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Effect of Various Boron Forms and Rates on Growth, Yield and Quality Traits of Sugar Beet (*Beta Vulgaris* L.)

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Abstract

Two field experiments were carried out at the Experimental Farm faculty of agriculture, New Valley University, New Valley Governorate, Egypt during the 2019/2020 and 2020/2021seasons, to study impact of various rates from normal and nano boron on growth, yield and quality of some sugar beet cultivars. Seven foliar applications of boron (borax) $Na_2B_4O_7.10\ H_2O$ (11% B) and nano boron oxide were sprayed on sugar beet after 60 and 90 days from sowing). for each boron form spraying (control, 100,200,300 ppm borax and 100,200,300 ppm nano boron oxide twice at 60 and 90 days from sowing). was arranged horizontally. as well as sugar beet cultivars (Gazelle, Kawemira and Hossam) were distributed in vertically. The obtained results revealed that boron foliar application at the rate of 300 ppm nano boron oxide fed^{-1}twice at 60 and 90 days from sowing. recorded the highest significant mean values of root length(cm), root diameter(cm), single root weight(kg/plant), leaves weight/plant (kg $plant^{-1}$), root yield (ton fed^{-1}), sucrose percentage, sugar recovery percentage and sugar yield (ton fed^{-1}) traits in the two growing seasons. Meantime, Hossam cultivar was superior to the others of all studied traits. All interaction effects showed significant differences for traits in the two growing seasons. Were obtained from Hossam cultivar with 300 ppm nano boron oxide fed^{-1} twice at 60 and 90 days from sowing.

Keywords: sugar beet, sugar cultivars, nano boron, sugar yield. sucrose percentage

Introduction

Expanding cultivation of sugar beet (*Beta vulgaris L*.) on the newly reclaimed lands should be hardly pushed to increase the sugar crop area, consequently increasing local production of sugar. Sugar beet is considered the second most crucial sugar crop in Egypt. Improvement in sugar beet production can be achieved by applying boron fertilizer. The world harvested 252,968,843 metric tons of sugar beets in 2020. The world's largest producer was Russia, with a 33,915,086 metric tons' harvest. The average yield of sugar beet crops worldwide was 58.2 tons per hectare. with a per capita consumption of about 23 kg. While in Egypt the per capita consumption is about 34 kg (**FAO, 2020**). In Egypt, sugar beet is the first source of sugar (about 70%) after sugar cane (about 30%) the cultivated area in the year (2021) was 610 thousand fed-1 with a root yield of 13.3 million tons (**CCSC, 2021**). Total sugar production in Egypt (from sugar cane and sugar beet) is about 3 million tons which provide 87% self-sufficiency (**CCSC, 2021**).

Boron is a micronutrient that is involved in numerous cell and structural functions, such as cell structure, biosynthesis and lignification, cell elongation, and membrane permeability y (**Lewis, 2019**). boron deficiency usually occurs during the vegetative stage of plants in soils that are poor in organic content and regions with low precipitation (**Kitir et al., 2019**). Therefore, it has to be externally supplied. However, as boron is a micronutrient with limited mobility throughout the plant (**Brown et al., 2002; Miwa and Fujiwara, 2010**), the foliar application of boron should have a local effect on the plant. sugar beet is a boron sensitive crop that needs more boron (**Cooke and Scott, 2012**). In the scarcity of boron, the normal growth and production of sugar beet are affected, and in severe cases, the growing point wilts, or even causes “heart rot” and fails to produce normal growth and development. Boron deficiency is regarded as one of the main constraints for the decline of sugar beet production in many countries (**Porcel et al., 2018**). Boron is beneficial for plant growth when soil available boron is 0.5-1 mg/kg, however, plant toxicity occurs when soil hot-water soluble B level exceeds 5 mg/kg (Liu, 2002), and excessive B content in plants is considered to be above 100 mg/kg (**Yanqun and Kehui, 2000**).

