0.29 + 0.343 (K + Na) + 0.094 α-amino-N.

4- Sugar recovery % (S.R. %) was calculated using the following equation according to Cooke and Scott (1993) :

Sugar recovery % (S.R. %) = sucrose % - sugar loss %

5- Recoverable sugar yield (ton fed.$^{-1}$) (R.S.Y.) was calculated using the following equation:

Recoverable sugar yield (ton fed.$^{-1}$) = root yield (ton fed.$^{-1}$) X sugar recovery (%).

6- Sugar loss yield (ton fed.$^{-1}$) = root yield (ton fed.$^{-1}$) X sugar loss %

The analysis of variance was carried out according to Gomez and Gomez (1984) using MSTAT computer software. This individual season data are going to be presented herein. Means of the different treatments were compared using the least significant difference (LSD) test at 0.05 level of probability.

Results and Discussion:

1. Effect of boron concentrations

Results in Table 2 suggest that, there were significant effects of boron concentration on top and root fresh and dry weights in both seasons. The highest mean values of top fresh weight (672.73 and 655.03 g plant^{-1}), top dry weight (115.73 and 114.85 g plant^{-1}), root fresh weight (1186.73 and 1177.27 g plant^{-1}) and root dry weight (241.97 and 254.08 g plant^{-1}), top fresh weight (3.76 and 3.84 ton fed.$^{-1}$), root fresh weight (24.99 and 24.62 ton fed^{-1}) and root dry weight (4.46 and 4.47 ton fed.$^{-1}$) in the first and second seasons, respectively. The increase in top and root fresh and dry weights by boron concentrations, could be attributed to the stimulating effect of boron on photosynthesis process in plant such as translocation of sugar and carbohydrates of assimilates from the top to root, which lead to increasing in root and sugar yield.

Sucrose concentration and sugar recovery (S.R.%) was significantly increased by increasing boron concentration in both seasons, while recoverable sugar yield (S.R.Y. ton fed.$^{-1}$) was significantly increased by increasing boron concentration in first season only (Table 3). The highest mean values of sucrose (17.75 and 17.81 %) sugar recovery (14.77 and 14.75 %) and S.R.Y. were obtained by the higher level of boron application (100 ppm) compared with the untreated plant. It could be concluded that the application of high level of foliar spray boron lead to a rise in yield or quality of sugar beet crop grown in newly reclaimed soil. The positive effect of boron on sugar beet growth and quality traits was reported by several investigators. These results were supported by other studies, Bondok, 1996, El-Hawary 1999 and Gezgin *et al*., 2001 found that root and sugar yields were increased by increasing boron fertilizer. On the other hand, El-Geddawy *et al*., 2000 indicated that application of boron at a rate of zero to 1.0 Kg acre^{-1} did not significantly effect on root length and diameter, root, top and sugar yields,

Soluble non-sugars i.e. K, Na and α-amino-N mmol 100 g^{-1} beet paste) are regarded as impurities because they interfere with sugar extraction. The results showed that Na and α-amino-N concentrations were significantly decreased by increasing boron levels. The lowest mean values of α-amino-N concentration (2.03 mmol 100 g^{-1} beet paste) and Na concentration (1.65 mmol 100 g^{-1} beet paste) were obtained by using higher level of boron (100 ppm) in the first season (Table 3). However K concentration was significantly increased by increasing boron levels in both seasons. The highest mean values of K concentration (5.66 and 5.78 mmol 100 g^{-1} beet paste) were obtained by using higher level of boron (100 ppm) in the first and second seasons, respectively.

2. Effect of boron spraying time:

Data in Table 2 show that application of boron at different times resulting in a significant increase in yield and quality traits. The highest mean values of top fresh weight (633.5 and 634.3 g plant^{-1}), top dry weight (117.0 and 118.4 g plant^{-1}) root fresh weight (1141.3 and 1128.7 g plant^{-1}) and root dry weight (233.7 and 237.3 g plant^{-1}), top fresh weight (3.60 and 3.71 ton fed.$^{-1}$), root fresh weight (25.10 and 24.90 ton fed.$^{-1}$) and root dry weight (4.42 and 4.41 ton fed.$^{-1}$) was obtained by using boron at 70 days after planting in the first and second seasons, respectively.

The presence of boron is essential to facilitate sugar transport within plant. The highest mean values of sucrose (17.67 and 17.19 %), sugar recovery (14.77 and 14.22 %) was obtained by using boron at 70 days after planting in the first and second seasons, respectively (Table 3). Also, the highest mean values of recoverable sugar yield (R.S.Y.) (2.61 ton fed.$^{-1}$) was obtained by using boron at 70 days after planting in the first season only. However, sugar loss %, sugar loss yields (ton fed.$^{-1}$) and recoverable sugar yield (S.R.Y. ton fed.$^{-1}$) were not significantly affected by different times of boron application in both seasons. El-Geddawy *et al.* (2007) indicated that application of boron at 105 had greater effect on qualitative yield of sugar beet than boron application at 60 days after planting (DAP), though there was no significant difference among the treatments. The least sucrose concentration was observed at the control, increasing significantly along with the increase in boron concentration.

