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RESEARCH ARTICLE

Effect of nitrogen and boron fertilization on the productivity and quality of sugar beet

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Abstract

The agricultural policy in Egypt supports sugar beet farmers to increase the cultivated area and thus increase sugar production and reduce the gap between sugar production and consumption. Therefore, the sugar beet crop occupies an important place in the Egyptian crop cycle as a winter crop not only in fertile soils, but also in poor, saline, alkaline and calcareous soils. A field experiment was conducted at Shandaweel Agricultural Research Station, Sohag governorate, Egypt (latitude of 24.54o N and longitude of 32.94o E) during 2019/2020 and 2020/2021 successive winter growing seasons. The objective of this investigation was to find out the optimal levels of nitrogen and boron to get the maximum productivity and quality of sugar beet. Randomized Complete Block Design (RCBD) using a split-plot arrangement with three replications was used in both growing seasons. Three levels of nitrogen (60, 80 and 100 kg N/fed.) were allocated in the main plots and four boron concentrations (0, 80, 160 and 240 ppm/fed.) were sprayed twice on the beet foliage, grown in the sub-plots at 70 and 100 days after sowing. The results revealed that boron and nitrogen levels had a significant effect on vegetative traits, i.e., chlorophyll a and b, root length and diameter, quality characteristics (sucrose%, Na, K, α-amino N, quality index%) and productivity parameters of sugar beet (root and sugar yields/fed) in the two growing seasons. The highest root diameter and root yield, recoverable sugar yield was produced by applying 80 or 100 kg N/fed. with 240 ppm boron, in both growing seasons. Application of 80 kg N /fed. with 240 ppm of boron gave the highest values of sugar lost to molasses %. On the contrary, Na, K and α-amino N were decreased. Supplying sugar beet with 80 kg N/fed. with foliar application of 240 ppm boron is recommended under conditions of the present works in Sohag governorate to obtain the highest recoverable sugar yield, sucrose and quality index of sugar beet.

Keywords: *Beta vulgaris;* Boron; Nitrogen fertilizer; Quality index; Sugar yield**.**

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Introduction

Sugar beet (*Beta vulgaris.* saccharifera, L.) is a plant that is mostly grown in the world as raw materials for sugar processing (Varga et al. 2022). Sugar is considered a strategic commodity, and it is considered an inexpensive source of energy. Nowadays, sugar beet became the first sugar crop preceding sugarcane in sugar production in Egypt. Sugar produced from sugar beet reached 1.836 million tons, representing 67.7% of total sugar production in Egypt, while the amount of sugar gained from sugarcane was 0.876 million tons, constituting 32.3% (Sugar Crops Council, annual report 2021). The Egyptian Government's strategy aims to fulfill sugar needs depending on increasing sugar production from sugar beet throw expanding its area, where it can be grown in variable soil and climatic conditions, in addition to its low water requirements as a winter crop (Abou-Elwafa et al. 2020) compared with sugarcane. Therefore, it was necessary to study the fertilization requirements of sugar beet under Sohag governorate environmental conditions.

Sugar beet quality involves two concepts, the percent of sucrose and the level of impurities in roots, both of which affect the extraction of sucrose. The low quality of sugar beet roots is one of the problems that face expanding its growing area (Ferweez et al. 2011). Nitrogen is an essential structural element for plant growth, while its excessive application may degrade root quality and its storage ability, while root yield can be improved by adjusting nitrogen fertilization levels (FAO and IFA 2000). Growth, physiological and chemical aspects of the yield and quality of sugar beet are significantly influenced by nitrogen fertilizer.

As a result, nitrogen fertilization should be managed to provide greater portions of roots with high levels of purity and sucrose concentration (Mekdad 2015). In this respect, Nawar and Saleh (2003) found that applying more nitrogen as a soil fertilizer improved root length, diameter, and weight as well as root, top and sugar yields. Moreover, impurities in terms of potassium, sodium and α-amino nitrogen, as well as sugar lost to molasses, were significantly increased by increasing nitrogen levels (Ramadan et al. 2003). Controlling the physiological and biochemical activities of plants requires proper mineral feeding. If they are lacking, these processes may shift, which would disrupt plant growth and decrease crop yield.