Nanomaterial (NM) has been defined as the material with any external dimension in nanoscale or the surface or internal structure in nanoscale dimensions, while a nanoparticle (NP) is a nano-entity, with all three external dimensions in nanoscale, as per the International Organization for Standardization (ISO) **Boverhof et al. (2015)**. The nanomaterials (NMs) are described as natural or artificial materials, comprising of particles, as aggregates/ agglomerates or occurring independently, where about 50% or more are in the number-size distribution, with the size ranging between 1 and 100 nm, as per the European Commission (2011).

So, the objective of this investigation was to study Effect of various boron forms and rates on growth, yield and quality traits of sugar beet (*Beta vulgaris* L.)

Materials and Methods

Experimental Site Description

Two field experiments were carried out at Experimental Farm faculty of agriculture, New Valley University, New Valley Governorate, Egypt during the 2019/2020 an2020/2021seasons, to study effect of various boron forms and rates on growth, yield and quality traits of sugar beet.

Table 1: Physical and chemical properties of the experimental soil in 2019/ 2020 and 2020/2021 season.

Mechanical Texture soil		
Clay %	1.5	2.0
Silts %	18	19
Sands %	80.5	81
Texture soil	sandy loam	sandy loam
Chemical analysis		
PH	8.6	8.7
EC (ds/m^{-1})	2.22	1.72
Soluble anions concentration (meq L^{-1})		
Co_3–	-	-
HCo_3–	1	1.1
Cl-	14.5	14.9
SO_4–	6.650	6.800
Soluble cations concentration (meq L^{-1})		
Ca++ (meg/l)	6.5	6.14
Mg++ (meg/l)	4.5	4.4
Na+ (meg/l)	10.40	10.50
Sp A (saturation percent)	29.00	30.00
K+ (meg/l)	0.75	0.80
Available N (ppm)	206	70
Available P (ppm)	7.68	1.87
Available K (ppm)	128	149
boron (mg B kg^{-1} soil)	0.58	0.44
Available Cu++ (ppm)	0.064	0.058
Available Fe++ (ppm)	0.75	0.80
Available Mg++ (ppm)	0.364	0.400
Available Zn++ (ppm)	0.144	0.139

Experimental treatments and design

The design of the experiment was randomized complete block design (RCBD) using a strip split plot arrangement with three replications. Boron foliar application (control (C_0), 100 (C_1), 200 (C_2), 300 (C_3) ppm of borax and 100 (C_4), 200 (C_5), 300 (C_6) ppm nano boron oxide twice in a row at 60 and 90 days from sowing). as well as three sugar beet cultivars (Gazelle, Kawemira and Hossam) were arranged in sub plot. The experimental unit area was 10.50 m^2 consisted of five rows, 60 cm width and 3.5 m length (1/400 fed^{-1}).

Cultural Practices

Sugar beet seeds were sown in hills 20 cm apart on 15 and 20 October in the 1st and 2nd seasons, respectively. Seedlings were thinned at the four-leaf stage to one plant per hill. Calcium super phosphate was added at the rate of 200 kg fed^{-1} (30kg P_2O_5) during soil preparation. Nitrogen was applied in the form of urea (46 % N) at the rate of 200 kg fed^{-1}. at two equal doses, the first half was applied after thinning and second half after one month later. There is no previous summer crop. All other recommended cultural practices for sugar beet crop were done according to the recommendations of the ministry of Agriculture.

Measured traits: The following traits were recorded at harvest.

A. Vegetative traits.

At harvest (210 days after planting) five guarded plants from each plot were taken to estimate root length (cm), root dimeter (cm), single root weight (kg plant^{-1}) and leaves weight/plant (kg plant^{-1}) traits were determined.

B. Roots yield (ton fed^{-1}).

Each experimental unit plants were harvested then roots were separated, weighted then transformed into roots yield (ton fed^{-1}).

