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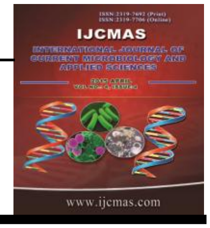

Original Research Article

Sugar Beet Productivity As Affected By Nitrogen Fertilizer and Foliar Spraying With Boron

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A B S T R A C T

Two field experiments were conducted at the farm of the Faculty of Agriculture, Demo, Fayoum University, Egypt, during 2012/13 and 2013/14 growing seasons. The objective of this investigation was to study the effect of nitrogen fertilization and boron foliar spraying on plant traits, juice quality and yield of Kawemira sugar beet variety grown in sandy loam soil. The experimental design was a split-plot design with three replications. Two levels of nitrogen *i.e.*, 100 (N_1) and 140 (N_2) kg N/fed were allocated in the main plots and six boron concentrations *i.e.*, 0 (B_0), 30 (B_1), 60 (B_2), 90 (B_3), 120 (B_4) and 150 (B_5) ppm applied at two times (80 and 110 days) after sowing in the sub-plots. Results indicated that N levels significantly increased all studied traits *i.e.*, root length and diameter, as well as root, and top fresh weight, in addition to yield of root, top, biological, gross sugar, white sugar and loss sugar, also K, Na and α-amino N. Whereas harvest index was decreased. Insignificant differences were observed on white sugar and purity (%). Application of 120 (B_4) and 150 (B_5) ppm boron significantly improved root yield and its attributes and percentage of gross and white sugar. On contrarily Na, K, α-amino N, loss sugar percentages, harvest index and loss sugar yield were decreased. Maximum root, top, sugar yields/fed and root quality produced by 140 (N_2) kg N/fed and 120 (B_4) and/or 150 (B_5) ppm boron. Correlation analysis revealed the presence of highly significant r values between gross sugar yield with each of root yield and gross sugar (%). The letter two traits were among ones contributed to variation of the former trait.

Keywords

Sugar beet
Beta vulgaris L.
Nitrogen
Boron
Sugar yield
Quality
Correlation

Introduction

Sugar beet (*Beta vulgaris* L.) is the second crop for sugar production in Egypt after sugar cane. Recently, sugar beet crop has been favorable importance in local crop rotation as a winter crop not only in fertile soils, but also in poor, saline, alkaline and calcareous soils. Moreover, it could be economically grown in newly reclaimed soils. Nowadays, manure is being extensively used as a robust tool to maximize crop productivity. Deficiency of soil nutrients such as nitrogen, phosphorus, potassium, zinc and boron has been identified as the major constraints in beet crop production and, based on plant needs, should be added to the soil accordingly. The availability of micronutrients in the soil can strongly affect the production and quality of sugar beet.

Nitrogen being "the motor of plant growth, while unbalanced and excess will decrease quality of crops particularly storage ability" (FAO and IFA, 2000). Nitrogen fertilizer has a pronounced effect on the growth, physiological and chemical characteristics of the yield and quality of sugar beet. There by, nitrogen fertilization should be managed to produce high root tonnage with high sucrose concentration and purity levels. In this respect, El-Harriri and Gobarah Mirvat (2001) and Nawar and Saleh (2003), found that increasing nitrogen application as soil fertilizer significantly increased length, diameter and weight of roots as well as root, top and sugar yield t/fed. Moreover, impurities in terms of potassium, sodium and α-amino nitrogen as well as sugar loss in molasses were significantly increases by increasing nitrogen levels (Ramadan *et al.*, 2003).

Foliar spraying of boron found to be increased root yield since roots absorbed boric acid and its uptake depending on soil pH and soil boron content (Gerendas and Sattelmatcher, 1990) due to chloroplast formation and sink limitations (Tersahima and Evans, 1988) and changes in cell wall which affected by boron deficit and led to secondary effects in plant metabolism, development and growth (Loomis and Durst, 1992). Boron is by far the most important trace elements needed for sugar beet because without an adequate supply, the yield and quality of roots is very depressed (Cooke and Scott 1993). Soil application, as well as, a foliar spray of boron were equally effective, hence the root fresh weight, sucrose %, root and top yields significantly increased by increasing boron levels (Jaszczolt, 1998). Barker and Pilbeam (2007) stated that sugar beet crop has high requirements for boron.