Boron is regarded as a crucial nutrient, especially for sugar beet, where it plays a key part in sucrose transport from leaves to roots, in addition to other biological functions such as respiration, cell division and water relations. Boron primarily affects the growth and strength of cell walls, as well as the stimulation or inhibition of metabolic processes (Nemeat Alla et al. 2021).

In this connection, spraying boron had a positive effect on root diameter, root, top and sugar yields/fed. and sucrose% (Enan 2011; Nemeat Alla 2017) and give the highest values of sucrose, extractable sugar, sugar yield, root yield and quality index (Abbas et al. 2014; Mekdad 2015; Shritinnahar et al. 2020). Otherwise, impurities contents (K, Na, α-amino N) and sugar lost to molasses% decreased (Mekdad 2015; Nemeat Alla 2017).

The objective of this work was to investigate the optimal level of nitrogen and boron fertilization needed to obtain the highest root yield and quality of sugar beet under conditions of Sohag governorate.

Materials and methods

A field experiment was conducted at Shandaweel Agricultural Research Station, Sohag governorate, Egypt, (latitude of 24.54o N and longitude of 32.94o E) in 2019/2020 and 2020/2021 growing seasons.

The studied treatments were layout in Randomized Complete Blocks Design (RCBD) was used in a split-plot arrangement with three replications to lay out twelve treatments, representing the combinations among three nitrogen fertilizer levels (60, 80 and 100 kg N/fed.) and four rates of boron (0, 80, 160 and 240 ppm). Nitrogen levels were added as a side dressing of Urea (46% N) for beets in the main plots, in two equal doses at age of 30 days (immediately after thinning) and 15 days later, while boron rates were sprayed as a boric acid on beet tops grown in the sub-plots after 70 and 100 days from sowing. Overall application of 30 kg of P2O5, in the form of calcium super-phosphate (15% P2O5) was applied at land preparation, while 24 kg K2O/fed. as potassium sulfate (48% K2O) was added with the two N-doses.

Sugar beet multi-germ variety viz "Lilly" was sown in both growing seasons. Sowing took place in the third week of October, while harvesting was done after 195 days from planting, in both growing seasons. The recommended agricultural practices for growing sugar beet were followed. Soil samples were collected at random from the experimental field at a depth of 30 cm from the soil surface before soil preparation to determine the chemical and physical soil properties (Table 1), mechanical analysis (Piper 1950), soil pH (Jackson 1967), total soluble salts (Richards 1954), total carbonates (Dexter et al. 1967) and Organic matter (Hesse and Hesse 1971) were determined.

Table 1. Soil physiochemical properties of the experimental sites in the 2019/2020 and 2020/2021growing seasons.

	Growing season	2019/2020	2020/2021
Mechanical analysis	Fine sand%	21%	37%
	Coarse sand%	1.46%	1.14%
	Silt%	42%	32%
	Clay%	35.54%	29.86%
Soil texture		Clay loam	Clay loam
Chemical analysis	Organic matter (%)	0.62	0.65
	Available N%	0.164	0.220
	$CaCO_3$%	1.40	1.50
	Soluble anions & cations (meq/100 g soil (1:5)		
	CO_3^-	----	----
	HCO_3^-	0.26	0.33
	Cl^-	0.79	0.90
	SO_4^{--}	1.00	1.15
	Ca^{++}	0.50	0.55
	Mg^{++}	0.24	0.34
	Na^+	1.17	1.33
	K^+	0.14	0.16
	Boron	0.48 ppm	0.47 ppm
	EC, dS/m (1:5)	0.21	0.24
	pH (1:2.5)	7.3	7.2

Studied traits

Growth traits

Leaf chlorophyll: A portable chlorophyll meter (SPAD - 502, Konica Minolta Sensing, Inc., Japan) was used to determine leaf chlorophyll contents (SPAD) on attached leaves after 120 days from planting (Minolta 1989).

At harvest, samples of roots were collected at random from the three middle rows of each plot to measure root length (cm) and diameter (cm).

Quality characteristics

At harvest, five plants were randomly taken from the guarded ridges of each plot to determine the following traits:

Sucrose percentage (Pol%) was determined using a Saccharometer, according to the procedure outlined by Le Docte (1927).

Impurities (K, Na, and α-amino N concentration) in root were estimated as meq/100 g beet as described by the sugar company using Auto Analyzer (Cooke and Scott, 1993).

Sugar loss into molasses (%): SLM%= 0.14 (Na + K) + 0.25 (α-amino N) + 0.5 (Cooke and Scott, 1993).

