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EFFECT OF HILL SPACING AND NITROGEN AND BORON FERTILIZATION LEVELS ON YIELD AND QUALITY ATTRIBUTES IN SUGAR BEET

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ABSTRACT: *Two field trials were carried out in Sakha Res. Station, Kafr EL-Sheikh Governorate (31 N^o,30 E^o at an altitude,elev 6 m) in two successive seasons (2012/2013 and 2013/2014) to find out the performance of sugar beet crop under different plant population as well as nitrogen and boron fertilization levels. This work included 27 treatments representing the combinations between three hill spaces (15, 20 and 25 cm), three nitrogen levels (80, 100 and 120 kg N/fed) and three boron concentrations (tap water "control", 105 and 210 ppm) as a foliar spray. A split-plot design with three replicates was used, where hill spaces were allocated in the main plots, meanwhile, the combinations between nitrogen and boron treatments were distributed in the sub-plots.*

The results showed that root diameter, root fresh weight, nitrogen and potassium concentrations of root and yields of root and tops were significantly increased with the increase in hill spaces from 15 to 25 cm. The highest significant values of sucrose and sugar yield were significantly obtained with 20 cm between hills, meanwhile, the purity percentage was recorded with 15 cm between hills, in both seasons.

Root length, diameter and fresh weight, potassium and sodium concentrations in root as well as yields of root and tops were significantly increased by increasing nitrogen levels from 80 to 120 kg N/fed, in both seasons. The highest average of sucrose percentage was recorded with 100 kg N/fed, whereas, sugar yield was the highest with 120 kg N/fed, in the two seasons.

Increasing boron levels from up to 210 ppm significantly increased root length, diameter and fresh weight, sucrose and purity percentages, as well as yields of root, top and sugar and boron concentration in root, in both seasons..

The combination between hill space of 25 cm and 120 kg N/fed gave the highest averages of root diameter and yields of root and top and the lowest purity percentage. Sugar yield recorded the greatest value with the combination between hill space of 20 cm and 120 kg N/fed, in the two seasons.

The highest average of sucrose percentage was recorded with the combination between 100 kg N/fed and 210 ppm boron in both seasons. The second order interaction of 25 cm hill space, 120 kg N/fed and 210 ppm boron gave the highest significant top yield in the 1st season as well as root yield in the 2nd season. Sugar yield recorded the highest value with the interaction between hill space of 20 cm, 120 kg N/fed and 210 ppm boron.

Key words: *Sugar beet, plant population, fertilization, yield.*

INTRODUCTION

Plant density per unit area of cultivated land is a major factor in determining the quality and quantity of the sugar roots, for instance, optimum plant density provides a larger area of nutrients which allows plant sufficient quantity of water, light and thus raises the efficiency of photosynthesis which contribute to increase the dry matter proportion in the roots and higher roots yield per unit area (Freckleton *et al.*, 1999). Many researchers have been conducted to determine the optimum plant population densities for high root and sugar yields, as well as, the quality. Nassar (2001) found that sucrose content and recoverable sugar percentages were linearly decreased with the reduction in plant density. He added that root and sugar yields were maximized with plant density of 42000 plants/fed. Ramazan (2002) recommended that plant establishment should be 70 000 - 110 000 plants/ha^{-1}. El-Bakary (2006) studied the effect of ridge width and distance between hills on sugar beet plants harvested at 210 days after sowing. He found that row width and hill spacing significantly effected root fresh weight, root length and diameter and TSS %, sucrose %, root and sugar yields/fed, in the two seasons. The optimum plant densities in sugar beet is very necessary to have high root yield with good quality. Ismail and Allam (2007) reported that sowing sugar beet at 70000 and 105000 per/ha^{-1} gave high values of yield and quality traits. Their results revealed that plant densities significantly enhanced root length and diameter, fresh weight/plant as well as sodium % and sucrose % in both seasons, in addition sugar yield in the 2nd season. They added that sowing sugar beet at 28000 and 42000 plants/fed gave the highest yield of root and sugar and quality traits. Masri (2008) observed a positive effect of increasing plant density from 87500 to 100000 plants ha^{-1} as well as significant increase in sucrose content, purity, extractable sucrose and sugar yield. Nafei *et al.* (2010) showed that increasing plant population from 28000 to 42000 plants/fed caused a significant positive response in root length, diameter, root fresh weight/plant, sucrose %, TSS % and phosphorus % in roots as well as top, root and sugar yields. Hozayn *et al.* (2013) in Kafr El-Sheikh, studied the effect of five planting densities (16, 24, 32, 36 and 40 thousands plants/fed) on yield and quality of sugar beet plants grown on a clay soil. Growing sugar beet at 36000 plants/fed increased the yield of fresh roots and fresh foliage as well as sugar yield as compared to the other plant densities, the same plant density recorded the highest values for most of the studied quality characters.

Concerning nitrogen fertilizer effects, Seadh (2008) found that application of 150 kg N/fed produced the highest values of root and top yields and its components. While, fertilizing beet plants with 125 kg N/fed produced the highest sugar yield/fed. Optimum means of sucrose and purity percentages were obtained with using 75 kg N/fed. Abdel-Motagally and Attia (2009) in sandy calcareous soil, observed that increasing nitrogen levels significantly increased root and foliage fresh and dry weights and sugar yield (ton/ha^{-1}) of sugar beet. Increasing nitrogen levels up to 285 kg/ha^{-1} significantly increased impurities (Na, K and alpha-amino-N) and sugar loss percentage. El-Hosary *et al.* (2010) and Sarhan *et al.* (2012) found that increasing nitrogen fertilizer levels caused significant increase in yield, yield components and quality of sugar beet. Gobarah, Mirvat *et al.* (2010) reported that increasing N levels from 60 to 150 kg N/fed significantly increased root yield, yield components and Na, K and alpha-amino-N contents. Khalil (2010) found that increasing nitrogen levels from 80 to 100 and 120 kg/fed significantly increased root length, root diameter, root fresh weight/plant, root yield and the percentages of Na, K, alpha-amino-N and sugar loss to molasses. Abo-Shady *et al.* (2011) found that increasing nitrogen levels from 75 to 90 and 105 kg N/fed caused significant increase in Na, K and alpha-amino-N in root contents and sugar loss in molasses. Osman (2011) indicated that increasing N levels up to 120 kg/fed gave high averages of root length, root diameter, fresh weight/plant and root and sugar yields/fed. While, gradual reduction in sucrose % and purity % had been detected with increasing nitrogen level over 80 kg N/fed. Abdou (2013) in sandy soil, found that increasing nitrogen levels from 100 to 120 and 140 kg/fed significantly increased root fresh weight, root length and diameter as well as root and sugar yields/fed. On the other hand, it significantly decreased TSS, sucrose and purity percentages. El-Sarag and Moselhy (2013) found that increasing N levels from 105 to 210 kg/ha^{-1} caused significant increase in root, top and sugar yields/ha. Omar and Mohamed (2013) found that increasing nitrogen levels from 50 up to 125 kg N/fed caused significant increase in root dimensions, top fresh weight/plant, root fresh weight/plant, Na %, K %, sugar loss % in molasses (SLM %) and root yield/fed. Top and recoverable sugar yields were responded only to 100 kg N/fed. The highest average of sugar, purity and extractable sugar percentages were produced with using low nitrogen level (50 or 75 kg N/fed). Abdou and Badawy (2014) reported that increasing nitrogen levels from 70 to 90, 110 and 130 kg N/fed significantly increased root fresh weight, root length, root diameter, TSS % and root and sugar yields/fed, in both seasons.

