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YIELD AND QUALITY RESPONSE OF SOME SUGAR BEET VARIETIES TO NITROGEN AND BORON FERTILIZATION IN SANDY SOIL

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ABSTRACT

Two field experiments were carried out at El-Nubaria, El-Buhira Governorate Egypt, during 2017/2018 and 2018/2019 seasons. The objective was to study the effect of foliar applications (0 and 150 ppm /fed of boron) and nitrogen fertilization levels (80, 100 and 120 kg N/fed) on response, yield and quality of three sugar beet varieties (Betamax, Dena and Sara) in sandy soil. A split-split plot design with three replicates was used. The seeds of the three varieties were sown on the 1st week of October and harvested after 210 days in both seasons. The obtained results showed that foliar application of 150 ppm boric acid/fed recorded a significant increase in root fresh weight and root yield values in both seasons compared to the control. While, foliar application of boron caused a positive reduction effect on impurities (Na, K and alpha amino-N). However, it corrected sugar %, quality of sugar index and sugar yield. Soil application of 100 kg N/fed resulted in significant increases in root fresh weight, roots and tops yields (t/fed) in both seasons, compared with plots treated with 80 kg N/fed, respectively. Fertilizing sugar beet plants with 100 kg N/fed was enough to produce the highest percentages of sucrose, corrected sugar %, quality of sugar index and corrected sugar yield in both seasons. Sara variety showed superior values over the other two varieties in LAI, root fresh weight and roots as well as tops yields t/fed in both seasons. While, Betamax variety attained the least values of the impurity contents in both seasons. The highest means of root weight, roots and top yields resulted from applying boron at 150 ppm boron/fed and 100 kg N/fed in both seasons. Foliar application of 150 ppm boron/fed on Sara variety plants produced the highest values for root fresh weight and root yield in both seasons. Significant positive association was obtained between corrected sugar yield and root yield, leaf area index, top yield, sucrose %, nitrogen and quality index. Corrected sugar yield was highly significantly correlated with root fresh weight and sucrose %; while, significant negative correlation were shown between quality index and both potassium and sodium. These traits will enable the agronomists to realize high income of sugar yield in sugar beet varieties. Use of factor analysis has the potential of increasing the comprehension of the casual relationship of variables and can help to determine the nature and sequence of traits to be evaluation sugar beet varieties trails. Applying these conditions could be recommended for growing sugar beet varieties with 100 kg N/fed fertilization and boron application at the rate of 150 ppm boron/fed increase roots, tops and corrected sugar yield t/fed.

Key words: *Boron and Nitrogen fertilization, Sugar beet varieties, sandy soil, Correlation, Factor analysis.*

1. INTRODUGTION

Nitrogen fertilization has a remarkable effect on sugar beet growth since it increases leaf area, root dimension, number of green leaves and root fresh weight.Thus, the economic yield of sugar beet roots which will be supplied to sugar factories will increase (Crivineanu, 1995). Whereas, much nitrogen fertilization led to increased roots yield and their impurities contents, but it reduced sucrose content in roots and consequently limits refined sucrose production (Hills and Albert, 1971). Increasing nitrogen fertilizer led to reduced sucrose content in root and increased impurities that hinder sucrose crystallization process (Stevens *et al.,* 2007). In this regard, Kemp *et al.* (1994), Besheit *et al.* (1995) and Moustafa *et al.* (2000) mentioned that the drop in juice purity largely reflects increasing content of amino nitrogen and total soluble solids, which is caused by excessive uptake of nitrogen. Increasing nitrogen application from 50 up to 125 kg N/fed caused significant increases in root dimensions, top and root fresh weight/plant, Na%, K%, sugar lost in molasses and root yield/fed (Omar and Mohamed 2013). The highest average of sugar, purity and extractable sugar percentages were produced with using 100 kg N/fed. Abdou and Badawy (2014) and El-Geddawy and Makhlouf (2015) reported that increasing nitrogen rates from 100 to 130 kg N/fed significantly increased root fresh weight, root dimensions and root sugar yields/fed. However, the impurities of root contents become high. The highest average of sucrose percentage was recorded with 100 kg N/fed, while, sugar yield recorded the highest value with the rate of 120 kg N/fed.