Gobarah Mirvat and Mekki (2005) revealed that application of boron rates from zero up to 1.5 Kg/acre increased root length, diameter and root yield. Moreover, increasing boron fertilizer up to 2.0 Kg/acre resulted in the highest sugar yield (6.611 t/acre). Sucrose and juice purity percentages were also increased by adding higher concentration of boron which might be attributed to decrease Na and K uptake in root juice. Similar results were recorded by Gezgin *et al.* (2001), Dordas *et al.* (2007), Hellal *et al.* (2009) and Kristek *et al.* (2009). Armin and Asgharipour (2012) who indicated that highest root yield and sucrose concentration were obtained by spraying with 12% boric acid. Therefore, the objective of this work aimed to investigate the effect of different nitrogen and boron rates on root yield and quality of Kawemira sugar beet variety.

Materials and Methods

Two field experiments were conducted at the farm of the Faculty of Agriculture, Demo (29°17` N; 30°53` E), Fayoum University, Egypt, during the two successive seasons of 2012/13 and 2013/14. The objective of this investigation was to study the effect of nitrogen and boron fertilizer rates on plant characteristics, juice quality and yield of Kawemira sugar beet variety under sandy loam soil with an electrical conductivity (ECe) of 3.36 (dS/m) and a pH of 7.52. Each experimental basic unit included 5 ridges, 60 cm apart and 3.5 m long, comprising an area of 10.5 m^2 (1/400 fed). The preceding summer crop was corn (*Zea mays* L.) in both seasons. Experiments were sown on September 12^{th} and 17^{th} in the first and second seasons, respectively. Sugar beet was hand sown 3-5 balls/hill using dry sowing method on one side of the ridge in hills 20 cm apart. Plants were thinned to one plant/hill (35000 plants/ fed) at the age of 35 days. The recommended agricultural practices for growing sugar beet were followed except the factors under study which arranged in split-plot design. Nitrogen levels as 100 (N_1) and 140 (N_2) kg N\fed were arranged in the main treatments and applied in three equal doses. While, six boron rates in the form of boric acid *i.e.* 0 (B_0), 30 (B_1), 60 (B_2), 90 (B_3), 120 (B_4) and 150 (B5) ppm were applied as foliar spray in two sprays (80 and 110 days) and randomly distributed in sub treatments. The foliar solutions volume was 200 L/fed conducted by hand sprayer. Physical and chemical analyses of soil at the experimental site in both seasons of study are presented in Table 1.

The studied traits

Yield and Yield Components

At harvest (210 days from sowing), five plants were chosen at random from the inner ridges of each plot to determine yield components traits as follows:

1. Root length (cm).
2. Root diameter (cm).
3. Root fresh weight (kg/plant).
4. Top fresh weight (kg/ plant).
5. Harvest index (HI): was calculated by using the following equation

$$HI = \frac{Root\ yield\ (t/fed)}{Root\ yield\ (t/fed) + Top\ yield\ (t/fed)}$$

From each plot, at harvesting time, were collected and cleaned, and then roots and tops were separated and weighted in kilograms and converted to estimate:

1. Root yield (t/fed).
2. Top yield (t/fed).
3. Gross sugar yield (t/fad). It was calculated by multiplying root yield by gross sugar percentage.
4. White sugar yield (t/fad). It was calculated by multiplying root yield by white sugar percentage.
5. Losses sugar yield (t/fad). It was calculated by multiplying root yield by loss sugar percentage.

Quality parameters

All parameters were determined in Delta Sugar Company Limited Laboratories at El-Hamoul, Kafr El-Sheikh Governorate according to the method of McGinnus (1971).

The parameters of quality included:

1. Gross sugar %

Juice sugar content of each treatment was determined by means of an Automatic Sugar Polarimetric according to McGinnus (1971).