C. Quality parameters:

A sample of 10 kg of roots were chosen at random from each plot to determined root quality in Sugar and Integrated Industries Company Laboratory at Abu Korkas Sugar Factory, in Minia governorate, Egypt. The following traits were determined:

Sucrose percentage: Juice sugar content of each treatment was determined by means of an Automatic Sugar Polarimetry according to **A.O.A.C. (2005).**

Sugar recovery percentage (RS%). determined according to the procedure of Abou-Korkas Sugar Company was determined by using the following formula **Reinfeld et al. (1974**). by the following equation=(Pol-0.29)-0.343(K^+&Na^+)-α-amino nitrogen (0.094). where Pol%= sucrose%, K, Na and α-amino nitrogen in milli-equivalent/100g in beet).

Sugar yield. (ton fed^{-1}): It was determined by multiplications of root yield (ton fed^{-1}) by sugar recovery percentage.

Statistical Analysis

All collected data were analyzed with analysis of variance (ANOVA) procedures using Co. stat computer program V 6.303(2004). Differentiate between means. were compared using the least significant differences L.S.D. at $_{0.05}$ level of probability. (**Gomez and Gomez, 1984**).

Results and Discussions

Yield Attributes Traits

The recorded data in Tables 2,3,4 and 5 reveal that there were significant differences in root length (cm), root diameter, single root weight and leaves weight/plant (kg $plant^{-1}$) traits of sugar beet among the studied boron application rates in both seasons. It could be denoted that the highest mean values of root length (40.07 and 39.67 cm), root diameter (12.67 and 13.48 cm), single root weight (1.522 and 1.448 kg) and leaves' fresh weight (0.708 and 1.227 kg $plant^{-1}$) in the first and second seasons, respectively). were obtained from the application at the rate 300 ppm nano boron oxide fed^{-1} at 60 and 90 days after sowing. compared with the others boron application rates. The primary role of boron in sugar transport, cell division, cell-wall synthesis, differentiation, root elongation, membrane functioning, regulation of hormone levels of plant and the generative growth of plants. (**El-Sherpiny,.2016**). Similar trend was observed by **Kandil et al., (2020).**

Also, the presented data in Tables 2,3,4 and 5 revealed that root length, root diameter and single root weight traits were significantly affected by the tested sugar beet cultivars in the two growing seasons. Hossam sugar beet cultivar produced the highest mean values of root length (36.57 and 35.33 cm), root diameter (10.45 and 11.35 cm), single root weight (1.290 and 1.134 kg) and leaves' fresh weight (0.580 and 1.037 kg $plant^{-1}$) in the first and second seasons, respectively. The differences between the sugar beet cultivars in root length (cm), root diameter (cm), single root weight and leaves weight/plant (kg $plant^{-1}$). could be due to the variation in the gene make-up and its response to the environmental conditions. These results are in conformity with those reported by **Erciyes et al., (2016), Mekdad and Rady (2016) and Mehanna et al. (2017).**

Furthermore, the all involved interactions in this respect had a significant influence on root length (cm), root diameter (cm), single root weight and leaves weight/plant (kg $plant^{-1}$) traits in the two growing seasons. Thus, the highest mean values of root length (40.16 and 40.00 cm), root diameter (12.67 and 13.82 cm), single root weight (1.588 and 1.647 kg) and leaves' fresh weight (0.719 and 1.250 kg) in the first and second season, respectively. Planting Hossam sugar beet cultivar which was sprayed by at the rate 300ppm nano boron oxide fed^{-1} at 60 and 90 days after sowing.

Table 2. Impact of bulk and nanoparticles boron and their interaction on three sugar beet cultivars root Length (cm) during 2019/2020 and2020/2021 seasons.