Boron is essential for providing sugars, which are needed for root growth in all plants. In this connection, Allen *et al*. (2007) suggested that boron increases the rate of transport of sugars (which are produced by photosynthesis in mature plant leaves) to actively growing regions, and also in developing roots. Many attempts were conducted to determine the preferable rate of boron application to reach a good quality of sugar beet,e.g., Abo El-Hamd and Esmail (2008) and Enan (2011) found that increasing B levels up to 200 ppm as boric acid/fed significantly improved root length, root diameter, root fresh weight/plant and sugar yield/fed. Mohamed *et al.* (2014) showed that increasing boron fertilizer up to 0.20 g/L resulted in the highest recoverable sugar compared with the untreated. Sucrose, recoverable sucrose and juice purity percentages were also increased by adding high 0.20 and 0.25 g/L levels of boron. Ali (2015) found that application of 120 and 150 ppm boron significantly improved root yield and percentage of gross and white sugar. On the contrary Na, K, α-amino N and loss of sugar percentages, decreased. Correlation analysis revealed the presence of highly significant *r* values between root yield and gross sugar (%). Many studies suggested the effect of combination of nitrogen and boron supplementation on yield and quality. In this respect, Ali and Shaaban (2020) studied the influence of nitrogen at three levels (190, 240 and 290 kg N ha^{-1} and boron at 0, 1.2, and 2.4 kg ha^{-1}) on sugar beet grown in a sandy soil. They found that integration of 290 kg N ha^{-1} with 1.2 kg B ha^{-1} improved the growth, sugar yields and their quality, under semi-arid conditions. Correlation analysis showed that root yield and root fresh weight were highly significant. The varietal difference among varieties might be attributed to their genetic constituents and their capacity to advantage from the environmental factors (Hozayn, *et al*. 2013). In this concern, Enan *et al*. (2016) found that Polat variety surpassed Natoura and Henrike varieties, which recorded the maximum values of root diameter, fresh and top weights/plant as well as top yield/fed. Aly *et al*. (2017) results indicated that Karim variety had the highest values in leaf area index (LAI), root and foliage fresh weighs (g/plant), as well as root and extracted sugar yields (t/fed). Meantime, Nancy surpassed Karim in sucrose %, extracted sugar% and quality index%.

The present study was performed to evaluate the effect of nitrogen and boron fertilization levels on the yield and quality of sugar beet varieties performances under sandy soil conditions.

2. MATERIALS AND METHODS

Two field experiments were carried out at El-Nubaria (latitude of 30^0 38/ N, longitude of 42^0 01/ E, and elevation of 33 m above sea level), El-Buhira Governorate, Egypt, during 2017/2018 and 2018/2019 seasons to study the effect of two foliar applications (0 and 150 ppm Boron/fed) and three nitrogen fertilization rates (80, 100 and 120 kg N/fed) on the yield, growth and quality of some sugar beet varieties, i.e. Sara (*E-type*, Nederland),Dena (*N-type*, Nederland) and Betamax (*Z type*, France). The two foliar applications of boron were applied as zero (control= check treatment) and 150 ppm B/fed as (boric acid 17% B). A split-split plot design with three replicates was used, where boron foliar treatments were placed in the main plots, while nitrogen fertilization treatment were placed in sub plots, where the sub-sub plots were randomly planted with the three sugar beet varieties, with three replications. Each experimental basic Ppot area was 15 m^2 (1/280 fed) including five ridges of 60-cm width and 5-m length, each. The preceding summer crops were maize. Sugar beet seeds was planted on the 1^{st} week of October in both seasons and harvested after 210 days from sowing date.

Calcium superphosphate (15.0% P_2O_5) was applied during soil preparation at the rate of 200 kg/fed. Potassium sulfate (48% K_2O) at the rate of 50 kg/fed was applied with the second nitrogen dose.

Nitrogen fertilizer in the form of ammonium nitrate (33.5% N) was added in three equal doses, after thinning and at 3-week intervals later. Boron was sprayed as Boric acid (17% B) in two equal doses at the age of 60 and 75 days after sowing. Soil samples were taken before sowing at random from every location area at a depth of 0-30 cm from soil surface and prepared for mechanical and chemical analysis. Properties for the experimental soil determined according to Piper (1955) are illustrated in Table (1). Other agricultural practices were applied as recommended for growing sugar beet in the region.

D. Impurities of juice, in terms of Sodium (Na) and Potassium (K) concentrations were estimated as meq/100g beet according to the procedures of Sugar Company, by Automated Analyzer, as described by Brown and Lilliand (1964). Alpha-amino-N was determined using Hydrogenation method according to Carruthers *et al.* (1962).

At harvest, sugar beets of three ridges from all sub-sub plots were uprooted, topped and weighed to determine the following parameters:
1. Top yield (t/fed).
2. Root yield (t/fed).
3. Corrected sugar yield (t/fed), which was calculated according to the following equation: Corrected sugar yield (t/fed) = roots yield (ton/fed) x corrected sugar %.

Table (1): Particle size distribution and some chemical properties of the soil of the experimental site in 2017/2018and 2018/2019 seasons.