Proper plant nutrition is an important factor for improving productivity and quality of agricultural production (Gobarah, Mirvat *et al.,* 2014). Boron is the most important trace element needed by sugar beet because without an adequate supply the yield and quality of roots are depressed (Cooke and Scott 1993). Bonilla *et al.* (1980) examined the effects of deficient and toxic levels of boron on various aspects of nitrogen metabolism in sugar beet mentioned that root fresh weight, sucrose %, root and top yields were significantly increased by increasing boron levels (Jaszczolt, 1998 and Gobarah, Mirvat and Mekki, 2005) and Thus, application of boron to sugar beet significantly increased the root yield and yield components and also increased recoverable sugar percent and sugar yield, while decreased Na and K in root juice, and hence increased juice quality. El-Hawary (1994) found that the root fresh weight, sucrose percentage, top, root and sugar yield/fed were significantly increased with increasing boron levels up to 200 ppm. Osman *et al.* (2003) fertilized sugar beet plants with three boron levels (0, 1 and 2 kg/fed), they found that increasing the level of boron up to 2 kg/fed increased sucrose and purity percentages as well as sugar yield/fed. Pospišil *et al.* (2005) reported that the application of 50 l/ha of Fertina B (3% N + 4% B) increased the root and sugar yields by 16.7 %. Further increase of Fertina B rates reduced the root and sugar yields and lowered the technological quality of sugar beet roots. Kristek *et al.* (2006) studied the effect of foliar fertilization with Fertina B element (1.0 kg B/ha^1) on sugar beet root yield and quality, they found that root yield was higher by 13.86 ton/ha^{-1} (19.4%), sugar concentration higher by 1.46% (relative 10.8%) and sugar yield higher by 3.15 t/ha^{-1} (39.5%) than the control. Based upon these results, foliar fertilization with 1.0 kg B/ha^{-1} is suggested for soils characterized by insufficient boron supply. It should be added through two top dressings, first prior leaves formation and second 10 -14 days later. Allen and Pilbeam (2007) emphasized that sugar beet crop has high requirements for boron when adequate boron nutrition is critical for high yield and quality of crops. Boron increases the rate of transport of sugars to actively growing regions and also in developing fruits. Ouda (2007) studied the effect of chemical and bio-fertilizer of N and boron as well as their interactions on yield and quality of sugar beet. The results of interaction effects showed that significant interactions of application of nitrogen and cerealin + boron, but most of them did not give additional information except root yield and sugar yield ton/fed. Hellal *et al*. (2009) concluded that the yield of sugar beet was highly and positively correlated with N, K and B content in root and shoot. Gobarah, Mirvat *et al.* (2010) examined the effect of four levels of boron on sugar beet i.e. (0, 1, 1.5 and 2 kg/acre), they found that increasing boron fertilizer up to 2 kg/acre resulted in the highest sugar and recoverable sugar yields. Sucrose recoverable, sucrose and juice purity percentages were also increased. Enan (2011) found that the highest averages for root diameter, root fresh weight, (root, top and sugar yield/fed), sucrose and TSS % were obtained by increasing boron to the level 200 ppm. Abido (2012) mentioned that application of 80 ppm boron significantly improved root yield and its attributes and root quality, on contrarily harvest index was decreased. Armin and Asgharipour (2012) reported that foliar application of 1.22 kg B/ha^{-1} increased root yield and sucrose concentration, decreasing potassium, sodium, alpha-amino-N and molasses sugar compared with those of the control.

The aim of this work was to find out the best combination between hill spacing, nitrogen fertilizer and boron foliar application to gain the most impact on sugar beet quality and quantity.

MATERIALS AND METHODS

Two field trials were conducted in Sakha Res. Station, Kafr EL-Sheikh Governorate (31 N^o,30 E^o at an altitude, elev. 6 m) during the two successive seasons (2012/2013 and 2013/2014) to find out the performance of sugar beet crop under different plant populations, as well as, nitrogen and boron fertilization levels.

A split-plot design with three replicates was conducted. The main plots were occupied by hill spacing (15, 20 and 25 cm). Meanwhile, the combinations between three nitrogen levels (80, 100 and 120 kg N/fed "fed = 0.42 ha^{-1}") and three boron concentrations (tap water spray "control", 105 and 210 ppm) were distributed in the sub-plots. Nitrogen fertilizer was added as urea (46.5 % N) in two equal doses, the 1st one after thinning and the 2nd one month later, meanwhile boron, was sprayed once on the foliage as boric acid by the above mentioned concentration after 90 days from sowing.

Plot area was 21 m^2 including 6 ridges of 50 cm in width and 7 meter in length. The preceding crop was rice in both seasons. Soil samples were taken at random from the experimental sites at a depth of 0.0 – 30 cm from soil surface. Soil physical and chemical properties of the experimental sites are presented in Table (1). Phosphorus fertilizer in form of calcium superphosphate (15.5 % P_2O_5) was applied at the level of 31 kg P_2O_5/fed during seedbed preparation, whereas, potassium fertilizer in form of potassium sulphate (48 % K_2O) was added at the level of 48 kg K_2O/fed with the 1st nitrogen application.

Table (1): Soil mechanical and chemical properties of the experimental sites in the two seasons of 2012/2013 and 2013/2014.

	2012/2013	2013/2014
Soil depth (cm)	0 – 30	0 - 30
Mechanical soil distribution		
Sand %	19.4	18
Silt %	24.4	23.6
Clay %	56.2	58.4
Texture Class	Clay	Clay
Chemical analysis in soil extraction		
a) Cations meq/l		
Ca^{++}	3.1	2.89
Na^{+}	4.86	4.65
K^{+}	0.4	0.53
Mg^{++}	1.3	1.8
b) Anions meq/l		
Cl^{-}	2.41	2.27
SO_4^{--}	3.45	4
HCO_3^{-}	3.8	3.6
$CaCO_3$	3.82	4
Available B ppm	0.39	0.43
Available N ppm	39.70	36.80
Available P ppm	15.20	16
Available K ppm	389	421
pH	8.2	8.0
E.C ds/m	0.96	0.99

Sugar beet variety viz Heliospoly was sown on the 1st week of October in both seasons. Plants were thinned to one plant/hill when the plant aged 45-day after sowing. All the other practices for such as hoeing irrigation etc… were carried out as usual in sugar beet field according Sugar Crops Res. Inst. recommendations (SCRI).

Recorded data*:*

At harvest (210 days after sowing), a sample of five guarded plants was randomly taken from each sub-plot to determine the following characters:

A. Root yield attributes:

1. Root length (cm).
2. Root diameter (cm).
3. Root fresh weight/plant (g).

B. Juice quality and chemical constituents:

1. Impurities percentages in terms of potassium (K) and sodium (Na) were determined in Delta Sugar Company Laboratories at Kafre EL-Sheikh Governorate; meanwhile nitrogen element was estimated in the digested solution using micro Kjldahl apparatus according to Pergl (1945).
2. Boron element was determined according to A.O.A.C., (1995).
3. Sucrose percentage was determined as described by Le Docte (1927).
4. Purity percentage was calculated according to the following equation:
   Purity % = (sucrose % x 100) / TSS %

C. Root, top and sugar yields (ton/fed):

At harvest, plants of the four guarded rows of each sub-plot were uprooted topped, cleaned and weighed to estimate root and top yields (ton/fed). Sugar yield was calculated according to the following equation:

Sugar yield (ton/fed) = root yield (ton/fed) x sucrose %.

Statistical analysis:

The collected data were statistically analyzed according to Snedecor and Cochran (1981). Least Significant Difference (LSD) method was used to compare the differences between treatment means at 5% level of probability as mentioned by Waller and Duncan (1969).

RESULTS AND DISCUSSION

A. Root yield attributes:

A. 1. Root length:

Results given in Table (2) show the influence of hill spaces and nitrogen and boron fertilization levels on sugar beet root length. Data obtained cleared that hill spaces significantly affected root length in both seasons. Narrow hill space of 15 cm surpassed the other hill spaces in respect with root length. This increase may be due to the high competition between plants for plant growth resources.

As for the influence of nitrogen effect on root length, it could be noted that there was a significant positive response in this trait with the increase in the applied dose of nitrogen fertilizer. Similar effect was shown on root length due to boron fertilization, where increasing the applied dose of boron continuously raised the values of this trait in both seasons. The positive influence of nitrogen on root length could be due to its role in cell division and elongation as a principal component in chlorophyll component. This result is in agreement with that reported by Omar and Mohamed (2013) and Abdou and Badawy (2014). Amin (2005) as they, reported that increasing N levels significantly increased root length and its diameter, root fresh weight, top, root and sugar yield.

Concerning the influence of boron fertilization on root length, the obtained results cleared that there was a significant positive increase in root length due to the gradual increase in the spraying concentration of boron from 105 to 210 ppm, in both seasons. The effective role of boron on root growth has been reported by Abido (2012). Table (2) showed that the interaction between sowing hill spaces and nitrogen

Table 2

levels significantly affected the averages of root length in the two seasons. Increasing the applied levels of nitrogen increased root length significantly. This observation was completely true under the three hill spaces, but with the different magnitudes.

A. 2. Root diameter:

Results illustrated in Table (2) pointed out that the wider sown sugar beet plants in the wider hill spacing increased their root thickness. This results was fairly true in both seasons. This root diameter increment was gradual and significant. This finding may be due to that the wider distance between hills decreased the competition between plants which allowed better conditions for the plant grown and in turn was reflected on root growth.

Table (2) revealed that root diameter responded significantly to the increase in the applied level of nitrogen up to 120 kg N/fed. This observation was true in both seasons. The results obtained indicate to the important role of nitrogen in plant growth as an essential elements in chlorophyll component which in turn was reflected on plant growth in terms of root dimensions. This result coincides with those found by Osman (2011) and Omar and Mohamed (2013).