BORON	cultivars			Mean of Boron	Cultivars			Mean of Boron
	Gazelle	Kawemira	Hossam		Gazelle	Kawemira	Hossam	
C_0	30.15	31.40	32.08	31.21	29.67	30.33	31.00	30.33
C_1	32.99	33.91	34.16	33.69	31.33	32.00	32.33	31.89
C_2	34.22	35.15	35.35	34.91	33.00	34.00	34.00	33.67
C_3	36.37	36.76	36.97	36.70	34.00	35.00	35.00	34.67
C_4	37.16	37.54	37.81	37.50	35.33	36.00	37.00	36.11
C_5	38.22	39.17	39.45	38.95	37.33	38.00	38.00	37.78
C_6	39.90	40.15	40.16	40.07	39.00	40.00	40.00	39.67
Means of cultivars	35.57	36.3	36.57	--	34.24	35.05	35.33	--
F test &L.S.D.at $_{0.05}$	F.TEST		L.S.D.at $_{0.05}$		F.TEST		L.S.D.at $_{0.05}$	
Cultivars	**		0.083		**		0.108	
Boron	**		0.154		**		0.346	
Interaction	**		0.113		**		0.339	

Table 3: Impact of bulk and nanoparticles boron and their interaction on three sugar beet cultivars root diameter(cm) during 2019/2020 and 2020/2021 seasons.

BORON	cultivars			Mean of Boron	cultivars			Mean of Boron
	Gazelle	Kawemira	Hossam		Gazelle	Kawemira	Hossam	
C_0	8.16	8.55	8.90	8.54	8.80	9.36	9.71	9.29
C_1	9.16	9.35	9.50	9.34	10.07	10.17	10.37	10.20
C_2	10.00	10.14	10.32	10.16	10.98	11.15	11.20	11.11
C_3	10.56	10.68	10.78	10.67	11.35	11.63	12.15	11.71
C_4	10.94	11.37	11.73	11.35	12.27	12.44	12.66	12.46
C_5	11.83	11.90	12.10	11.94	12.83	13.11	13.15	13.03
C_6	12.48	12.71	12.81	12.67	13.16	13.45	13.82	13.48
Means of cultivars	10.45	10.67	10.88	---	11.35	11.62	11.87	--
F test &L.S.D.at $_{0.05}$	F.TEST		L.S.D.at $_{0.05}$		F.TEST		L.S.D.at $_{0.05}$	
Cultivars	**		0.041		**		0.053	
Boron	**		0.081		**		0.113	
Interaction	**		0.080		**		0.063	

Table 4 :Impact of bulk and nanoparticles boron and their interaction on three sugar beet cultivars on single plant weight during 2019/2020 and 2020/2021 seasons.

BORON	Cultivars			Mean of Boron	Cultivars			Mean of Boron
	Gazelle	Kawemira	Hossam		Gazelle	Kawemira	Hossam	
C_0	1.260	1.190	1.020	0.960	0.621	0.698	0.750	0.689
C_1	1.333	1.387	1.171	1.137	0.782	0.874	0.911	0.856
C_2	1.261	1.182	1.227	1.215	0.942	0.948	0.957	0.949
C_3	1.319	1.313	1.276	1.259	1.035	1.139	1.162	1.112
C_4	1.094	1.312	1.332	1.311	1.198	1.217	1.229	1.215
C_5	1.232	1.360	1.412	1.371	1.237	1.262	1.278	1.259
C_6	1.291	1.534	1.588	1.522	1.324	1.374	1.647	1.448
Means of cultivars	1.219	1.253	1.290	---	1.020	1.073	1.134	---
F test & L.S.D.at $_{0.05}$	F.TEST		L.S.D.at $_{0.05}$		F.TEST		L.S.D.at $_{0.05}$	
Cultivars	**		0.157		**		0.028	
Boron	**		0.159		**		0.053	
Interaction	**		0.130		**		0.036	

Table 5: Impact of bulk and nanoparticles boron and their interaction on three sugar beet cultivars on leaves weight/plant (kg plant^{-1}) during 2019/2020 and 2020/2021 seasons.