2017/2018											
Particle size			**Soil textural**		**Ec (dSm^{-1})**		**Soil pH (1:2.5)**		**Organic matter%**		**SP**
Sand%	**Silt%**	**Clay%**									
89.10	8.98	1.92	**Sandy**		4.84		7.63		1.16		19.5
Soluble cations (mq l^{-1})				**Soluble ions (mq l^{-1})**				**Available nutrients (mg/1kg soil)**			
Ca^{++}	**Mg^{++}**	**Na^{+}**	**K^{+}**	**Co_3^-**	**Hco_3^-**	**Cl-**	**So_4^-**	**N**	**P**	**K**	**B**
9.45	15.5	20.63	2.75	-	7.50	35.5	5.37	38.1	2.24	97.5	0.43
2018/2019											
Particle size			**Soil textural**		**Ec (dSm^{-1})**		**Soil pH (1:2.5)**		**Organic matter%**		**SP**
Sand%	**Silt%**	**Clay%**									
91.10	6.98	1.92	**sandy**		4.50		7.80		1.20		20.1
Soluble cations (mq l^{-1})				**Soluble ions (mq l^{-1})**				**Available nutrients (mg/1kg soil)**			
Ca^{++}	**Mg^{++}**	**Na^{+}**	**K^{+}**	**Co_3^-**	**Hco_3^-**	**Cl-**	**So_4^-**	**N**	**P**	**K**	**B**
8.09	14.3	19.60	2.90	-	6.19	34.05	4.54	40.0	2.45	105.0	0.40

2.1. The recorded data

LAI = Leaf area/plant (cm^2)/plant ground area (cm^2) was measured at 120 days from sowing date using the leaf area meter, model: 3000 A

At harvest, a sample of five plants was randomly collected from each treatment,and cleaned to determine the following characters:

1- Root fresh weight (g/plant),

2- Quality traits were determined in Beet Sugar Laboratory at Alexandria Sugar Factory, Egypt.

A. Sucrose percentage (Pol %) was estimated in fresh samples of sugar beet roots, using Saccharometer according to the method described in A.O.A.C (2005).

B. Corrected sugar % was calculated using the following equation according to Rainfeld (1974):

Corrected sugar % = Pol % - 0.343 (K+Na) – α-amino N (0.0939) - 0.29.

C. Juice quality index (QI%) was calculated according to Rainfeld *et al.* (1974) using the following equation: QI% = Corrected sugar % X 100/ Pol %.

2.2. Statistical analysis

All obtained data were statistically analyzed according to (MSTAT-C) computer software package. Least significant differences (LSD) method was used to test the differences between treatment means at 5% level of probability as described by Snedecor and Cochran (1981).

Simple correlation: a matrix of simple correlation coefficients between sugar yield and each of its components were computed as applied by Steel and Torrie (1980).

Factor analysis: this statistical approach was applied according to Cattell (1965) to reduce a large number of correlated variables to a much smaller No. of independent clusters of variables called factors. After loading of the first factor was calculated, the process was repeated on the residuals matrix to find further factors. When the contribution of a factor to the total percentage of the trace was less than 10%, the process was stopped. After extraction, the matrix of factor loadings was submitted to a varimax orthogonal rotation, as applied by Kaiser (1958). The purpose of rotation was to rebuilding the larger loadings in each factor and to suppress the minor loading coefficient to improve the opportunity of achieving meaningful biological interpretation of each factor.

3. RESULTS AND DISCUTION

The obtained results in Table (2), clear that fertilizing sugar beet plants with 150 ppm boric acid/fed recorded a significant increase in values of root fresh weight (kg) and root yield (ton), while leaf area index and top yield recorded insignificant raise in both seasons compared to control. Therefore, the important roles of boron on root dimension and foliage development could be attributed to the stimulant effect on rate of photosynthesis through carbohydrate metabolism and transport of the photosynthetic product from the leaves to the storage root. These results may be due to the fact that the foliar application by 150 ppm B/fed significantly increased LAI and root fresh weight, which may have increased the photosynthetic surface per unit area, which consequently promoted growth and nutrient uptake of plants by addition of boron which affects walls membrane. These results are in agreement with Aly *et al.* (2017).

The difference between 100 and 80 kg N/fed was significant at 5% probability on LAI, root fresh weight and yields of roots and top/fed in the 1st and the 2nd seasons respectively, while the difference between 120 and 100 kg N/fed nitrogen fertilization was not reached at the level 5%of significance. Addition of 100 kg N/fed resulted in a significant increase amounted to (0.16 and 0.12), (0.017 and 0.016 kg), (1.42 and 1.63 tons) and by (0.70 and 0.68 tons) in LAI, root fresh weight, yield of root and top t/fed in the first and second seasons compared with plots treated with 80 kg N/fed, respectively. These results may be attributed to the nitrogen and N role in excessive vegetative growth. These results are in harmony with these obtained by Abdou and Badawy (2014) and El-Geddawy and Makhlouf (2015).