Extractable sugar (%): (ES %) =Sucrose % - SLM % - 0.6 (Cooke and Scott 1993).

Quality index (Qz%): Qz%= (extracted sugar % / sucrose %) x100 (Cooke and Scott 1993).

Root and sugar yield traits

Harvested plants from the three middle rows of each plot were separated into roots and tops, and weighed in kg, which was converted into tons to estimate the following:

Root yield (ton/fed.).

Recoverable sugar yield (RSY; ton/fed.) was calculated using the following equation:

RSY=Root yield x Extractable sugar%

Statistical analysis

The collected data were statistically analyzed according to the method of Gomez and Gomez (1984). Differences among treatments were evaluated using the least significant difference test (LSD) at 5% of probability.

Results and discussion

Effect of nitrogen fertilization

The results in Table 2 showed that raising nitrogen fertilization levels from 60 to 80 and 100 kg N/fed. resulted in a gradual and significant increase in sugar beet growth traits in terms of chlorophyll a and b as well as root length and diameter.

These findings were true for these three traits in both growing seasons, except for root diameter, in the first one. These results can be attributed to the vital role of N as an essential and structural element in building-up plant cells and enhancing plant growth. These results agree with those reported by Nawar and Saleh (2003) found that applying more nitrogen as a soil fertilizer improved root length and diameter.

Table 2. Effect of nitrogen fertilizer levels on growth characteristics of sugar beet in the 2019/2020 and 2020/2021 growing seasons.

Traits	Chlorophyll A & B		Root length (cm)		Root diameter (cm)	
Season	2019/2(	2020/21	2019/2(	2020/21	2019/2(	2020/21
			Nitrogen fertilizer			
60 kg/fed	51.12	52.02	27.42	28.50	8.91	8.83
80 kg/fed	56.17	53.37	28.58	30.67	9.10	9.14
100 kg/fed	57.28	58.17	29.17	32.42	8.88	9.38
$LSD_{0.05}$	3.83	1.25	0.69	0.85	NS	0.18

As for sugar beet quality characteristics, data in Table 3 indicated that sucrose, α-amino and sugar lost to molasses increased significantly accompanying the increase in nitrogen fertilization level from 60 up to 100 kg N/fed., in the first growing season. While, in the second growing season, the results showed that fertilization had an insignificant effect on increasing nitrogen.

Table 3. Effect of nitrogen fertilizer levels on quality characteristics of sugar beet in the 2019/20 and 2020/21 growing seasons.

Traits	Sucrose (%)		K (%)		Na (%)		α-amino-N (%)		SLM (%)		ES (%)		Qz (%)	
Growing season	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21
							Nitrogen Fertilizer							
60 kg/fed.	16.05	16.58	3.95	3.95	1.92	1.94	3.15	4.11	2.11	2.35	13.35	13.63	82.88	83.53
80 kg/fed.	16.69	16.66	4.31	4.28	1.73	1.62	4.35	3.77	2.43	2.27	13.65	13.80	83.42	84.04
100 kg/fed.	17.06	16.36	4.84	3.89	1.45	1.79	5.28	4.02	2.70	2.30	13.76	13.46	84.17	83.97
$LSD_{0.05}$	0.78	NS	NS	NS	NS	NS	0.13	NS	0.07	NS	NS	NS	NS	0.47

NS: non-significant

These results coincide with those mentioned by Nawar and Saleh (2003) found that impurities in terms of α-amino nitrogen, as and sugar lost to molasses, were significantly increased by increasing nitrogen levels. On the other hand, insignificant differences in root content of K, Na and extractable sugar (in both growing seasons), and quality index (in the first growing season) sucrose% (in the second growing season) were detected as affected by the applied N-fertilizer levels. Data in Table 4 reveal substantial increases in root yield by 3.34 and 4.00, and 1.84 and 2.90 ton/fed. as N-fertilization level was increased from 60 to 80 and 100 kg N/fed, in the first and second growing seasons, respectively. These results could be due to the positive role of nitrogen in increasing sugar beet root length and diameter (Table 2). These results coincide with those mentioned by Nawar and Saleh (2003), and Mekdad (2015). Likewise, an appreciable increase amounted to 0.55 and 0.67 ton of sugar/fed. were produced from beets fertilized with 80 and 100 kg N/fed, in comparison to those received 60 kg N/fed. only, in the first growing season, corresponding to 0.31 and 0.34 ton/fed., in the second one, successively (Table 4). These results might be referred to the increase in sucrose%, extractable sugar% (Table 3) and root yield/fed. (Table 4). These results are in line with those found by Nawar and Saleh (2003) and Mekdad (2015).