BORON	cultivars			Mean of Boron	cultivars			Mean of Boron
	Gazelle	Kawemira	Hossam		Gazelle	Kawemira	Hossam	
C_0	0.346	0.422	0.440	0.403	0.667	0.750	0.783	0.733
C_1	0.473	0.484	0.499	0.485	0.840	0.870	0.880	0.863
C_2	0.499	0.499	0.519	0.506	0.907	0.927	0.963	0.932
C_3	0.544	0.549	0.562	0.552	1.037	1.063	1.077	1.059
C_4	0.586	0.612	0.636	0.611	1.093	1.113	1.123	1.110
C_5	0.675	0.687	0.688	0.683	1.143	1.167	1.180	1.163
C_6	0.697	0.709	0.719	0.708	1.203	1.227	1.250	1.227
Means of cultivars	0.546	0.566	0.580	---	0.984	1.017	1.037	
F test & L.S.D.at 0.05	F. test		L.S.D.at 0.05		F. test		L.S.D.at 0.05	
Cultivars	**		0.013		**		0.021	
Boron	**		0.019		**		0.046	
Interaction	**		0.012		**		0.035	

B. Roots yield (ton fed^{-1})

The data as shown in Table 6 reveal that roots yield fed.-1 was affected significantly by the tested boron rates in both seasons, where the roots yield was increased gradually by increasing boron rates in both seasons. The highest mean values of root yield (29.14 and 29.52 ton fed^{-1} in the two respective seasons). were produced from the highest concentration of nanoparticles was applied at the rate by 300ppm nano boron oxide fed^{-1} concentration in both seasons. This is to be logic, since the same boron rate gave the highest mean values with regard to root diameter, root length and single root weight traits as mentioned before Tables 2.3 and 4 and consequently produced the highest roots yield fed^{-1}. **Abd El-Hady (2017), Dewdar et al.,(2018) and Kandil et al. (2020).**

Moreover, roots yield was significantly differed by the tested sugar beet cultivars in the two growing seasons. Hossam sugar beet cultivar produced the highest roots yield (26.99 and 26.78 ton fed^{-1}) followed by Kawemira cultivar (26.65 and 27.32 ton fed-1) then Gazelle cultivar (26.36 and 26.79 ton fed-1) in the first and second seasons, respectively. This is to be logic since the same sugar beet cultivar gave the highest mean values with regard to root diameter, root length and single root weight and consequently produced the highest roots yield. These results are in agreement with those reported by **Erciyes et al., (2016), Mekdad and Rady (2016) and Mehanna et al., (2016).**

Here too, the obtained data in Table 6 focus that the interactions had a significant influence on roots yield fed.-1 in both seasons. The highest roots yield (29.46 and 29.88 ton fed^{-1}) in the first and second season, respectively. were obtained from Hossam sugar beet cultivar with application nano boron at rate 300ppm nano boron oxide fed^{-1} concentration.

Table 6. Impact of three sugar beet cultivars to bulk and nanoparticles boron and their interaction on root yield (ton fed^{-1}) at harvest time during 2019/2020 and 2020/2021 seasons.

BORON	Cultivars			Mean of Boron	Cultivars			Mean of Boron
	Gazelle	Kawemira	Hossam		Gazelle	Kawemira	Hossam	
C_0	23.57	23.73	24.57	23.96	20.71	22.12	23.12	21.98
C_1	24.98	25.37	25.69	25.35	23.64	24.00	24.33	23.99
C_2	25.95	26.26	26.40	26.20	24.73	25.43	26.10	25.42
C_3	26.56	26.80	26.80	26.72	26.47	26.68	26.84	26.66
C_4	26.80	27.20	27.61	27.20	27.34	27.87	28.31	27.84
C_5	27.91	28.00	28.40	28.10	28.44	28.63	28.88	28.65
C_6	28.75	29.20	29.46	29.14	29.20	29.50	29.88	29.52
Means of cultivars	26.36	26.65	26.99	---	25.79	26.32	26.78	---
F test & L.S.D.at 0.05	F. test		L.S.D.at 0.05		F. test		L.S.D.at 0.05	
Cultivars	**		0.083		**		0.194	
Boron	**		0.127		**		0.197	
Interaction	**		0.112		**		0.129	