Presented data in Table (2), revealed significant differences among sugar beet varieties in LAI, root fresh weight and roots as well as top yields t/fed in the 1st and the 2nd seasons. Sara variety showed the superiority over the other two varieties in all respect of the previous traits in both seasons. The variations among the tested sugar beet varieties in these traits might be due to their gene makeup. These observations coincide with those found by Hozayn, *et al.* (2013) and Aly *et al.,* (2017).

Results in Table (3) showed that sucrose % was considerablly affected by boron foliar application in both seasons. However, foliar application with boron significantly affected the root contents of impurities (Na, K and alpha amino-N) compared to without boron application in the 2nd only. The increase of sucrose % in sugar beet root referred to the actively role of boron in carbohydrate translocation from source as leaf to sink as roots Allen *et al.* (2007).

Table (2): Leaf area index (LAI), root fresh weight (kg), root and top yields (t/fed) affected by nitrogen and boron applications on three sugar beet varieties in 2017/18 and 2018/19 seasons.

Traits / Treatments	LAI		Root fresh weight (kg)		Root yield (t/fed)		Top yield (t/fed)	
	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19
Boron foliar application levels								
Without boron	3.34	3.45	1.078	1.103	24.70	24.79	9.05	9.32
150 ppm B/fed	3.39	3.50	1.124	1.131	25.17	25.34	9.20	9.56
F. Test	**ns**	**ns**	*	*	*	*	**ns**	**ns**
Nitrogen soil application levels								
80 kg N/fed	3.24	3.39	1.047	1.074	23.90	23.96	8.58	8.95
100 kg N/fed	3.40	3.51	1.118	1.135	25.32	25.59	9.28	9.63
120 kg N/fed	3.47	3.52	1.138	1.141	25.59	25.65	9.52	9.74
LSD at 0.05	**0.07**	**0.10**	**0.026**	**0.031**	**0.43**	**0.42**	**0.17**	**0.31**
Sugar beet varieties								
Betamax	3.12	3.18	0.943	0.959	23.16	23.30	7.89	8.29
Dena	3.38	3.46	1.098	1.119	24.94	24.97	9.08	9.37
Sara	3.61	3.79	1.262	1.273	26.71	26.92	10.41	10.66
LSD at 0.05	**0.05**	**0.09**	**0.026**	**0.028**	**0.40**	**0.37**	**0.20**	**0.20**

***and ns significant at 0.05 probability levels and non-significant, respectively.**

Fertilizing sugar beet plants with 100 kg N/fed was enough to produce the highest percentage of sucrose in beet root, without any significant variation with those applied at 120 kg N/fed, in both seasons. In the same Table, fertilizing with 80 kg N/fed recorded the least significant variance with 100 and/or 120 kg N/fed for K and Alpha amino-N in both seasons; however, insignificant variance was observed in Na trait in both seasons. These results are in harmony with those obtained Mohamed *et al.* (2014) and Ali (2015) who concluded that foliar application with boron increasing sucrose and purity percentages accompanied by decrease the impurities contents in sugar beet roots.

Data in Table (3) manifested those differences among the three sugar beet varieties in all traits in both seasons. The variety Betamax showed the superiority over the other two varieties in respect of sucrose % in both seasons; however, the variety attained the lowest values in respect of the impurity contents in sugar beet roots (Na, K and Alpha amino-N) in both seasons. Those variations among the tested sugar beet varieties might be due to their gene make-up. These observations coincide with those found by Hozayn *et al*. (2013) and Aly *et al.* (2017).

Results in Table (4) cleared that foliar application with 150 ppm boron/fed had a significant effect on corrected sugar%, quality sugar index and corrected sugar yield (ton/fed) compared with the check treatment in both seasons. These finding are in agreement with those mentioned by Ali (2015) and Ali and Shaaban (2020).

Corrected sugar %, quality sugar index (QI%) and corrected sugar yield in the same table considerably increased enough as the applied nitrogen levels raised from 80 kg up to 100 kg N/fed in both seasons, as well as QI only in the 2nd season. Application with the rate of 100 kg N/fed resulted in the highest values of these traits compared with 80 and/or 120 kg N/fed. These results assured the importance role of nitrogen element in metabolic process and the injury of the excessive amount of it on juice purity of sugar beet process. The positive effect of nitrogen effect of nitrogen element on sucrose, corrected sugar percentages and correct sugar yield/fed treatments was reported by Hills and Albert (1971), Stevens *et al.* (2007) and Omar and Mohamed (2013).