Regarding boron effect on root diameter, the data showed that root diameter responded significantly to the increase in boron level. Spraying sugar beet foliage by 210 ppm produced the highest averages of root thickness in both seasons. The relative advantage of boron element on root thickness may be due to the distinct role on photosynthates translocation process. Similar result was recorded by Abido (2012).

Regarding the interaction between the studied factors and its influence on root diameter, the data in Table (2) cleared that the combination between hill spaces and nitrogen fertilizer was the most effective interaction on this trait. Increasing the applied dose of nitrogen from 80 up 120 kg N/fed under the different hill spaces was accompanied by increasing root thickness, but with the different magnitudes. This result was fairly true in both seasons.

A. 3. Root fresh weight/plant:

Data in Table (3) cleared that root fresh weight of sugar beet/plant was significantly and gradually increased by the increase of hill spaces. This result was fairly true in both seasons. This finding may be due to the wider hill space allowed plants to grow better than the narrower space which was reflected on the plant growth and consequently root fresh weight. This result is in agreement with those reported by El-Bakary (2006) and Ismail and Allam (2007).

Regarding nitrogen fertilizer levels effect, the available data cleared that root fresh weight/plant was positively and significantly increased by the increase of the applied nitrogen levels up to 120 kg N/fed in both seasons. This result is due to the effective role of N on plant growth. This finding is in line with those reported by Omar and Mohamed (2013) and Abdou and Badawy (2014). Also, Hellal *et al.* (2009) found a positive effect of increasing N doses on sugar beet shoot and root weight.

Concerning boron application on root fresh weight, it is obviously shown that increasing boron foliar application attained a significant response in the values of root fresh weight/plant. This observation is due to the important role of boron in dry matter translocation which in turn was reflected on the final root fresh weight. These findings are in line with those of Enan (2011).

As for the interaction between the studied factors, the results revealed that most the various interaction were not significant in respect to their influence on root fresh weight, indicating that the main effect of each of hill spacing, N level and boron level dominated any interaction between them.

Table (3): Root fresh weight as affected by hill spacings, nitrogen and boron fertilization levels and their interactions (2012/2013 and 2013/2014 seasons).

Treatments		Root fresh weight (g/plant)							
		1st Season (2012/2013)				2nd Season (2013/2014)			
Hill spacing	Nitrogen (kg N/fed)	Boron (ppm)							
		control	105	210	Mean	control	105	210	Mean
15 cm	80	703	743	826	757	843	901	983	909
	100	829	903	999	910	932	1110	1048	1030
	120	1028	1165	1147	1113	985	1164	1228	1126
Mean		853	937	991	927	920	1058	1087	1022
20 cm	80	909	1030	1183	1041	832	989	1071	964
	100	1095	1155	1115	1122	1072	1148	1202	1141
	120	1175	1303	1362	1280	1154	1297	1302	1251
Mean		1060	1163	1220	1147	1019	1145	1192	1119
25 cm	80	1130	1153	1188	1157	1188	1202	1308	1233
	100	1141	1280	1310	1244	1207	1273	1343	1274
	120	1255	1426	1565	1415	1367	1520	1596	1494
Mean		1175	1286	1354	1272	1254	1332	1416	1334
Nitrogen	80	914	975	1066	985	954	1031	1121	1035
x	100	1022	1113	1141	1092	1070	1177	1198	1148
Boron	120	1153	1298	1358	1269	1169	1327	1375	1290
Mean		1029	1129	1188		1064	1178	1231	

Control: tap water, fed = 0.42 ha^{-1}.

LSD at 0.05 level for:

Hill spacing (A)	113.25	77.44
Nitrogen level (B)	38.02	42.10
Boron level (C)	38.02	42.10
A x B	NS	72.92
A x C	NS	NS
B x C	NS	NS
A x B x C	114.07	NS

B. Juice quality and chemical constituents:

B. 1. Nitrogen and boron concentrations in root:

Data given in Table (4) pointed out the influence of the studied factors on nitrogen and boron contents in sugar beet roots. Results showed that nitrogen content was the only significantly affected by hill spaces in both seasons, where increasing hill spaces were accompanied by a significant increase in nitrogen %. This finding may be due to a higher absorption in the wider hill space which was reflected on larger root fresh weight as observed in Table (3).

Concerning nitrogen fertilization effect, there was a gradual increase in the juice nitrogen content due to the increase in the applied level of nitrogen, on the contrary the values of boron were negatively affected by the increase in the applied doses of nitrogen. This result was fairly true in both seasons. Similar results were observed by Khalil (2010) and Abo-Shady *et al.* (2011).

Once more, it could be noted that increasing the spraying level of boron led to gradual decrease in juice nitrogen content in both seasons, however, this decrease was significant in only the 1st season. Meanwhile, nitrogen concentration significantly and positively decreased with increasing the dose of boron in both seasons.

As for the interaction between hill spaces and nitrogen level the data cleared a positive increase in juice nitrogen due to the increase in N- significantly in the 2nd season only.

The interaction between boron fertilizer and hill spaces appeared significant differences in respect to its effect on the nitrogen % in the 1st season only. Increasing the applied dose of boron under the 15 and 20 cm hill space decreased the contents of N %, however under the wider space of 25 cm between hills it decreased with the increase in the applied dose of boron. Concerning the interaction between hill spaces and nitrogen fertilization on the content of boron, the results obtained showed that under the different hill spaces, increasing the applied dose of nitrogen decreased the values of boron.

B. 2. Potassium and sodium concentrations in root:

Table (5) show the effect of the studied factors on potassium and sodium contents which are the most important impurities directly effected on sugar beet quality. The results in Table (5) revealed that increasing the distance between hills of sugar beet produced higher contents from potassium and sodium in the two seasons. This effect was significant in the two seasons for potassium and in the 1st season for sodium.

As for, the influence of nitrogen fertilizer level on the percentages of potassium and sodium, it could be noted that raising the applied dose of nitrogen from 80 up to 120 kg N/fed continuously and significantly increased potassium and sodium in both seasons. This result may be due to nitrogen effect on plant growth which increased the root length (Table 2) and hence increased the absorption of N (Table 4) and hence potassium and sodium (Table 5) in element absorption. This result is in agreement with that reported by Abo-Shady *et al.* (2011) and Omar and Mohamed (2013).

Regarding boron application effect on potassium and sodium percentages, the data demonstrated that the differences between boron application levels on potassium and sodium percentages were significant in the 1st season only. It could be noted that check treatment (tap water spray) almost recorded the highest potassium and sodium percentages. Increasing boron application decreased sodium content to different extents: Sodium content was 1.75 Meq 100 g 1 root for concentration of 4 %, 1.58 Meq 100 g 1 root for concentration of 8 % and 1.26 Meq 100 g 1 root for concentration of 12 %, which, compared with the control, decreased by 26 %, 34 and 47%, respectively, Armin and Asgharipour (2012) also observed that the highest potassium content was observed in the control, which decreased by 30.6 % at spraying with concentration of 12 %. On the other hand, Kristek *et al.* (2006) reported

Table 4

Table 5

that boron application had no impact on potassium content in sugar beet root. In the same trend Tariq *et al.* (1993) showed that application of boron decreased sodium content in sugar beet root. Similar results have also been reported by Javaheripour *et al.* (2005) in their study, however, application of 10 and 20 kg boric acid ha^{-1} prior to sowing did not increase the sodium content over the control.

The only significant interaction between the studied factors on potassium and sodium percentages was that between hill spaces and nitrogen fertilization. Under the three hill spaces increasing the supplied nitrogen fertilization levels increased potassium percentage and the highest values of this trait was under the widest hill space. Moreover, the highest value of sodium percentage was shown under the wider hill spaces of 20 and 25 cm by increasing nitrogen fertilization from 80 up to 120 kg N/fed.

B. 3. Sucrose percentage:

Data illustrated in Table (6) show the influence of hill spaces and the combination between nitrogen and boron fertilizer levels on sucrose percentage of sugar beet crop. The collected data pointed out that sowing beet on 20 cm hill space over passed significantly the others hill spaces *i.e.* 15 and 25 cm apart. This result may be indicate to that the suitable hill space was that 20 cm which attained the highest significant values for sucrose percentage in the two growing seasons, increasing the hill space to 25 cm decreased significantly sucrose % in both seasons, this finding may be due to that under the wider space between hills the which allowed more growth for roots and consequently high moisture content in turn low sucrose percentage. Masri (2008) observed a positive effect of increasing plant density from 87500 to 100000 plants ha^{-1} as well as significant increase in sucrose content, purity, extractable sucrose and sugar yield.