C. Quality trait

Concerning the effect of boron application on sucrose and sugar recovery percentage traits, data in Tables 7and8 point out sucrose percentage and sugar recovery percentages were affected significantly by boron application in both seasons. The sucrose percentage and sugar recovery percentages were increased gradually by increasing boron rates in the two growing seasons. The highest mean values of sucrose percentage (20.69 and 21.16 %) and sugar recovery percentage (17.07 and 16.23 %) in the first and second seasons, respectively. were recorded by the applied boron at the rate of 300 ppm nano boron oxide fed-1concentration after sowing. This increase may be due to the role of boron in higher plants by facilitating the short-and long-distance transport of sugar via the formation of borate-sugar complexes. In addition, boron may be of importance for maintaining the structural integrity of plasma plant cells membranes. This function is likely related to stabilization of cell membranes by boron association with some membrane constituents **(Brown et al., 2002)**. These results are in harmony with those obtained by **Abd El-Hady (2017), Dewdar et al., (2018) and Kandil et al., (2020).**

Regarding, the effect of studied sugar beet cultivars, the presented data in Tables7and 8 focus that sucrose percentage and sugar recovery percentage were significantly differed by studied sugar beet cultivars in both seasons. Hossam sugar beet cultivar produced the highest mean values of sucrose percentage (17.98 and 18.31 %) and sugar recovery percentages (14.43 and 14.29 %) in the first and second seasons, respectively. The difference among the three sugar beet cultivars of sugar recovery percentage could be due to the variation in the gene make–up and its response to the environmental conditions. These results are confirmed with those obtained by **Shalaby et al., (2011), Hozayn et al. (2013), Erciyes et al. (2016), Mekdad and Rady (2016) and Mehanna et al. (2016).**

Here too, the interaction between boron foliar application (bulk and nanoparticles boron) and cultivars had a significant ($P \leq 0.01$) effect on the sucrose percentage and sugar recovery percentage (%). in both seasons where, the highest mean sucrose percentage (20.90 and 21.71 %) and sugar recovery percentage (17.48 and 16.65 %). were obtained from Hossam sugar beet cultivar fertilized with rate by 300 ppm nano boron oxide fed-1concentration at 60 and 90 days after sowing.

Table 6. Impact of three sugar beet cultivars to bulk and nanoparticles boron and their interaction on root yield (ton fed^{-1}) at harvest time during 2019/2020 and 2020/2021 Seasons.

BORON	cultivars			Mean of Boron	cultivars			Mean of Boron
	Gazelle	Kawemira	Hossam		Gazelle	Kawemira	Hossam	
C_0	14.68	14.96	15.34	14.99	15.54	15.79	15.87	15.73
C_1	15.74	15.88	15.93	15.85	16.05	16.50	16.73	16.43
C_2	15.97	16.46	16.90	16.44	16.78	16.81	16.93	16.84
C_3	17.00	17.47	17.84	17.44	17.37	17.63	17.79	17.60
C_4	17.94	18.67	18.97	18.53	17.88	18.57	18.90	18.45
C_5	19.53	19.93	19.95	19.80	19.40	19.66	20.22	19.76
C_6	20.38	20.80	20.90	20.69	20.57	21.21	21.71	21.16
Means of cultivars	17.32	17.74	17.98	--	17.66	18.02	18.31	--
F test & L.S.D.at 0.05	F. test		L.S.D.at 0.05		F. test		L.S.D.at 0.05	
Cultivars	**		0.076		**		0.083	
Boron	**		0.092		**		0.126	
Interaction	**		0.134		**		0.093	

Table 7: Impact of bulk and nanoparticles boron and their interaction on three sugar beet cultivars on sugar recovery (%) at harvest time during 2019/2020 and 2020/2021 seasons.