Table (3): Sucrose% and impurities (Na, K and α- amino- N meq./100 g beet) traits affected by nitrogen and boron applications on three sugar beet varieties in 2017/18 and 2018/19 seasons.

Treatments \ Traits	Sucrose%		Impurities (meq./100 g beet) Na		K		α- amino N	
	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19
Boron foliar application levels								
without Boron	18.61	18.48	2.22	2.35	3.30	3.38	0.64	0.61
150 ppm B/fed	19.36	19.00	2.12	2.12	3.11	3.17	0.57	0.53
F. Test	*	*	**ns**	*	**ns**	*	**ns**	*
Nitrogen soil application levels								
80 kg N/fed	18.30	18.12	2.21	2.31	3.06	3.26	0.47	0.46
100 kg N/fed	19.34	19.20	2.14	2.24	3.25	3.26	0.61	0.58
120 kg N/fed	19.32	18.91	2.15	2.15	3.30	3.30	0.72	0.68
LSD at 0.05	**0.28**	**0.15**	**ns**	**Ns**	**0.15**	**0.08**	**0.04**	**0.03**
Sugar beet varieties								
Betamax	19.69	19.35	1.98	2.06	3.05	3.15	0.53	0.50
Dena	19.10	18.83	2.23	2.28	3.20	3.25	0.57	0.56
Sara	18.17	18.05	2.30	2.37	3.35	3.42	0.70	0.67
LSD at 0.05	**0.18**	**0.14**	**0.12**	**0.09**	**0.15**	**0.10**	**0.03**	**0.03**
*** and ns significant at 0.05 probability levels and non-significant, respectively**								

Results in Table (4) indicated significant differences among the three tested varieties in corrected sugar %, QI and corrected sugar yield in both seasons. The variety Betamax recorded the highest values corrected sugar % and QI in both seasons. Sara variety gave the highest corrected sugar yield in both seasons. However, insignificant differences were found between Sara and Dina varieties in the 1st season only for corrected sugar yield. These results are in line

Table (4): Corrected sugar %, quality index (QI) and corrected sugar yield (t/fed) affected by nitrogen and Boron applications on three sugar beet varieties in 2017/18 and 2018/19 seasons.

Traits / Treatments	Corrected sugar%		QI%		Corrected sugar yield (t/fed)	
	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19
Boron foliar application levels						
Without boron	16.37	16.17	87.92	87.45	4.04	4.00
150 ppm B/fed	17.22	16.85	88.93	88.63	4.32	4.26
F. Test	*	*	*	*	*	*
Nitrogen soil application levels						
80 kg N/fed	16.16	15.87	88.27	87.57	3.86	3.80
100 kg N/fed	17.14	16.97	88.61	88.36	4.33	4.34
120 kg N/fed	17.09	16.68	88.40	88.19	4.35	4.27
LSD at 0.05	**0.31**	**0.16**	**ns**	**0.34**	**0.10**	**0.09**
Sugar beet varieties						
Betamax	17.62	17.23	89.49	89.01	4.08	4.02
Dena	16.89	16.59	88.41	88.09	4.21	4.14
Sara	15.87	15.71	87.37	87.03	4.25	4.24
LSD at 0.05	**0.20**	**0.13**	**0.33**	**0.25**	**0.08**	**0.08**
*** and ns significant at 0.05 probability levels and non-significant, respectively**						

with those reported by Hozayn *et al.* (2013) and Aly *et al.* (2017).

Data in Table (5) clear that the interaction between boron foliar applications with nitrogen levels soil application had a significant effect on all traits in this table. The highest means root weight (1.149 and 1.167 kg), root yield (25.81 and 26.00 tons/fed) and top yield (9.52 and 9.92 tons/fed) resulted from applied boron on sugar beet plants by 150 ppm boron/fed and 100 kg N/fed in both seasons, respectively. The highest sucrose % (19.95%) resulted from boron (150 ppm) and (120 kg N/fed) in the 1st season and (19.34%) resulted from 150 ppm boron and fertilized sugar beet plants by 100 kg N/fed in the 2nd season.

Corrected sugar % was highest with fertilized sugar beet plants by 120 kg N/fed and 150 ppm of boron in the 1st season, while in the 2nd season the highest corrected sugar % resulted from growing sugar beet plants under foliar application with 150 ppm boron and 100 kg N/fed. These results are agreement with those obtained by Ali (2015) and Ali and Shaaban (2020).