Concerning nitrogen fertilizer levels on the values of sucrose percentage, the results in Table (6) revealed a statistical positive response to the applied dose of nitrogen, application 100 kg N/fed was enough to produce the highest significant values for this trait in both seasons. However, it could be noted that increasing the applied nitrogen level up to 120 kg N/fed reduced the values of sucrose percentage in the two seasons with insignificant differences between 80 and 120 kg N/fed in this respect. The decrease of root sucrose content due to the increase of N level beyond 100 kg N\fed could be attributed to a dilution effect caused by the increase in root fresh weight with each increase in N level up to 120 kg N\fed. This finding is in agreement with that found by Osman (2011) and Abdou (2013).

As for the effect of boron fertilizer levels on sucrose percentage, the results in Table (6) cleared that there was significant and continuous response in the values of sucrose % due to the increasing in the applied dose of boron fertilizer. Foliar spraying of boron at 210 ppm recorded the highest significant values of sucrose%. This observation was fairly true in the two growing seasons. The distinct effect of boron fertilization on this trait due to the essential role of boron in sugar translocation and, in turn, sugar storage in root. The role of boron element in this respect has been reported by Armin and Asgharipour (2012). Same observation was realized by Al-Mohmmad and Al-Geddawi (2001) who showed that boron consumption in sugar beet significantly reduced root rot, increasing the sugar yield due to increased glucose levels in roots and phloem sap, in their study, compared to the control, boron application increased sucrose concentration by 6.5% and 16% at the first and second years of study, respectively.

Once more the interaction between the studied factors appeared a significant influence on sucrose % due to the interaction between hill spaces and nitrogen fertilizer levels. It could be noticed that increasing the applied dose of nitrogen fertilizer almost recorded significant increase in the values of sucrose % in both seasons and that the highest value of sucrose % was recorded with the combination between 20 cm hill space and 100 kg N/fed. However

Table 6

increasing the applied dose up to 120 kg N/fed caused a significant reduction in sucrose percentage. This effect may be due to the bad effect of the high dose of nitrogen on this trait as a result to the effect of the high nitrogen dose on the purity.

Also, the combination between nitrogen and boron levels recorded a significant influence on the values of sucrose percentage in both seasons. It could be observed that under the same level of nitrogen (100 kg N/fed), increasing the spraying dose of boron positively increased the values of sucrose percentage in the two seasons. This effect could be due to the fruitful effect of nitrogen element on photosynthesis process and the pivotal effect on sucrose translocation in sugar beet roots.

B. 4. Purity percentage:

Results shown in Table (6) clear the relative effect of the hill space and both of nitrogen and boron fertilization levels on purity %. The results revealed that sowing hill space had similar influence on purity percentage as it was on sucrose %, where the middle hill space i.e. 20 cm recorded the highest positive effect on purity percentage. This influence might be due to the pronounced effect of this treatment on sucrose % which is considered the reflected mirror to the expected purity percentage.

Table (6) obviously showed that the highest values of purity % were attained with the lowest nitrogen application level (80 kg N/fed), however raising the additional dose of nitrogen depressed the values of purity percentage in both seasons. This finding may be due to the low impurities with the lower nitrogen application which increased purity %. This finding is in line with those stated by Osman (2011) and Abdou (2013).

Regarding the effect of boron fertilization levels on purity %, the obtained data showed that increasing spraying rate of boron gradually and significantly raised the values of purity percentage, This result was fairly true in both growing seasons. The effective role of boron on purity % comes through its beneficial effect on the values of sucrose % (Table 6). This result is in agreement with that reported by Abido (2012).

As for the interaction effect on purity %, the results in Table (6) cleared that the combination between nitrogen and boron fertilizer levels significantly affected purity % in only the 1st season.

C. Root, top and sugar yields

C. 1. Root yield per fed

Results given in Table (7) demonstrated the influence of hill spacing and each of nitrogen and boron fertilization levels as well as their interactions on root yield of sugar beet crop. It is clearly reveal that sugar beet root yield positively and continuously responded to hill spaces in both seasons, as the distance between hills was increased the root yield was also increased significantly. This observation was completely true in both growing seasons, and the highest root yield was recorded with sowing hills of 25 cm apart. The pronounced effect of the wider hill spaces due to the distinct effect of the wider hill spaces on growth criteria *i.e* root diameter and root fresh weight (Tables 2 and 3) and the assimilator organs in terms tops yield, the wider the hill space, the heavier, the individual root fresh weight, the heavier the root yield.

As to, the root yield as affected by nitrogen fertilization levels, the collected data illustrated in Table (7) indicated to root yield appeared a positive and significant response to the applied dose of nitrogen, increasing nitrogen level from 80 to 100 up to 120 kg N/fed improved root yield by 12.04 % and 25.00 % in the 1st season and 23.43 % and 21.09 % in the 2nd season, respectively. The relative influence of nitrogen fertilizer on root yield is mainly due to its effect on root growth rate in terms of root diameter and root fresh weight g/plant (Tables 2 and 3). Similar results were recorded by El-Sarag and Moselhy (2013) and Abdou and Badawy (2014).

Table (7): Root yield as affected by hill spacings, nitrogen and boron fertilization levels and their interactions (2012/2013 and 2013/2014 seasons).

Treatments		Root yield (ton/fed)							
		1st Season (2012/2013)				2nd Season (2013/2014)			
Hill spacing	Nitrogen (kg N/fed)	Boron ppm							
		control	105	210	Mean	control	105	210	Mean
15 cm	80	17.17	18.48	18.93	18.19	19.59	20.03	20.71	20.11
	100	19.83	21.25	22.05	21.04	20.62	22.34	23.49	22.15
	120	22.98	23.14	23.90	23.34	22.82	24.65	25.25	24.24
Mean		19.99	20.96	21.63	20.86	21.01	22.34	23.15	22.17
20 cm	80	19.28	20.07	22.00	20.45	19.36	22.15	23.12	21.54
	100	21.80	22.41	24.06	22.76	22.61	23.67	24.63	23.64
	120	24.06	24.37	26.16	24.86	25.37	26.56	27.26	26.40
Mean		21.72	22.28	24.07	22.69	22.45	24.13	25.00	23.86
25 cm	80	21.58	22.18	24.23	22.67	22.27	23.67	24.90	23.61
	100	24.37	24.89	25.43	24.90	25.09	25.80	26.51	25.80
	120	27.77	28.28	29.30	28.45	27.57	28.35	29.28	28.40
Mean		24.57	25.12	26.32	25.34	24.97	25.94	26.90	25.94
Nitrogen	80	19.34	20.24	21.72	20.44	20.41	21.95	22.91	21.76
x	100	22.00	22.85	23.85	22.90	22.77	23.94	24.88	23.86
Boron	120	24.94	25.26	26.46	25.55	25.25	26.52	27.26	26.35
Mean		22.10	22.79	24.01		22.81	24.14	25.02	

Control: tap water, fed: = 0.42 ha^{-1}

LSD at 0.05 level for:

	1st Season	2nd Season
Hill spacing (A)	1.012	0.243
Nitrogen level (B)	0.543	0.315
Boron level (C)	0.543	0.315
A x B	NS	NS
A x C	NS	NS
B x C	NS	NS
A x B x C	NS	0.945

Regarding the influence of boron fertilizer on root yield of sugar beet crop. Table (7) pointed out to a gradual and significant increase in the average of root yield due to the increase in the spraying boron application. Spraying sugar beet foliage by boron at 210 ppm level attained the highest significant increase in root yield. This results is in accordance with Armin and Asgharipour (2012) who found that boric acid concentrations significantly ($p<0.05$) affected root yield. Spraying with concentrations of 8% and 12% significantly increased yield over the control. At the same time, differences between control and spraying with concentration of 4‰ were not significant. The increase in the value of root yield as a result to the increase in boron application could be due to the favorable effect of boron element on growth criteria in Tables (2) and (3). Regarding the influence of the interaction of the examined factors on root yield, the available data in Table (7) cleared insignificant effect of the most different combinations on root yield.

C. 2. Top yield per fed:

Data given in Table (8) clear the influence of hill spaces and the combination between nitrogen and boron fertilization on tops yield. The available data revealed that tops yield significantly responded to the increase in hill spaces, increasing the distance between hills increased significantly and continuously the averages of tops yield in the two seasons. This finding may be due to under the wider hill spaces the competition between plants grown on space and land was decreased in turn was reflected on the values of tops yield.

Concerning the effect of nitrogen fertilizer levels on tops yield, the results in Table (8) showed that increasing the nitrogen fertilization level up to 120 kg N/fed significantly increased the values of tops yield in both seasons.

This result may be due to the important role of nitrogen in plant growth as an essential component in chlorophyll pigments. This result is in agreement with those reported by Abo-Shady *et al.* (2011) and El-Sarag and Moselhy (2013).

As for the effect of boron fertilizer level on tops yield, the results in Table (8) pointed out that this trait was significantly and gradually increased as the boron spraying level was increased up to 210 ppm. This finding may be due to the healthy role of boron on the plant grown which directly affected on growth vigor of the plants.