BORON	cultivars			Mean of Boron	cultivars			Mean of Boron
	Gazelle	Kawemira	Hossam		Gazelle	Kawemira	Hossam	
C_0	10.90	11.48	11.70	11.36	12.59	12.76	12.81	12.72
C_1	12.05	12.27	12.48	12.27	12.83	13.21	13.23	13.09
C_2	12.73	12.89	13.20	12.94	13.27	13.31	13.33	13.30
C_3	13.45	13.58	14.13	13.72	13.57	13.84	13.93	13.78
C_4	14.52	15.02	15.64	15.06	13.98	14.51	14.70	14.40
C_5	16.04	16.22	16.41	16.22	15.14	15.22	15.42	15.26
C_6	16.68	17.05	17.48	17.07	15.85	16.18	16.65	16.23
Means of cultivars	13.77	14.07	14.43	---	13.89	14.15	14.29	---
F test & L.S.D.at 0.05	F. test		L.S.D.at 0.05		F. test		L.S.D.at 0.05	
Cultivars	**		0.100		**		0.062	
Boron	**		0.132		**		0.102	
Interaction	**		0.078		**		0.097	

D. sugar yield. (ton fed^{-1})

The presented data in Table 9 reveal that sugar yield was affected significantly by boron spraying levels in both seasons. The sugar yield was increased by increasing boron spraying levels in both seasons. The highest mean sugar yield (4.97 and 4.48 ton fed^{-1}) in the first and second seasons, respectively. were produced from the highest concentration of nanoparticles boron (300 ppm nano boron oxide fed^{-1} in both seasons. This is to be expected since the same boron concentration gave the highest mean values with regard to root yield (ton fed^{-1}) and sucrose percentage and sugar recovery percentage and consequently produced the mean values with sugar yield in both seasons. These results are in harmony with those obtained by **Dewdar et al., (2018), Kandil et al., (2020) & Ferweez and Abd El-Monem (2018).**

Here too, sugar yield was significantly differed between the studied sugar beet cultivars in both seasons. Thus, Hossam sugar beet cultivar surpassed the other tested cultivars in this respect and recorded the highest mean values of sugar yield (3.92 and 3.73 ton fed^{-1}). in the first and second seasons, respectively. This is to be logic since the same sugar beet cultivars gave the highest mean values with regard to root yield (ton fed^{-1}), sucrose percentage and sugar recovery percentage. These results are confirmed with those obtained by **Abdel-Motagally (2015), Abd El-Hady (2017), Dewdar et al., (2018) and Kandil et al., (2020).**

Also, the data in Table 9 reveal that the interactions had a significant effect on sugar yield (ton fed.$^{-1}$) trait in the two growing seasons. The highest mean values of sugar yield (5.15 and 5.02 ton fed^{-1}) in the first and second seasons, respectively. These were obtained from fertilizing the cultivar sugar beet Hossam at a rate of 300 ppm nano boron oxide fed^{-1}

Table 8: Impact of bulk and nanoparticles boron and their interaction on three sugar beet cultivars on sugar recovery percentage (%) at harvest time during 2019/2020 and 2020/2021 Seasons.

BORON	cultivars			Mean of Boron	cultivars			Mean of Boron
	Gazelle	Kawemira	Hossam		Gazelle	Kawemira	Hossam	
C_0	2.57	2.72	2.87	2.72	2.93	3.01	3.03	2.99
C_1	3.01	3.11	3.20	3.11	3.11	3.26	3.28	3.22
C_2	3.30	3.38	3.48	3.39	3.35	3.39	3.40	3.38
C_3	3.57	3.63	3.78	3.66	3.49	3.56	3.64	3.56
C_4	3.89	4.08	4.32	4.10	3.68	3.84	3.91	3.81
C_5	4.47	4.54	4.66	4.56	4.06	4.15	4.23	4.15
C_6	4.79	4.98	5.15	4.97	4.36	4.47	4.61	4.48
Means of cultivars	3.66	3.78	3.92	---	3.57	3.67	3.73	---
F test & L.S.D.at $_{0.05}$	F. test		L.S.D.at $_{0.05}$		F. test		L.S.D.at $_{0.05}$	
Cultivars	**		0.012		**		0.032	
Boron	**		0.033		**		0.063	
Interaction	**		0.023		**		0.040	

Conclusion

From the obtained results the investigators could be recommended to planting Hossam sugar beet cultivar with at the rate of 300 ppm nano boron oxide fed^{-1} concentration at 60 and 90 days after sowing, under New Valley Governorate.

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