The results in Table 6 showed the interaction between foliar boron applications x sugar beet varieties. Sara variety produced the highest mean values for root fresh weight and root yield in both seasons and corrected sugar yield in the 2nd seasons only when applied by 150 ppm boron/fed compared with the other tested varieties. Meanwhile, the variety Betamax produced significantly higher values only in the 2nd season compared to the Dena and/or Sara varieties for sucrose and correct sugar %.

All the other interactions un-tabulated as N x V and B x N x V were insignificant effect on all traits under this study.

3.1. Simple correlation matrix

Correlation coefficients between all pairs of studied traits are shown in Table (7). The results revealed that there was a highly significant positive correlation between sugar yield and each of root yield (0.728**), top yield (0.644**), leaf area index (0.498**), sucrose % (0.483**), nitrogen (0.464**) and quality index (0.320**). The data cleared that significant positive correlation between sugar yield and root fresh weight (0.551*). There was highly significant positive correlation between quality and sucrose (0.809**) while, highly significant negative orrelation were observed between quality index and each of potassium (-0.740**) and sodium (-.698**). Accordingly, the breeder should exploit the previous traits to achieve high sugar yield of sugar beet. However, insignificant associations previous traits to achieve high sugar yield of sugar beet. However, insignificant associations were observed between sugar yield and each of potassium and sodium reducing sugar indicating that these traits may be independent in their genetic expression under the resent study. The sugar agronomists must take into account the interrelationships among the sugar yield components when planning the farming program.

Table (5): The interaction effect between boron and nitrogen application on some traits during 2017/18 and 2018/19 seasons.

Boron x Nitrogen levels interaction		Root fresh weight (kg)		Root yield (t/fed)		Top yield (t/fed)		Sucrose%		Corrected sugar%	
		2017/18	2018/19	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19
B1	N1	1.014	1.046	23.54	23.47	8.50	8.87	17.98	17.80	15.79	15.52
	N2	1.087	1.104	24.82	25.19	9.03	9.35	19.16	19.07	16.93	16.76
	N3	1.133	1.158	25.73	25.71	9.61	9.75	18.68	18.58	16.37	16.24
B2	N1	1.080	1.102	24.25	24.45	8.66	9.04	18.61	18.44	16.52	16.23
	N2	1.149	1.167	25.81	26.00	9.52	9.92	19.51	19.34	17.35	17.19
	N3	1.142	1.124	25.45	25.58	9.43	9.73	19.95	19.23	17.81	17.13
LSD at 5%		**0.037**	**0.043**	**0.60**	**0.59**	**0.23**	**0.31**	**0.40**	**0.21**	**0.43**	**0.23**

B1= control treatment, B2= 150 ppm Boron/fed as foliar application; N1, N2 and N3 = 80, 100 and 120 kg N/fed as soil application.

Table (6): Significant interactions between boron levels and sugar beet varieties of some traits in two growing seasons 2017/18 and 2018/19.

Boron x varieties interaction		Root fresh weight (kg)		Root yield (t/fed)		Sucrose%	Corrected sugar%	Corrected sugar yield (t/fed)
		2017/18	2018/19	2017/18	2018/19	2018/19	2018/19	2018/19
B1	Betamax	0.909	0.935	22.91	22.95	19.23	17.04	3.92
	Dena	1.098	1.113	25.05	25.03	18.55	16.23	4.06
	Sara	1.228	1.260	26.13	26.39	17.66	15.25	4.03
B2	Betamax	0.977	0.984	23.40	23.66	19.47	17.41	4.13
	Dena	1.098	1.124	24.82	24.92	19.10	16.95	4.22
	Sara	1.296	1.286	27.29	27.46	18.43	16.17	4.44
LSD at 5%		**0.037**	**0.040**	**0.56**	**0.52**	**0.20**	**0.19**	**0.11**

B1= zero treatment, B2= 150 ppm Boron/fed as foliar.

Table (7): Simple correlation coefficient among sugar yield and its components in sugar beet over 2017/18 and 2018/19 seasons.

Traits	RFW	LAI	TY	Sucrose%	Na	K	N	QI	RY	CSY
RFW	1	0.810**	0.873**	-0.302	0.335	0.133	0.486	-0.352	0.847**	0.551*
LAI		1	0.800**	-0.272	0.539	0.142	0.504*	-0.358	0.733**	0.498**
TY			1	-0.202	0.365	-0.035	0.594*	-0.254	0.869**	0.644**
Sucrose %				1	-0.346	-0.467	-0.087	0.809**	-0.241	0.483**
Na					1	0.231	0.454	-0.698**	0.364	0.021
K						1	-0.033	-0.740**	0.105	-0.291
N							1	-0.278	0.615**	0.464**
QI								1	-0.334	0.320**
RY									1	0.728**
CSY										1

*** and ** significant at 0.05 and 0.01 probability levels, respectively.**
RFW: Root fresh weight, LAI: leaf area index, TY: Top yield t/fed, SUC: Sucrose %, Na: Sodium, K: Potassium, QI: Quality index%; RY: Root yield (t/fed) and CSY: Corrected sugar yield (t/fed).