These results in Table 3 revealed that K concentration was significantly increased by increasing boron application at different time. The highest mean values of K concentration (5.52 and 5.57 mmol 100 g^{-1} beet paste) were obtained by applied the boron at 70 days after planting in the first and second seasons, respectively. However, Na and α-amino-N concentration were not significantly changed between different times of boron application in both seasons. Abd El-Gawad *et al*. (2004) reported that application of three micronutrients (Fe, Zn and Mn) in 105 DAP, compared to the time of their application in 60 DAP, had greater effect on qualitative components of sugar beet. Osman (2011) indicated that foliar spray of micronutrient solution level at 0.5 L fed.$^{-1}$ attained a highest values of root diameter and fresh weight plant^{-1} as well as sucrose %, purity % as well as root and sugar yields fed.$^{-1}$, while N, Na and K % were decrease. The reason for such a lack of differences between different boron application times can be due to short time-intervals between boron applications in different treatments. Similar results were obtained by Fawkia *et al*., 2012 and Salim *et al*., 2012.

3. Effect of interaction between time and concentration of boron:

Data in Table 2 revealed that tops and roots fresh and dry weights were significantly affected by interaction between time and boron concentration in both seasons. The highest mean values of top fresh weight (688.5 and 667.4 g plant^{-1}), root fresh weight (1215.4 and 1193.4 g plant^{-1}), top dry weight (121.4 and 122.5 g plant^{-1}), root dry weight (246.5 and 252.2 g plant^{-1}), top fresh weight (3.93 and 4.03 ton fed.$^{-1}$), root fresh weight (26.24 and 25.67 ton fed.$^{-1}$), top dry weight (0.92 and 0.91 ton fed.$^{-1}$) and root dry weight (4.62 and 4.64 ton fed.$^{-1}$) always obtained when the boron applied at 70 days after planting and the highest level of boron were used in the first and second seasons, respectively. The increase in tops and roots fresh and dry weights, caused by boron foliar application, could be attributed to the stimulating effect of boron on photosynthesis process in plant such as translocation of sugar and carbohydrates of assimilates from the top to root, which lead to increasing in root and sugar yield**.** These results suggest that, sucrose %

and sugar recovery % were significantly affected by interaction between time and boron concentration in both seasons (Table 3). The highest values of sucrose (18.22 and 18.23%) and sugar recovery (15.25 and 15.21 %) were obtained by applying boron at 70 days after planting combination with spray higher level boron concentration (100 ppm) in the first and second seasons, respectively.

The beneficial effects of boron on growth, yield and quality of sugar beet was emphasized by previous studies carried by Abd El-Aziz *et al*., 1992, Nemeat-Alla and El-Geddawy *et al*., 2000, Attia, 2004, Enan, 2004, Gobarah and Mekki, 2005, El-Hosary *et al*., 2007, Abdel-Motagally 2009 and Salim *et al*., 2012.

Conclusions:

It could be concluded that the best concentration and application time of boron was 100 ppm after 70 days after planting for attaining the maximize sugar yield and obtaining the best technological quality of sugar beet crop.

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تأثير تركيز ووقت الرش الورقي بالبورون على صفات المحصول والجوده لبنجر السكر المزروع في الأراضي حديثة الاستصلاح

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الملخص:

أجريت هذه الدراسة في محطة البحوث بالمزرعه الارشاديه – كلية الزراعة جامعة أسيوط خلال موسمي ٢٠١٠/٢٠١١ ، ٢٠١١/٢٠١٢ لدراسة تأثير تركيز ووقت الرش الورقي بالبورون على حاصل وجودة بنجر السكر النامى تحت ظروف الأراضي حديثة الاستصلاح.

تم استخدام القطاعات كاملة العشوائية في تصميم القطع المنشقة مرة واحدة في ثلاث مكررات حيث وزعت تركيزات الرش بالبورن (صفر و٥٠و١٠٠ جزء في المليون) في القطع الرئيسية في حين وزعت وقت الرش بالبورون (٣٥و ٧٠و ١٠٥ يوم) عشوائيا في القطع المنشقة.

أشارت النتائج إلى:-

١- تأثرت معنويا معظم صفات المحصول والجوده لمحصول بنجر السكر وهى صفات الوزن الاخضر والجاف لكل من العرش والجذور ونسبه السكروز وكميه المحصول بالرش زياده بالتركيز الأعلى من البورون (١٠٠ جزء فى المليون) مقارنه بالكنترول (الرش بالماء) فى كلا الموسميين.

٢- وجد أن وقت الرش الورقي بالبورون كان له تأثير موجب على المحصول والجودة بينما لم يكن له أى تأثير على الوزن الجاف للاوراق والسكر المفقود في المولاس ومحصول السكر ونسبة الشوائب في موسمي الزراعة.

٣- كان هناك تأثير معنوى للتفاعل بين تركيز البورون ووقت الرش على صفات المحصول و الجودة ماعدا السكر المفقود و وتركيز المركبات النيتروجينيه والصوديوم.

من نتائج هذه الدراسة وجد اقضل محصول من الجذور والسكر واحسن صفات جوده تم الحصول عليها بالرش بالبورون بتركيز ١٠٠ جزء فى المليون على ان يتم الرش بعد ٧٠ يوم بعد الزراعه تحت ظروف الأراضي المستصلحة حديثاً.