Table 4. Effect of nitrogen fertilizer levels on root and sugar yields in the 2019/20 and 2020/21 growing seasons.

Traits	Root yield (ton/fed)		RSY (ton/fed)	
Growing season	2019/20	2020/21	2019/20	2020/21
		Nitrogen Fertilizer		
60 kg/fed.	28.12	27.93	3.76	3.81
80 kg/fed.	31.46	29.77	4..31	4.12
100 kg/fed.	32.12	30.83	4.43	4.15
$LSD_{0.05}$	1.52	0.79	0.26	0.25

Effect of boron foliar nutrition

Results in Table 5 obtained that raising boron fertilization levels from 0 to 80, 160 and 240 ppm/fed. resulted in a gradual and significant increase in sugar beet growth traits in terms of chlorophyll a and b as well as root length and diameter. These findings were true for these three traits in both growing seasons. These results may be due to the role of boron in cell elongation and formation of new leaves, where it was found that beet plants suffering from boron deficiency had thick, stiff and smaller leaves (Nemeat Alla 2017). Moreover, boron has an active role in transportation of photo assimilates from the leaves to the roots. These results are in agreement with those reported by Abbas et al. (2014) and Shritinnahar et al. (2020) pointed out that the application of boron increased growth traits.

Table 5. Effect of boron concentration (ppm) on growth characteristics of sugar beet in the 2019/20 and 2020/21 growing seasons.

Traits	Chlorophyll A & B		Root length (cm)		Root Diameter (cm)	
Growing season	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21
			Boron Concentration (ppm)			
0	50.27	50.91	25.33	28.22	8.52	8.47
80	52.82	53.22	27.22	30.00	9.08	8.88
160	56.13	55.66	29.44	31.33	9.02	9.44
240	60.20	57.79	31.56	32.56	9.22	9.67
$LSD_{0.05}$	1.33	0.61	0.54	0.49	0.24	0.18

As for sugar beet quality characteristics, data in Table 6 indicated that sucrose, sugar lost to molasses, extracted sugar and quality index increased significantly accompanying the increase in boron fertilization level from 0, 80, and 160 up to 240 ppm/fed, in both growing seasons. While increasing boron fertilization decreased sodium% in both growing seasons and increased α-amino in the first growing season. These results may be due to that boron element is important to many vital metabolic processes especially those that are associated with photo assimilates transportation to the storage organ (Nemeat Alla 2017). These results coincide with those mentioned by Shritinnahar et al. (2020) pointed out that the application of 150 ppm of boron increased sucrose% and quality index. On the other hand, insignificant differences in root content of K % (in both growing seasons) and α-amino in the second growing season only were detected as affected by the applied boron fertilizer levels.

Table 6. Effect of boron concentration on quality characteristics of sugar beet in the 2019/20 and 2020/21 growing seasons.

Traits	Sucrose (%)		K (%)		Na (%)		α-amino-N (%)		SLM (%)		ES (%)		Qz (%)	
Growing season	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21
	Boron Concentration (ppm)													
0	15.67	16.24	4.40	3.97	2.08	2.08	3.61	4.26	2.31	2.41	12.75	13.23	81.38	82.71
80	16.21	16.46	4.15	4.16	1.75	1.88	4.20	4.11	2.38	2.38	13.23	13.48	83.28	83.34
160	16.99	16.54	4.43	4.02	1.57	1.60	4.46	3.81	2.46	2.24	13.94	13.70	83.98	84.42
240	17.53	16.90	4.47	3.97	1.41	1.57	4.75	3.69	2.51	2.20	14.42	14.10	85.32	84.91
$LSD_{0.05}$	0.43	0.56	NS	NS	0.33	0.41	0.12	NS	0.06	0.15	0.42	0.63	1.09	0.68