It is worthwhile to state that the large sample size (n=144) of data may be a reason of the significance of some small values of correlation coefficients. The present results are similar to those reported by Ghareeb *et al*. (2013).

3.2. Factor analysis

The factor analysis technique divided the nine sugar yield components into two independent groups or factors, which explained 74.75% of the total variability in the dependence structure. The factors were constructed by applying the principal component approach to establish the dependent relationship between sugar yield attribute in sugar beet. Factor loadings that greater than 0.5 were considered important. A summary of the composition of variables of the two extracted factors with loading are given in Table (8).

With the screen test, we ploted the eigen values associated with each component and look ed for a "break" between the components with relatively large Eigen values and those with small eigen values. The components that appear the break before the break are assumed to be more meaningful (Fig. 1). The higher loading displaying variables on first factor (six traits) were root diameter, root fresh weight, leaf area index, top yield, and nitrogen and root yield (Table 8).

Table (8): Summary of factor loadings for the ten traits of sugar beet.

Variables	Loading	Communality	Eigen values	% of variance	Suggested factor name
Factor I					
Root fresh weight	0.871	0.830	51.107	44.73	**Growth & nitrogen factor**
Leaf area index	0.846	0.775			
Sodium	0.622	0.483			
Nitrogen	0.665	0.521			
Top yield	0.855	0.903			
Root yield	0.874	0.863			
Factor II					
Sucrose %	0.651	0.683	23.546	29.92	**Sugar & quality factor**
Potassium	-0.754	0815			
Quality	0.742	0.990			
Cumulative variance	**74.65**				

- Extraction method: principal component analysis.

- Rotation method: varimax with Keiser normalization.

Factor I included six variables which accounted for 44.73 % of the total variability. The six variables were root fresh weight, leaf area index, sodium, nitrogen, top yield and root yield. It contains the variables usually regarded as a growth factor. The six variables had high communality with factor I. Therefore, this factor may be called growth and nitrogen factor.

Factor II was responsible for 29.92 % of the total variability in the dependence structure. It included three traits namely, sucrose %, potassium and quality. The sign of the loading values indicates the direction of the relationship between the factor and its related traits. So, the negative sign of the sucrose and quality indicate the negative correlation coefficients with each of the other two variables in factor II. Therefore, this factor may be called sugar and quality factor. These results were in agreement with Ghareeb *et al*. (2013) and Seiller and Stafford (1985).

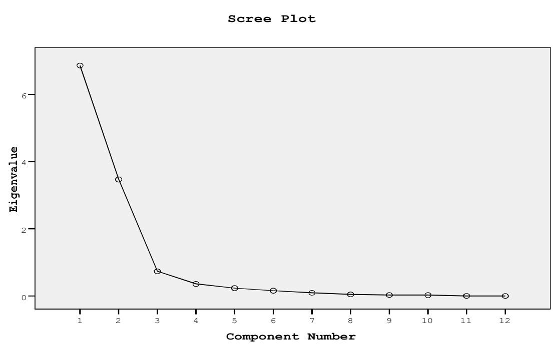

Fig. (1): Eigen values corresponding to different factors components.

Finally, it could be recommended from the previous results that, the important traits overall statistical procedures of analysis were root fresh weight, top yield and root yield in factor I. The quality variable had high communality with factor II. These traits will enable the agronomists to realize high income of sugar yield in sugar beet varieties. Use of factor analysis by plant breeders has the potential of increasing the comprehension of the casual relationship of variables and can help to determine the nature and sequence of traits to be selected in a breeding program or evaluation sugar beet varieties trails.

Conclusion

Under these conditions of work, it could be recommended that growing sugar beet varieties with fertilization of 100 kg N/fed and boron application at the rate of 150 ppm boron/fed increases roots, tops and corrected sugar yield t/fed. Sara variety plants gave the highest values of root and corrected sugar yield when applied by 150 ppm boron/fed. Factor analysis grouped the studied nine traits as sugar yield components into two main factors accounting for 74.65% of the total variability in the dependence structure. Factor I included six variables which accounted for 44.73% of the total variability. The six variables were root fresh weight, leaf area index, sodium, nitrogen, top yield and root yield. It contains the variables usually regarded as a growth factor. The six variables had high communality with factor I. Therefore, this factor may be called growth and nitrogen factor. Factor II was responsible for 29.92% of the total variability in the dependence structure. It included three traits namely: sucrose%, potassium and quality.