The interaction effects between the three studied factors cleared that increasing nitrogen and/or boron fertilizer under the three hill spaces significantly increased tops yield in both seasons, however, this effect was significant in the 2nd season for the combination between hill spaces and nitrogen fertilizer and for the combination between hill spaces and boron fertilizer in the 1st season. This result may be considered as a good indication to the pronounced effect of hill spaces on plant growth.

C. 3. Sugar yield per fed:

The results in Table (9) pointed out that increasing hill spaces from 15 to 20 cm apart significantly raised the values of sugar yield in both growing seasons. However, the increase of hill space up to 25 cm caused a significant reduction in the values of sugar yield. This distinct effect of hill space of 20 cm due its pronounced influence on the values of sucrose and purity percentages (Table 6) which in turn was reflected on the average of sugar yield. This finding was in line with El-Bakary (2006).

Illustrated data in Table (9) revealed that there was a significant increase in the sugar yield as the supplied nitrogen level was increased up to 120 kg N/fed. This finding was fairly true in both seasons. The effective role of nitrogen fertilizer levels on sugar yield could be due to its distinguished influence on both of root yield (Table 7) and tops yield (Table 8). Similar results were recorded by Abdou (2013) and Abdou and Badawy (2014).

Table (8): Top yield as affected by hill spacings, nitrogen and boron fertilization levels and their interactions (2012/2013 and 2013/2014 seasons).

Treatments		Top yield (ton/fed)							
		1st Season (2012/2013)				2nd Season (2013/2014)			
Hill spacing	Nitrogen (kg N/fed)	Boron (ppm)							
		control	105	210	Mean	control	105	210	Mean
15 cm	80	6.55	8.05	9.30	7.97	7.62	8.39	8.99	8.33
	100	8.45	9.18	10.37	9.33	9.02	9.66	10.47	9.72
	120	10.10	10.82	12.25	11.06	11.00	11.42	11.89	11.43
Mean		8.37	9.35	10.64	9.45	9.21	9.82	10.45	9.83
20 cm	80	8.66	9.33	10.13	9.38	11.19	11.60	12.18	11.66
	100	9.77	10.61	11.26	10.55	11.92	12.60	13.27	12.60
	120	11.71	12.26	12.70	12.22	13.55	14.19	14.74	14.16
Mean		10.05	10.74	11.36	10.72	12.22	12.80	13.40	12.80
25 cm	80	10.66	11.19	11.62	11.16	12.03	12.40	13.17	12.53
	100	11.80	12.53	12.96	12.43	12.56	13.20	13.59	13.12
	120	13.42	14.39	15.34	14.38	14.61	15.55	16.57	15.57
Mean		11.96	12.70	13.31	12.66	13.07	13.72	14.44	13.74
Nitrogen	80	8.63	9.53	10.35	9.50	10.28	10.80	11.45	10.84
x	100	10.00	10.77	11.53	10.77	11.17	11.82	12.44	11.81
Boron	120	11.74	12.49	13.43	12.55	13.05	13.72	14.40	13.72
Mean		10.12	10.93	11.77		11.50	12.11	12.76	

Control: tap water, fed = 0.42 ha^{-1}

LSD at 0.05 level for:

	1st Season	2nd Season
Hill spacing (A)	0.198	0.976
Nitrogen level (B)	0.133	0.295
Boron level (C)	0.133	0.295
A x B	NS	0.511
A x C	0.231	NS
B x C	NS	NS
A x B x C	0.400	NS

Table (9): Sugar yield as affected by hill spacings, nitrogen and boron fertilization and their interactions (2012/2013 and 2013/2014 seasons).

Treatments		Sugar yield (ton/fed)							
		1st Season (2012/2013)				2nd Season (2013/2014)			
Hill spacing	Nitrogen (kg N/fed)	Boron ppm							
		control	105	210	Mean	control	105	210	Mean
15 cm	80	3.06	3.65	3.91	3.54	3.73	4.06	4.36	4.05
	100	3.96	4.41	4.83	4.40	4.28	4.76	5.19	4.74
	120	4.44	4.65	4.92	4.67	4.57	5.08	5.39	5.01
Mean		3.82	4.24	4.55	4.20	4.19	4.63	4.98	4.60
20 cm	80	3.79	4.27	4.86	4.31	4.10	4.86	5.18	4.71
	100	4.73	5.00	5.52	5.08	4.94	5.35	5.79	5.36
	120	4.84	5.06	5.62	5.17	5.34	5.83	6.13	5.77
Mean		4.45	4.78	5.33	4.85	4.80	5.35	5.70	5.28
25 cm	80	3.65	4.30	4.84	4.27	3.88	4.53	5.18	4.53
	100	4.28	4.56	4.80	4.55	4.65	4.83	5.09	4.86
	120	4.69	4.99	5.31	5.00	4.89	5.17	5.30	5.12
Mean		4.21	4.62	4.98	4.60	4.47	4.84	5.19	4.84
Nitrogen x Boron	80	3.50	4.07	4.54	4.04	3.90	4.48	4.91	4.43
	100	4.32	4.66	5.05	4.68	4.62	4.98	5.36	4.99
	120	4.65	4.90	5.28	4.95	4.94	5.36	5.61	5.30
Mean		4.16	4.54	4.96		4.49	4.94	5.29	

Control: tap water, fed = 0.42 ha^{-1}

LSD at 0.05 level for:	1st Season	2nd Season
Hill spacing (A)	0.250	0.176
Nitrogen level (B)	0.148	0.104
Boron level (C)	0.148	0.104
A x B	0.256	0.180
A x C	NS	NS
B x C	NS	NS
A x B x C	NS	0.311

As to the influence of boron fertilizer on sugar yield, the obtained results clearly show that as the spraying concentration of boron was increased up to 210 ppm, the yield of sugar was increased. This result was valid in the two seasons, and is mainly due to the essential role of boron on storage process of sugar in the root which consequently reflected on sugar yield. Our results are in agreement with Enan (2011).

Concerning the influence of the interaction of the studied factors, the results given in Table (9) obviously show that the most effective combination between the and quantity needed from fertilization studied factors was that between plant densities and nitrogen fertilization, raising the applied nitrogen level significantly increased the averages of sugar yield under the different three hill spaces. These results are fairly true in both growing seasons.

Also, it could be noted that the highest response for this combination was under hill space of 20 cm apart. This result may be throw some light about the relation between plant population.

Conclusion

Our results emphasized the importance of boron foliar application by the rate up to 210 ppm in addition to applying nitrogen fertilizer by 100-120 kg/fed with respect to the 20 cm hill space as this combination recorded the highest averages of studied parameters under the conditions of present study.

REFERENCES

A. O. A. C. (1995). Official methods of analysis published by the A.O.A.C., Box 540, Washington.

Abdel-Motagally, F. M. F. and K. K. Attia (2009). Response of sugar beet plants to nitrogen and potassium fertilization in sandy calcareous soil. Int. J. Agric. Biol., 11 (6): 965-700.

Abdou, M. A. (2013). Effect of nitrogen fertilization and harvesting dates on sugar beet productivity and quality in newly reclaimed sandy soils. J. Plant Production, Mansoura Univ., 4 (12): 1871-1882.

Abdou, M. A. and Shimaa A. Badawy (2014). Sugar beet productivity and quality as affected by nitrogen fertilizer levels and irrigation withholding date. Minufiya J. Agric. Res., 39(1): 181-189.

Abido, W. A. E. (2012). Sugar beet productivity as affected by foliar spraying with methanol and boron. International Journal of Agriculture Sciences. 4(7):287-292, 2012.

Abo-Shady, Kh. A., S. S. Zalat and M. F. M. Ibrahim (2011). Influence of use of nitrogen fertilizer levels and sources for late sowing date on yield and quality of sugar beet (*Beta vulgaris* L.) in North Nile Delta. J. Plant Production, Mansoura Univ., 2(3): 425-436.

Allen V. Barker and David J. Pilbeam. Ed. (2007). Handbook of plant nutrition. (Books in soils, plants and the environment). Boron by Umesh C. Gupta. Pp 241-278).

Al-Mohmmad, H. and S. Al-Geddawi (2001). Effect of boron on heart rot and on yield of sugar beet. Arab J. Plant Protection, 19(1): 45-48.

Amin, Gehan, A.M. (2005). Study of some agricultural practices on sugar beet. M.Sc.Thesis, Fac. of Agric., Zagazig Univ.

Armin, M. and M. Asgharipour (2012). Effect of time and concentration of boron foliar application on yield and quality of sugar beet. American-Eurasian J. Agric. & Environ. Sci., 12 (4): 444-448.

Bonilla, C. Cadahia, O. Carpena and V. Hernando (1980). Effects of boron on nitrogen metabolism and sugar levels of sugar beet. Plant and Soil 57, 3-9.