2. Extractable white sugar %

Corrected sugar content (white sugar) of beets was calculated by linking the beet non-sugar K, Na and α-amino N (expressed as a mill equivalent/100 g of beet) according to Harvey and Dotton (1993) as follows:

$$ZB = pol-[0.343(K+NA) + 0.094\ AmN + 0.29]$$

Where:

ZB = Corrected sugar content (% per beet) or extractable white sugar
Pol = Gross sugar %
AmN = α -amino-N determined by the “blue number method”.

3. Loss sugar% = Gross sugar % - white sugar %

4. Juice purity percentage

Juice purity % (Qz) = ZB/ Pol x100

5. Soluble non-sugar content

The soluble non-sugars (potassium, sodium and α -amino nitrogen in meq/100 g of beet) in roots were determined by means of an Automatic Sugar Polarimetric.

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the spilt plot design as published by Gomez and Gomez (1984), using MSTAT statistical package (MSTAT-C). Least Significant Difference (LSD) method was used to test the differences between treatment means at 5% level of probability.

Result and Discussion

A. Effect of nitrogen fertilization

The results in Tables 2, 3 and 4 show that root and top fresh weight, harvest index, yield of root, top, biological, gross sugar, white sugar and loss sugar t\fed., impurities in terms of (Na, K and α-amino N) and loss sugar % in both seasons were significantly ($P \leq 0.05$) affected by application of 140 (N2) kg N/fed compared with application of 100 (N_1) kg N/fed. Root length and diameter (cm) in the 1st season and gross sucrose (%) in the 2nd season were also affected by the same manner. It could be stated that application of the higher level of nitrogen 140 (N_2) kg N/fed significantly increased all studied growth, yield and quality of sugar beet traits and consequently produced the highest values. It was noticed that applying 140 (N_2) kg N/fed caused significant increases in root fresh weight, top fresh weight, root yield, top yield, biological yield, gross sugar yield, white sugar yield and loss sugar yield by 17.78 & 29.13; 45.95 & 38.46; 6.84 & 11.97; 28.68 & 21.69; 11.04 & 13.57; 14.93 & 17.84; 14.57 & 16.92 and 20.51 & 35.29 %, in the first and second season respectively compared with 100 (N_1) kg N/fed. Harvest index of the crop received 140 kg N/fed was significantly decreased by 3.85 & 1.20 % in the two season respectively compared to 100 (N_1) kg N/fed. Overall, nitrogen fertilizer application of 140 (N_2) kg N/fed recorded the highest values for all studied traits. On the other hand, the application of 100 (N_1) kg N/fed recorded the lowest values, except harvest index. While, insignificant differences were observed between two levels of nitrogen application on white sugar and purity (%). The increase in root and sugar yield as a result of increasing nitrogen fertilizer levels may be due to the importance of nitrogen as one of the macronutrient elements for plant nutrition and its role in increasing vegetative growth through enhancing leaf initiation, increment chlorophyll concentration in leaves which may reflected in improving photosynthesis process and increasing fresh root weight. The previous results are in harmony with those reported by Jozefyova *et al.* (2004), Kandil *et al.* (2004), Leilah *et al.* (2005), Stevens *et al.* (2008), Abd El-Motagally and Attia (2009), Stevens (2011) and Mekdad (2012). The non-sucrose components most relevant for “technical quality” of sugar beet are potassium, sodium and α-amino nitrogen. The soluble non-sugars K, Na and α-amino-N in fresh root (mg/100 g beet) are regarded as impurities because they interfere with sugar extraction. Values of K, Na and α-amino-N as affected by nitrogen fertilizer were shown in Table 4. There was evidence for significant difference in soluble non-sugar due to nitrogen application in both seasons for K, Na and α-amino-N %. The nitrogen level of 140 (N_2) Kg/fed gave the highest values of K, Na and α-amino-N% (4.24, 0.99 and 1.60) in the first season and (4.23, 1.17 and 1.54) in the second season, respectively. Excess nitrogen fertilizer may decrease the sugar percentage, lowering the recoverable sugar and increasing the impurities or non-sucrose substances such as proteins and α- N content.