NS: non-significant

Results in Table 7 exhibited a substantial increase in root yield by 1.46, 2.69 and 3.58, and 1.06, 1.98 and 3.63 ton/fed. as boron fertilization level was raised from 0 to 80, 160 and 240 ppm/fed., in the first and second growing season, respectively. These results may be due to that boron promotes vital functions in sugar beet, such as maintaining the balance between sugar and starch and K+ transport, also, adding boron to sugar beet during the growth stage had a great effect on sucrose concentration and root yield (Kandil et al. 2020). These results coincide with those mentioned by Dewdar et al. 2015; Pirzad et al. (2019) and Shritinnahar et al. (2020) who pointed out that the application of boron increases root yield. Likewise, an appreciable increase in sugar yield of 0.34 and 0.20, 0.72 and 0.40, and 1.01 and 0.75 ton/fed. were obtained from beets fertilized with 80, 160 and 240 ppm/fed., in the first and second growing seasons, respectively, compared to the control treatment (Table 7). These results might be referred to as the increase in sucrose%, extractable sugar% (Table 3) and root yield (Table 4). These results are in with those found Nemeat Alla (2017) showed that spraying sugar beet with boron increased sugar yields.

Table 7. Effect of boron concentration on root and sugar yields in the 2019/20 and 2020/21 growing seasons.

Traits	Root yield (ton/fed)		RSY (ton/fed)	
Growing season	2019/20	2020/21	2019/20	2020/21
	Boron Concentration (ppm)			
0	28.64	27.84	3.65	3.69
80	30.10	28.90	3.99	3.89
160	31.33	29.82	4.37	4.09
240	32.22	31.47	4.66	4.44
$LSD_{0.05}$	0.34	0.31	0.14	0.20

The interaction effects

Data in Table 8 pointed to a significant influence of the interaction between the applied nitrogen and boron fertilizers on sugar beet growth traits in terms of chlorophyll A and B, root length and diameter, in both growing seasons. The results showed insignificant variance in chlorophyll A and B between 0 and 80 ppm of boron when beets were fertilized with 60 kg N/fed. (in the first growing season). However, the difference between these two levels of boron reached the level of significance by supplying beets with 80 and/or 100 kg N/fed.

In the second growing season, the variance in this trait was insignificant in the case of spraying boron at 160 and/or 240 ppm combined with 100 kg N/fed. However, the difference between these two levels of boron was significant with 60 and/or 80 kg N/fed. The results cleared that the difference between 0 and 240 ppm in their effect on root length (in the first growing season) was most distinguished (7.00 cm), when beets were given 100 kg N/fed., which was 6.00 cm and 5.66 cm with 80 and 60 kg N/fed., respectively.

Table 8. Effect of the interaction between nitrogen fertilizer and boron concentration on growth characteristics of sugar beet in the 2019/20 and 2020/21 growing seasons.

Treatments		Chlorophyll A & B		Root length (cm)		Root Diameter (cm)	
N levels	Boron Conc. (ppm)	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21
60 kg N/fed.	0	48.70	49.18	24.67	26.33	8.32	8.10
	80	49.77	51.80	26.33	27.66	9.17	8.57
	160	51.90	52.80	28.33	29.00	9.03	9.13
	240	54.13	54.30	30.33	31.00	9.10	9.50
80 kg N/fed.	0	51.02	49.23	25.67	28.00	8.63	8.57
	80	53.93	51.67	27.33	30.00	9.20	8.73
	160	58.90	54.33	29.67	31.66	9.20	9.50
	240	60.83	58.23	31.67	33.00	9.37	9.77
100 kg N/fed.	0	51.10	54.30	25.67	30.33	8.60	8.73
	80	54.77	57.70	28.00	32.33	8.87	9.33
	160	57.60	59.83	30.33	33.33	8.83	9.70
	240	65.63	60.83	32.67	33.66	9.20	9.74
$LSD_{0.05}$		2.30	1.05	0.93	0.84	0.42	0.14

As for sugar beet quality characteristics were significantly affected by the interaction between nitrogen and boron fertilizer in both growing seasons, except, K% and α-amino in the second growing season and Qz% in the first growing season. The results showed insignificant variances in quality characteristics between 160 and 240 ppm of boron when beets were fertilized with 60 or 80 kg N/fed. (in both growing seasons). The results cleared that the difference between 0 and 240 ppm in their effect on quality characteristics in both growing seasons was most distinguished. The highest values of quality characteristics were mostly produced at the highest N-level (100 kg N/fed. with 240 ppm of boron) in both growing seasons.