Cooke, D. A. and R. K. Scott (1993). The Sugar Beet Crop. Chapman and Hall London. 1993:262-265.

El-Bakary, H. M. Y. (2006). Studies on yield and quality parameters of some sugar beet varieties. M. Sc. Thesis, Fac. of Agric., Al-Azhar Univ.

El-Hawary, M. A. (1994). Effect of boron and zinc fertilization on growth and yield of sugar beet plants grown under different soil salinity levels. Al-Azhar. J. Agric. Res., 20 (2): 25-35.

El-Hosary, A. A., M. I. Salwau, A. M. M. Saad, I. H. El-Geddawy and B. S. Ibrahim (2010). Sugar beet yield and its components as affected by sowing date, mineral-N and biofertilizers. Egypt. J. Appl. Sci., 25 (8 A): 349-366.

El-Sarag, E. I. and S. H. Moselhy (2013). Response of sugar beet quantity and quality to nitrogen and potassium fertilization under sandy soil conditions. Asian J. Crop Sci., 5(3): 295-303.

Enan, S.S.A.M. (2011). Effect of transplanting and foliage fertilization with potassium and boron on yield and quality traits of sugar beet sown under saline soil conditions. J. Biol. Chem. Environ.Sci., vol.6 (2): 525-546.

Freckleton, R. P., A. R. Watkinson, D. J. Webb and T. H. Thomas (1999). Yield of sugar beet in relation to weather and nutrients. Agric. Forest Meteorology, 93:39-51.

Gobarah, Mirvat E. and B. B. Mekki (2005). Influence of boron application on yield and juice quality of some sugar beet cultivars grown under saline soil conditions. J. Appl. Sci., Res., (5): 373-379.

Gobarah, Mirvat E., M. H. Mohamed and M. M. Tawufik (2010). Effect of sources and rates of nitrogenous fertilization on yield, quality and nitrogen utilization efficiency in sugar beet (*Beta vulgaris* L.). Egypt. J. Agron., 32 (2): 123-137.

Gobarah, Mirvat E., M. M. Tawfik, Sahar M. Zaghloul1 and Gehan A. Amin (2014). Effect of Combined Application of Different Micronutrients on Productivity and Quality of Sugar Beet Plants (Beta vulgaris L.). International Journal of Plant & Soil Science 3(6): 589-598.

Hellal, F. A., Taalab, A. S. and Safaa, A. M. (2009). Influence of nitrogen and boron nutrition on nutrient balance and Sugar beet yield grown in calcareous Soil. Ozean Journal of Applied Sciences 2 (1): 1-10.

Hozayn, M., M. M. Tawfik, H. M. Abd El-Ghany, and A. M. Korayem (2013). Effect of Plant Density on Yield and Sugar Quality Characteristics of Sugar Beet. Journal of Applied Sciences Research, 9(1): 1004-1009.

Ismail. A. M. A. and S. M. Allam (2007). Yield and technological traits of sugar beet as affected by plant densities P and K fertilization. The 3rd conf. Sustain. Agric. Develop. Fac. Agric., Fayoum Univ. ,12-14 Nov.

Jaszczolt, E. (1998). Influence of two methods of fertilizing sugar beet with trace elements on the yields of roots and sugar.106:232-234.

Javaheripour, M. A., N. Rashidi and A. Baghizade (2005). Manure, potassium and boron impacts on quantitative and qualitative yield of sugar beet in Bardsi. Sugar Beet, 21(1): 23-56.

Khalil, S. R. A. (2010). Study of performance and behavior of some sugar beet varieties under different environmental conditions. Ph. D. Sc. Thesis, Fac. of Agric., Fayoum Univ.

Kristek, A., Biserka Stojić and Suzana Kristek (2006). Effect of the foliar boron fertilization on sugar beet root yield and quality. Poljopriverda. 12(1): 22-26.

Le Docte, A. (1927). Commercial determination of sugar beet root using the Sacks Le-Docte Process. Int. Sugar J. 29: 488-492.

Masri. M. I. (2008). Effect of nitrogen level and planting density on sugar beet yield and its attributes. Egypt. J. Aaron. 30 (2): 119-136.

Nafei, A. I., A. M. H. Osman and Maha M. El.Zeny (2010). Effect of plant densities and potassium fertilization rates on yield and quality of sugar beet crop in sandy reclaimed soil s.J.of plant production ,Mansoura Univ.,1(2):299-237.

Nassar, A. M. (2001). Effect of plant density on the productivity of some sugar beet varieties. J. Agric. Sci. Mansoura Univ 26 (12): 7533-7546.

Omar, A. E. A. and H. Y. Mohamed (2013). Effect of nitrogen and bio fertilization on yield and quality of sugar beet under drip irrigation in newly reclaimed sandy soils. Zagazig J. Agric. Res., 40 (4): 661-674.

Osman, A. M. H., G. S. El-Sayed, M. S. H. Osman and K. S. El-Sogheir (2003). Soil application of some micro-elements with relation to yield and quality of sugar beet varieties (Beta vulgaris L.). Annals Agric. Sci., Moshtohor, 41 (3): 1135-1152.

Osman, A. M. H. (2011). Influence of foliar spray of some micronutrients and nitrogen fertilizer on productivity of sugar beet under newly reclaimed soils. J. Plant Production, Mansoura Univ., 2(9): 1113-1122.

Ouda, Sohier M. M. (2007). Effect of chemical and bio-fertilizer of nitrogen and boron on yield and quality of sugar beet. Zagazig Journal of Agricultural Research. 34 (1), 1-11.

Pergl, F. (1945). Quantitative Organic Micro Analysis 4th Ed. J. and Churchill LTD., London.

Pospišil, M., A. Pospišil and S. Sito (2005). Foliar application of liquid fertilizer Fertina B to sugar beet. Listy Cukrovarnické a Reparské,121:(5/6), 174-177.

Ramazan, C. (2002). Root yield and quality of sugar beet in relation to sowing date, plant population and harvesting date interactions. Turk. J. Agric., 26: 133-139.

Sarhan, H. M.; M. A. E. Abdou and H. M. Al-Sayed (2012). Effect of planting systems, plant density and nitrogen fertilizer levels on productivity and quality of sugar beet. J. Plant Production, Mansoura Univ., 3(10): 2567-2580.

Seadh, S. E. (2008). Some factors affecting sugar beet productivity under newly reclaimed sandy saline soils. Proc. of the International Conf. IS – 2008 "Meeting the Challenges of Sugar Crop & Integrated Industries in Developing Countries", IAPSIT, Al Arish, Egypt, pp 110-115.

Snedecor, G.W. and W. G. Cochran (1981). Statistical methods 7th Ed Iowa State Univ. Press, Ames, Iowa, USA.

Tariq, M., J. K. Khattak and G. Sarwar (1993). Effect of boron on the yield and quality of sugar beet in Peshawar valley. Kohat University of Science & Technology, Khyber, 6: 97-106.

Waller, R. A. and D. B. Duncan (1969). A bays rule for symmetric multiple comparison problem. Amer. Stat. Assoc. J. 1485-1503.

تأثير المسافة بين الجور ومستويات التسميد بالنيتروجين والبورون علي مؤشرات المحصول والجودة في بنجر السكر

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الملخص العربى

أقيمت تجربتان حقليتان في محطة سخا للبحوث الزراعية بمحافظة كفر الشيخ (٣١ شمالا و٣٠ شرقا و٦ م فوق سطح البحر) خلال موسمي ٢٠١٣/٢٠١٢ ، ٢٠١٤/٢٠١٣ لدراسة تأثير المسافة بين الجور والتسميد بكل من النيتروجين والبورون علي محصول وجودة بنجر السكر.

اشتملت الدراسة علي ٢٧ معاملة هي عبارة عن التوافيق بين ثلاث مسافات بين الجور (١٥ ، ٢٠ ، ٢٥ سم) وثلاث مستويات للسماد النيتروجيني (٨٠ ، ١٠٠ ، ١٢٠ كجم ن/ف) وثلاث معاملات للرش بالبورون (الرش بماء الصنبور ، ١٠٥ ، ٢١٠ جزء في المليون) وذلك في تصميم قطع منشقة مرة واحدة وثلاث مكررات حيث وضعت المسافات بين الجور في القطع الرئيسية بينما وزع التوافق بين مستويات النيتروجين والبورون في القطع الشقية.

ويمكن إيجاز أهم النتائج فيما يلى :

١. أوضحت النتائج أن كل من قطر الجذر والوزن الغض للجذر/نبات والنسبة المئوية لكل من النيتروجين والبوتاسيوم في الجذور ومحصولي الجذر والعرش قد إزداد معنويا بزيادة مسافة الزراعة من ١٥ إلي ٢٥ سم بين الجور. وتحققت أعلي قيم معنوية للنسبة المئوية للسكروز ومحصول السكر بالزراعة علي مسافة ٢٠ سم بين الجور، بينما زادت معنويا النسبة المئوية للنقاوة بالزراعة علي مسافة ١٥ سم بين الجور في كلا الموسمين.