Also, there was an increase in the absorption of Na element from the soil by roots accompanied with increasing nitrogen fertilizer level. The previous findings are supported by those obtained by Lauer (1995), Smit *et al.* (1995), Jozefyova *et al.* (2004), Hoffmann (2005), Tsialtas and Maslaris (2005), Awad-Allah *et al.* (2007), Seadh *et al.* (2007), Telep, *et al.* (2008), Abd EL-Motagally and Attia (2009), Manderscheid *et al.* (2010), and Gobarah Mirvat *et al.* (2011), who found that increasing N supply increased juice impurities such as Na content.

B. Effect of Boron Concentrations

A significant effect was detected due to boron concentrations applied on root length and diameter, root and top fresh weight, root yield, top yield, biological yield, gross and white sugar yield, loss sugar yield, harvest index, gross and white sugar %, purity %, impurities in terms of (Na, K and α-amino N) and loss sugar % in both seasons. Increasing boron concentrations up to 120 (B_4) and 150 (B_5) ppm significantly ($P \leq 0.05$) increased all studied traits. Foliar spraying of boron at 120 (B_4) and 150 (B_5) ppm increased root length, root diameter, root and top fresh weight, root yield, top yield, biological yield, gross and white sugar yield, gross and white sugar and purity (%) by 18.98 & 21.73; 20.37 & 24.28; 46.28 & 70.91; 93.75 & 60.00; 19.23 & 23.58; 54.89 & 66.33; 24.14 & 30.01; 34.55 & 37.48; 38.60 & 42.77; 12.89 & 12.28; 16.35 & 16.55 and 3.48 & 3.94 %, in the first and second season respectively compared with the control treatment. While harvest index, impurities in terms of (Na, K and α-amino N), and loss sugar decreased by 6.10& 4.71; 61.60&59.40; 20.05&24.02; 40.00&45.58 and 33.99&36.88 % in the two season respectively compared to the control treatment. The positive effect of boron may be due to its role in cell elongation where, in case of boron deficiency, plant leaves were smaller, stiff and thick. Gobarah Mirvat and Mekki (2005), indicated that root yield, sucrose percentage increased by boron addition which may be attributed to decrease Na and K uptake in root juice. These results are in harmony with those obtained by Hellal *et al.* (2009), Abido (2012), Armin and Asgharipour (2012), Abbas *et al.* (2014) and Dewdar *et al.* (2015).

C. Interactions Effect

Regarding the interaction effect between nitrogen and boron foliar spraying, the results clearly showed a significant ($P \leq 0.05$) effect on Na, K, sugar molasses and purity percentages which presented in figures 5, 6, 7 and 8 respectively, also loss sugar yield figure 3 in both seasons, as well as root diameter (Fig. 1) in the first season, top fresh weight and α-amino N (Fig. 2 and 4) in the second one. While, insignificant differences were observed between the combined application of N+B treatments on root length, root fresh weight, gross and white sugar %, root yield, top yield, biological yield, harvest index, gross and white sugar yield. It could be stated that highest averages of root diameter, top fresh weight and purity were obtained from 140 (N_2) kg N /fed with 120 (B_4) and 150 (B_5) ppm boron.

Table.1 Physical and chemical analysis of soil at the experimental site in the two seasons of the study

Seasons	2012/13	2013/14
Physical analysis		
coarse sand%	59.3	58.1
fine sand%	15.7	14.9
Loam%	13.7	15.1
clay%	11.3	11.9
Texture class	Sandy loam	Sandy loam
Chemical analysis		
ECe (ds/m)	3.12	3.61
pH	7.54	7.51
Organic matter %	1.09	1.11
available N (ppm)	52.7	54.6
available P (ppm)	5.19	5.39
available K (ppm)	141	149