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إستجابة حاصل وجودة بعض أصناف بنجر السكر للتسميد بالنيتروجين والبورون فى الأراضى الرملية

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ملخص

أجريت تجربة حقلية بمنطقة النوبارية بمحافظة البحيرة – مصر فى موسمي 2018/2017، 2019/2018 بهدف دراسة تأثير مستويان من الرش الورقى بالبورون (صفر، 150 جزء فى المليون/فدان من البورون) ومستويات من التسميد النيتروجينى (ثلاث مستويات 80، 100، 120 كجم ن/فدان) على إستجابة حاصل وجودة ثلاثة من أصناف بنجر السكر (بيتاماكس، دينا وساره) فى الأراضى الرمليه. إستخدم تصميم القطع المنشقة مرتين فى ثلاثة مكررات. زرعت تقاوى الأصناف فى الأسبوع الأول من شهر أكتوبر وحصدت بعد 210 يوماً من الزراعه فى كلا الموسمين. أظهرت النتائج المتحصل عليها الأتى: سجلت معاملة الرش الورقى بمعدل 150 جزء فى المليون بورون/فدان على نباتات بنجر السكر زيادة معنوية فى قيم الوزن الطازج للجذر، حاصل الجذور لكلا الموسمين مقارنة بالمعامله القياسيه. بينما اعطت المعامله بالبورون تأثيرا ايجابي خافض للشوائب (الصوديوم – البوتاسيوم و النيتروجين الأمينى)؛ فى كل الحالات تأثرت لحد كبير صفات نسبة السكروز، نسبة السكر المصحح، دليل جودة السكر، وحاصل السكر المصحح بالطن/فدان بالرش الورقى بالبورون فى كلا الموسمين. أدت إضافة النيتروجين أرضياً بمعدل 100 كجم/فدان إلى زيادات معنويه الوزن الطازج للجذر، حاصل كل من الجذور والعرش طن/فدان فى كلا الموسمين مقارنة بالقطع التجريبيه المعامله بمعدل 80 كجم ن/فدان. نباتات بنجر السكر المسمدة بمعدل 100 كجم ن/فدان كانت كافية لإنتاج القيم الأعلي فى نسبة السكروز، نسبة السكر المصحح% ودليل جودة السكر وحاصل السكر المصحح بالطن/فدان فى كلا الموسمين. أظهر الصنف ساره تفوقاً ملحوظاً على باقى الأصناف فى دليل مساحة الورقه، الوزن الطازج للجذور، وحاصل كل من الجذور والعرش لكلا الموسمين. فى حين أحرز الصنف بيتاماكس القيم الاقل فى محتوى الشوائب فى كلا الموسمين. نتجت المتوسطات الأعلى من وزن الجذر الطازج وحاصلى الجذور والعرش من البورون بمعدل 150 جزء فى المليون بورون/فدان، 100 كجم نيتروجين/فدان المعامل على نباتات بنجر السكر. معاملة الرش بمعدل 150 جزء فى المليون بورون/فدان على نباتات الصنف ساره أنتجت القيم الأعلى فى الوزن الطازج للجذر وحاصل الجذور فى كلا الموسمين.

أوضحت النتائج وجود إرتباطات معنوية موجبة بين محصول السكر وكل من محصول الجذور، ومحصول العرش، ودليل مساحة الأوراق، والنسبة المئوية للسكروز، والنيتروجين، والجودة. وإرتباط معنوي موجب بين الجودة والنسبة المئوية للسكروز بينما أظهرت وجود إرتباط معنوي سالب بين الجودة وكل من البوتاسيوم، والصوديوم. أظهرت نتائج تحليل العامل أن الصفات تحت الدراسة تجمعت في عاملين ساهما 74.65بنحو % في التباين الكلي لمحصول السكر، ةقد تضمن العامل الأول صفات وزن الجذور الطازج، ودليل مساحة الأوراق، والصوديوم، والنيتروجين، ومحصول العرش، ومحصول الجذور، وقد ساهم هذا العامل بنحو 44.73% من التباين الكلي لمحصول السكر وسمي بعامل النمو والنيتروجين. أما العامل الثاني فقد ساهم بنحو 29.92% في التباين الكلي لمحصول السكر وإشتمل علي صفة النسبة المئوية للسكروز، والبوتاسيوم، والجودة وسمي بعامل السكر والجودة.

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