Table 9. Effect of the interaction between nitrogen fertilizer and boron concentration on quality characteristics of sugar beet in the 2019/20 and 2020/21 growing seasons.

Treatments		Sucrose (%)		K (%)		Na (%)		α-amino-N (%)		SLM (%)		ES (%)		Qz (%)	
N levels	Boron Conc. (ppm)	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21
60 kg N/fed.	0	15.43	16.12	3.90	3.91	2.11	2.34	2.00	4.45	1.84	2.49	12.99	13.02	81.17	82.03
	80	15.78	16.62	3.88	3.89	2.02	2.01	3.27	4.53	2.14	2.46	13.04	13.56	82.47	83.50
	160	16.52	16.57	4.18	4.05	1.77	1.60	3.55	3.71	2.22	2.22	13.70	13.74	83.60	84.43
	240	16.48	17.03	3.86	3.93	1.77	1.81	3.77	3.74	2.23	2.24	13.65	14.20	84.30	84.17
80 kg N/fed.	0	15.63	16.22	4.29	4.26	2.25	1.83	3.98	4.45	2.41	2.47	12.61	13.15	81.03	82.40
	80	16.37	16.35	3.91	4.29	1.64	1.80	4.26	3.43	2.34	2.21	13.42	13.54	84.20	83.70
	160	17.20	16.73	4.19	4.22	1.72	1.45	4.49	3.84	2.45	2.26	14.15	13.88	83.84	84.50
	240	17.56	17.35	4.86	4.35	1.33	1.38	4.66	3.35	2.55	2.14	14.43	14.61	84.60	85.57
100 kg N/fed.	0	15.94	16.39	5.03	3.72	1.89	2.07	4.85	3.86	2.68	2.28	12.66	13.51	81.93	83/70
	80	16.48	16.40	4.67	4.31	1.59	1.84	5.08	4.37	2.64	2.46	13.24	13.34	83.17	82.83
	160	17.27	16.32	4.94	3.81	1.21	1.74	5.35	3.86	2.70	2.24	13.97	13.47	84.50	84.33
	240	18.55	16.32	4.70	3.70	1.12	1.50	5.82	3.98	2.77	2.22	15.18	13.49	87.07	85.00
$LSD_{0.05}$		0.75	0.97	0.87	NS	0.57	0.54	0.21	NS	0.10	0.26	0.73	1.09	NS	0.81

NS: non-significant

Data in Table 10 pointed to a significant influence of the interaction between the applied nitrogen and boron fertilizers on sugar beet (root and sugar yield/fed.), in both growing seasons. The results showed insignificant variance in root yield between 80 and 160 ppm of boron when beets were fertilized with 60 kg N/fed. (in the first growing season). However, the difference between these two levels of boron reached the level of significance by supplying beets with 80 and/or 100 kg N/fed.

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The results showed insignificant variance in sugar yield/fed. between 80 and 160 ppm of boron when beets were fertilized with 60 kg N/fed. (in the second growing season). However, the difference between these two levels of boron reached the level of significance by supplying beets with 80 and/or 100 kg N/fed. The highest values of root and sugar yields were mostly produced from the highest N-level (100 kg N/fed. with 240 ppm of boron) in both growing seasons, which gave 33.69 and 32.62, and 5.11 and 4.40 ton/fed. from root and sugar yields in the first and second growing seasons, respectively.

Table 10. Effect of interaction between nitrogen fertilizer and boron concentration on root and sugar yield in the 2019/20 and 2020/21 growing seasons.

Treatments		Root yield (ton/fed)		RSY (ton/fed)	
N levels	Boron Conc. (ppm)	2019/20	2020/21	2019/20	2020/21
60 kg N/fed.	0	26.87	26.34	3.49	3.43
	80	28.00	27.33	3.65	3.71
	160	28.58	28.32	3.92	3.89
	240	29.10	29.72	3.97	4.22
80 kg N/fed.	0	29.24	28.04	3.69	3.69
	80	30.30	28.91	4.07	3.92
	160	32.43	30.05	4.59	4.17
	240	33.86	32.07	4.89	4.69
100 kg N/fed.	0	29.82	29.15	3.78	3.94
	80	31.99	30.47	4.24	4.06
	160	32.98	31.10	4.61	4.19
	240	33.69	32.62	5.11	4.40
$LSD_{0.05}$		0.59	0.54	0.25	0.35

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