Fig.1

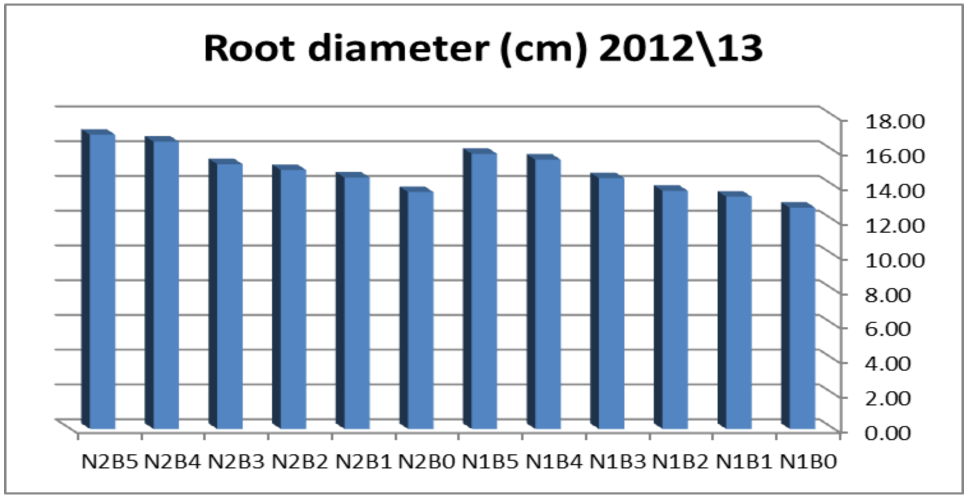


Table.2 Effect of nitrogen and boron fertilizer levels on sugar beet quantity (root length and diameter, root and top fresh wt., root and top yield) in 2012/13 and 2013/14 seasons

Treatments	Root length (cm)		Root diameter (cm)		Root fresh wt. (kg/plant)		Top fresh wt. (kg/plant)		Root yield (t/fed)		Top yield (t/fed)	
	2012\13	**2013\14**	**2012\13**	**2013\14**	**2012\13**	**2013\14**	**2012\13**	**2013\14**	**2012\13**	**2013\14**	**2012\13**	**2013\14**
A- Nitrogen fertilization												
100 kg N/fed (N1)	35.82	36.93	13.42	14.26	1.35	1.27	0.37	0.26	33.04	29.41	7.74	5.81
140 kg N/fed (N2)	37.70	38.82	14.44	15.28	1.59	1.64	0.54	0.36	35.30	32.93	9.96	7.07
LSD (5%)	1.60*	NS	0.81*	NS	0.11*	0.12**	0.14*	0.02**	1.69*	3.00*	0.66**	1.12*
B- Boron concentration (ppm)												
Control without 0 (B0)	34.25	34.56	12.96	13.18	1.21	1.10	0.32	0.25	31.67	28.37	7.05	5.02
Boron 30 ppm (B1)	34.77	35.69	13.21	13.92	1.35	1.20	0.37	0.26	32.31	28.73	7.75	5.34
Boron 60 ppm (B2)	35.34	36.93	13.57	14.30	1.44	1.37	0.41	0.28	33.28	29.49	8.16	5.75
Boron 90 ppm (B3)	36.93	38.36	13.99	14.84	1.49	1.49	0.47	0.30	34.38	30.64	8.89	6.41
Boron 120 ppm (B4)	40.75	42.07	15.60	16.02	1.77	1.67	0.54	0.38	37.76	34.76	10.33	7.76
Boron 150 ppm (B5)	38.53	39.65	14.24	16.38	1.57	1.88	0.62	0.40	35.63	35.06	10.92	8.35
LSD (5%)	0.89**	2.49**	0.40**	0.41**	0.10**	0.12**	0.04**	0.02**	1.16**	0.97**	0.72**	0.56**
C-Interaction	**NS**	**NS**	**0.56****	**NS**	**NS**	**NS**	**NS**	**0.03****	**NS**	**NS**	**NS**	**NS**

Table.3 Effect of nitrogen and boron fertilizer levels on sugar beet quantity (harvest index, yields of biological, gross sugar, white sugar and loss sugar) in 2012/13 and 2013/14 seasons