٢. أدت زيادة مستوي التسميد النيتروجيني حتي ١٢٠ كجم ن/ف إلي زيادة معنوية في كل من الطول والقطر والوزن الغض للجذر/نبات والنسب المئوية للبوتاسيوم والصوديوم في الجذور وكذلك محصولي الجذر والعرش في الموسمين، بينما سجلت النسبة المئوية للسكروز أعلي القيم مع التسميد النيتروجيني بمستوي ١٠٠ كجم ن/ف، في حين سجل محصول السكر أعلي القيم مع معدل ١٢٠ كجم ن/ف.

٣. ازداد الطول والقطر والوزن الغض للجذر/نبات والنسب المئوية للسكروز والنقاوة ومحصول الجذر والعرش والسكر ونسبة البورون في الجذور معنويا وذلك بزيادة مستوي الرش بالبورون إلي ٢١٠ جزء في المليون.

٤. أدي التوافق بين مسافة الزراعة ٢٥ سم بين الجور والتسميد النيتروجيني بمعدل ١٢٠ كجم ن/ف إلي تحقيق اعلي القيم في قطر الجذر ومحصولي الجذر والعرش وأقل قيمة للنسبة المئوية للنقاوة. بينما أعطى التوافق بين ٢٠ سم بين الجور و ١٢٠ كجم ن/فدان أعلى قيمة لمحصول السكر وذلك في كلا الموسمين.

٥. أدي التوافق بين التسميد النيتروجيني بمستوي ١٠٠ كجم ن/ف والرش بالبورون بمعدل ٢١٠ جزء في المليون إلي زيادة معنوية في النسبة المئوية للسكروز في كلا الموسمين.

٦. أدي التفاعل من الدرجة الثانية بين الزراعة فى جور على مسافة ٢٥ سم والتسميد النيتروجيني بمعدل ١٢٠ كجم ن/ف والرش بالبورون بمعدل ٢١٠ جزء في المليون الي زيادة معنوية في محصول العرش في الموسم الأول ومحصول الجذر في الموسم الثاني، كما سجل محصول السكر اعلي قيم بالزراعة على مسافة ٢٠ سم بين الجور والتسميد النيتروجيني بمعدل ١٢٠ كجم ن/ف والرش بالبورون بمعدل ٢١٠ جزء في المليون وكانت هذه الزيادة معنوية في الموسم الثاني فقط.

Table (2): Root length and diameter as affected by hill spacings, nitrogen and boron fertilization levels and their interactions (2012/2013 and 2013/2014 seasons).

Treatments		Root length (cm)								Root diameter (cm)							
		1st Season (2012/2013)				2nd Season (2013/2014)				1st Season (2012/2013)				2nd Season (2013/2014)			
		Boron ppm								Boron ppm							
Hill spacing	Nitrogen (kg N/fed)	control	105	210	Mean	control	105	210	Mean	control	105	210	Mean	control	105	210	Mean
15 cm	80	23.51	24.79	25.18	24.49	23.33	24.11	26.08	24.51	8.07	9.17	9.93	9.06	8.64	9.17	10.00	9.27
	100	26.85	29.46	29.12	28.48	26.11	27.22	29.30	27.54	9.20	10.50	11.40	10.37	10.48	11.06	11.70	11.08
	120	30.61	31.44	32.50	31.52	28.05	30.50	32.69	30.41	11.17	11.97	12.20	11.78	11.20	12.43	11.82	11.82
Mean		26.99	28.56	28.93	28.16	25.83	27.28	29.35	27.49	9.48	10.54	11.18	10.40	10.11	10.89	11.17	10.72
20 cm	80	19.78	21.89	23.11	21.59	19.00	21.67	23.80	21.49	9.27	10.10	10.04	9.80	8.96	10.33	10.93	10.07
	100	22.50	24.83	25.89	24.41	24.33	24.78	27.19	25.43	9.98	11.17	11.84	11.00	10.49	11.11	11.93	11.18
	120	24.43	26.88	28.32	26.54	26.94	30.08	29.22	28.75	11.30	11.94	11.66	11.63	12.03	12.73	13.90	12.89
Mean		22.24	24.53	25.77	24.18	23.43	25.51	26.74	25.22	10.18	11.07	11.18	10.81	10.49	11.39	12.26	11.38
25 cm	80	15.74	19.19	18.02	17.65	17.02	17.97	18.91	17.97	10.50	11.20	11.90	11.20	11.23	12.10	13.10	12.14
	100	18.69	20.97	22.13	20.60	21.49	22.49	23.93	22.64	12.17	12.60	12.30	12.36	12.33	13.90	13.06	13.10
	120	20.84	23.79	25.84	23.49	23.44	26.32	28.29	26.02	13.30	13.83	14.28	13.80	14.07	14.73	15.33	14.71
Mean		18.43	21.31	22.00	20.58	20.65	22.26	23.71	22.21	11.99	12.54	12.83	12.45	12.54	13.58	13.83	13.32
Nitrogen x Boron	80	19.68	21.95	22.10	21.25	19.79	21.25	22.93	21.32	9.28	10.16	10.63	10.02	9.61	10.53	11.34	10.50
	100	22.68	25.09	25.71	24.49	23.98	24.83	26.81	25.21	10.45	11.42	11.85	11.24	11.10	12.02	12.23	11.78
	120	25.30	27.37	28.89	27.18	26.15	28.97	30.06	28.39	11.92	12.58	12.71	12.41	12.43	13.30	13.69	13.14
Mean		22.55	24.80	25.57		23.30	25.02	26.60		10.55	11.39	11.73		11.05	11.95	12.42	
Control: water tap, fed = 0.42 ha^{-1}																	
LSD at 0.05 level for:																	
Hill spacing (A)					0.864				2.766				0.636				0.433
Nitrogen level (B)					0.551				0.574				0.247				0.300
Boron level (C)					0.551				0.574				0.247				0.300
A x B					0.955				0.994				0.428				0.519
A x C					NS				NS				0.428				NS
B x C					NS				NS				NS				NS
A x B x C					NS				NS				NS				NS

Table (4): Nitrogen and boron concentrations in root as affected by hill spacings, nitrogen and boron fertilization levels and their interactions (2012/2013 and 2013/2014 seasons).

Treatments		Nitrogen in root %								Boron in root (ppm)							
		1st Season (2012/2013)				2nd Season (2013/2014)				1st Season (2012/2013)				2nd Season (2013/2014)			
Hill spacing	Nitrogen (kg N/fed)	Boron ppm								Boron ppm							
		control	105	210	Mean	control	105	210	Mean	control	105	210	Mean	control	105	210	Mean
15 cm	80	1.73	1.60	1.43	1.59	0.93	0.97	0.83	0.91	39.00	40.00	39.00	39.33	36.00	37.33	38.33	37.22
	100	1.83	1.87	1.60	1.77	1.70	1.67	1.63	1.67	31.50	31.00	33.00	31.83	41.00	39.67	41.83	40.83
	120	2.30	1.53	2.00	1.94	1.33	1.17	1.27	1.26	25.83	25.50	33.50	28.28	33.17	34.50	35.33	34.33
Mean		1.96	1.67	1.68	1.77	1.32	1.27	1.24	1.28	32.11	32.17	35.17	33.15	36.72	37.17	38.50	37.46
20 cm	80	1.83	1.67	1.47	1.66	1.53	1.27	1.43	1.41	34.00	38.33	38.33	36.89	35.67	37.50	42.00	38.39
	100	2.63	2.30	2.11	2.35	1.97	1.60	1.80	1.79	38.00	41.50	44.50	41.33	35.83	39.00	37.00	37.28
	120	2.17	2.23	1.80	2.07	2.20	1.93	1.93	2.02	14.50	25.50	28.50	22.83	29.33	32.33	33.67	31.78
Mean		2.21	2.07	1.79	2.02	1.90	1.60	1.72	1.74	28.83	35.11	37.11	33.69	33.61	36.28	37.56	35.81
25 cm	80	2.10	2.13	2.04	2.09	2.13	2.13	1.97	2.08	35.50	37.50	41.50	38.17	41.50	44.67	43.83	43.33
	100	2.60	2.53	2.54	2.56	1.95	2.07	2.07	2.03	28.50	34.50	34.17	32.39	32.50	37.67	38.33	36.17
	120	2.30	2.30	2.70	2.43	2.33	2.33	2.23	2.30	15.00	20.50	23.50	19.67	18.00	23.67	28.67	23.44
Mean		2.33	2.32	2.43	2.36	2.14	2.18	2.09	2.14	26.33	30.83	33.06	30.07	30.67	35.33	36.94	34.31
Nitrogen x Boron	80	1.89	1.80	1.65	1.78	1.53	1.46	1.41	1.47	36.17	38.61	39.61	38.13	37.72	39.83	41.39	39.65
	100	2.36	2.23	2.08	2.22	1.87	1.78	1.83	1.83	32.67	35.67	37.22	35.19	36.44	38.78	39.06	38.09
	120	2.26	2.02	2.17	2.15	1.96	1.81	1.81	1.86	18.44	23.83	28.50	23.59	26.83	30.17	32.56	29.85
Mean		2.17	2.02	1.97		1.79	1.68	1.69		29.09	32.70	35.11		33.67	36.26	37.67	

Control: water tap, fed = 0.42 ha^{-1}.

LSD at 0.05 level for:

Hill spacing (A)	0.388	0.331	NS	NS
Nitrogen level (B)	0.149	0.139	4.555	2.582
Boron level (C)	0.149	NS	4.555	2.582
A x B	NS	0.241	NS	4.472
A x C	0.259	NS	NS	NS
B x C	NS	NS	NS	NS
A x B x C	NS	NS	NS	NS

Table (5): Potassium and sodium concentrations in root as affected by hill spacings, nitrogen and boron fertilization levels and their interactions (2012/2013 and 2013/2014 seasons).

Treatments		Potassium in root %								Sodium in root %							
		1st Season (2012/2013)				2nd Season (2013/2014)				1st Season (2012/2013)				2nd Season (2013/2014)			
Hill spacing	Nitrogen (kg N/fed)	Boron (ppm)								Boron (ppm)							
		control	105	210	Mean	control	105	210	Mean	control	105	210	Mean	control	105	210	Mean
15 cm	80	5.43	5.40	5.37	5.40	4.27	4.60	4.47	4.44	3.14	3.01	2.85	3.00	1.85	2.08	1.90	1.94
	100	5.14	5.12	5.16	5.14	4.99	4.90	4.81	4.90	2.90	2.97	2.87	2.91	1.99	1.87	1.58	1.82
	120	5.49	5.23	5.28	5.33	5.12	5.14	5.26	5.17	2.98	2.95	2.78	2.90	1.80	1.98	2.23	2.00
Mean		5.35	5.25	5.27	5.29	4.79	4.88	4.85	4.84	3.01	2.98	2.83	2.94	1.88	1.98	1.90	1.92
20 cm	80	4.44	4.30	4.04	4.26	4.10	4.06	4.04	4.07	2.47	2.17	2.39	2.34	2.17	2.12	1.92	2.07
	100	4.57	4.51	4.48	4.52	3.95	3.92	3.87	3.91	2.63	2.61	2.68	2.64	2.00	1.97	1.91	1.96
	120	4.42	4.37	4.35	4.38	4.24	4.19	4.31	4.24	2.59	2.43	2.52	2.51	1.94	2.37	2.37	2.23
Mean		4.48	4.39	4.29	4.39	4.09	4.06	4.07	4.07	2.56	2.40	2.53	2.50	2.04	2.15	2.07	2.09
25 cm	80	5.99	5.84	5.92	5.92	5.05	5.01	4.92	4.99	2.93	2.90	2.78	2.87	1.63	2.05	2.10	1.93
	100	6.15	6.07	6.08	6.10	4.98	4.87	4.83	4.89	2.94	3.00	2.99	2.98	2.35	2.17	1.93	2.15
	120	6.70	6.26	6.52	6.49	5.70	5.17	5.13	5.33	4.00	3.34	3.59	3.64	2.70	2.74	2.38	2.61
Mean		6.28	6.06	6.17	6.17	5.24	5.02	4.96	5.07	3.29	3.08	3.12	3.16	2.23	2.32	2.14	2.23
Nitrogen x Boron	80	5.29	5.18	5.11	5.19	4.47	4.56	4.48	4.50	2.85	2.69	2.67	2.74	1.88	2.08	1.97	1.98
	100	5.29	5.23	5.24	5.25	4.64	4.56	4.50	4.57	2.82	2.86	2.85	2.84	2.11	2.00	1.81	1.98
	120	5.54	5.28	5.38	5.40	5.02	4.83	4.90	4.92	3.19	2.91	2.96	3.02	2.15	2.37	2.33	2.28
Mean		5.37	5.23	5.25		4.71	4.65	4.63		2.95	2.82	2.83		2.05	2.15	2.04	

Control: water tap, fed = 0.42 ha^{-1}

LSD at 0.05 level for:

Hill spacing (A)	0.361	0.157	0.190	NS
Nitrogen level (B)	0.081	0.102	0.113	0.150
Boron level (C)	0.081	NS	0.113	NS
A x B	0.141	0.177	0.195	0.260
A x C	NS	NS	NS	NS
B x C	NS	NS	NS	NS
A x B x C	NS	NS	NS	NS

Table (6): Sucrose and purity percentages as affected by hill spaces, nitrogen and boron fertilization levels and their interactions (2012/2013 and 2013/2014 seasons).

Treatments		Sucrose percentage								Purity percentage							
		1st Season (2012/2013)				2nd Season (2013/2014)				1st Season (2012/2013)				2nd Season (2013/2014)			
Hill spacing	Nitrogen (kgN/fed)	Boron ppm								Boron ppm							
		control	105	210	Mean	control	105	210	Mean	control	105	210	Mean	control	105	210	Mean
15 cm	80	17.86	19.74	20.62	19.41	19.03	20.29	21.07	20.13	88.20	89.43	88.87	88.83	90.18	90.80	91.06	90.68
	100	19.99	20.73	21.91	20.88	20.76	21.29	22.11	21.39	87.07	88.40	88.93	88.13	88.77	90.46	91.89	90.37
	120	19.30	20.07	20.65	20.01	20.02	20.60	21.35	20.66	84.43	83.87	85.30	84.53	84.78	85.58	87.67	86.01
Mean		19.05	20.18	21.06	20.10	19.94	20.73	21.51	20.72	86.57	87.23	87.70	87.17	87.91	88.95	90.21	89.02
20 cm	80	19.64	21.27	22.07	20.99	21.18	21.94	22.38	21.83	87.60	86.97	88.30	87.62	86.93	87.86	87.68	87.49
	100	21.67	22.33	22.94	22.31	21.87	22.63	23.51	22.67	85.50	87.10	87.67	86.76	85.70	86.74	88.33	86.92
	120	20.08	20.75	21.47	20.77	21.05	21.97	22.48	21.83	82.83	83.13	84.57	83.51	83.93	84.58	85.51	84.68
Mean		20.46	21.45	22.16	21.36	21.37	22.18	22.79	22.11	85.31	85.73	86.84	85.96	85.52	86.39	87.17	86.36
25 cm	80	16.93	19.40	19.99	18.77	17.38	19.13	20.80	19.10	84.37	84.50	85.23	84.70	81.71	82.79	83.81	82.77
	100	17.55	18.32	18.88	18.25	18.54	18.70	19.21	18.82	81.73	84.57	83.87	83.39	82.05	82.79	83.60	82.81
	120	16.86	17.64	18.13	17.54	17.75	18.22	18.12	18.03	79.83	80.30	81.20	80.44	76.46	78.00	78.81	77.75
Mean		17.11	18.45	19.00	18.19	17.89	18.68	19.38	18.65	81.98	83.12	83.43	82.84	80.07	81.19	82.07	81.11
Nitrogen x Boron	80	18.14	20.14	20.89	19.72	19.20	20.45	21.42	20.36	86.72	86.97	87.47	87.05	86.27	87.15	87.51	86.98
	100	19.74	20.46	21.25	20.48	20.39	20.87	21.61	20.96	84.77	86.69	86.82	86.09	85.51	86.66	87.94	86.70
	120	18.74	19.49	20.08	19.44	19.61	20.26	20.65	20.17	82.37	82.43	83.69	82.83	81.72	82.72	84.00	82.81
Mean		18.87	20.03	20.74		19.73	20.53	21.23		84.62	85.36	85.99		84.50	85.51	86.48	

Control: water tap, fed = 0.42 ha^{-1}

LSD at 0.05 level for:

	Sucrose 1st Season	Sucrose 2nd Season	Purity 1st Season	Purity 2nd Season
Hill spacing (A)	0.623	0.635	0.907	1.324
Nitrogen level (B)	0.429	0.335	0.448	0.783
Boron level (C)	0.429	0.335	0.448	0.783
A x B	0.743	0.580	NS	1.356
A x C	NS	NS	NS	NS
B x C	0.743	0.580	0.776	NS
A x B x C	NS	NS	NS	NS