Treatments	**Biological yield**		**Harvest index %**		**Gross sugar yield**		**White sugar yield**		**Loss sugar yield**	
	2012\13	**2013\14**	**2012\13**	**2013\14**	**2012\13**	**2013\14**	**2012\13**	**2013\14**	**2012\13**	**2013\14**
					A- Nitrogen fertilization					
100 kg N/fed (N_1)	40.77	35.22	0.81	0.84	6.43	5.55	6.04	5.20	0.39	0.34
140 kg N/fed (N_2)	45.27	40.00	0.78	0.83	7.39	6.54	6.92	6.08	0.47	0.46
LSD (5%)	2.03*	4.13*	0.01**	0.01*	0.69*	0.52*	0.66*	0.48*	0.02*	0.09*
					B- Boron concentration (ppm)					
Control without 0 (B_0)	38.73	33.39	0.82	0.85	6.05	5.23	5.57	4.77	0.49	0.46
Boron 30 ppm (B_1)	40.05	34.06	081	0.84	6.29	5.34	5.83	4.90	0.47	0.44
Boron 60 ppm (B_2)	41.44	35.24	0.80	0.83	6.55	5.59	6.11	5.18	0.44	0.41
Boron 90 ppm (B_3)	43.27	37.06	0.79	0.82	6.91	5.92	6.50	5.54	0.41	0.38
Boron 120 ppm (B_4)	48.08	42.51	0.79	0.82	8.14	7.19	7.72	6.81	0.43	0.37
Boron 150 ppm (B_5)	46.54	43.41	0.77	0.81	7.52	6.99	7.16	6.64	0.36	0.36
LSD (5%)	1.67**	1.32**	0.01**	0.01**	0.25**	0.25**	0.23**	0.25**	0.04**	0.02**
C-Interaction	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.05****	**0.03****

Table.4 Effect of nitrogen and boron fertilizer levels on sugar beet quality (gross sugar, white sugar, α-amino, Na, K, purity and loss sugar %) in 2012/13 and 2013/14 seasons

Treatments	Gross sugar %		White sugar %		α-amino N %		Na %		K %		Purity %		Loss sugar %	
	2012\13	2013\14	2012\13	2013\14	2012\13	2013\14	2012\13	2013\14	2012\13	2013\14	2012\13	2013\14	2012\13	2013\14
A- Nitrogen fertilization														
100 kg N/fed (N1)	19.39	18.79	18.21	17.59	0.66	0.72	0.66	0.68	3.82	3.85	93.85	93.58	1.18	1.20
140 kg N/fed (N2)	20.91	19.79	19.56	18.37	1.60	1.54	0.99	1.17	4.24	4.23	93.47	92.78	1.35	1.42
LSD (5%)	NS	0.66	NS	NS	0.21**	0.79*	0.18*	0.42*	0.19*	0.27*	NS	NS	0.09**	0.18*
B- Boron concentration (ppm)														
Control without 0 (B_0)	19.08	18.40	17.55	16.80	1.40	1.47	1.25	1.33	4.44	4.58	92.01	91.32	1.53	1.60
Boron 30 ppm (B_1)	19.46	18.54	18.02	17.01	1.33	1.38	1.08	1.23	4.32	4.47	92.65	91.75	1.43	1.54
Boron 60 ppm (B_2)	19.65	18.93	18.34	17.54	1.24	1.22	0.90	1.05	4.12	4.16	93.33	92.72	1.31	1.38
Boron 90 ppm (B_3)	20.07	19.28	18.88	18.04	1.04	1.02	0.68	0.82	3.95	3.91	94.02	93.61	1.20	1.23
Boron 120 ppm (B_4)	21.54	20.66	20.42	19.58	0.92	0.89	0.55	0.60	3.82	3.63	94.78	94.78	1.12	1.08
Boron 150 ppm (B_5)	21.10	19.94	20.08	18.92	0.84	0.80	0.48	0.54	3.55	3.48	95.21	94.92	1.01	1.01
LSD (5%)	0.57**	0.41**	0.55**	0.42**	0.20**	0.26**	0.14**	0.08**	0.14**	0.20**	0.41**	0.37**	0.08**	0.07**
C-Interaction	**NS**	**NS**	**NS**	**NS**	**NS**	**0.36***	**0.20****	**0.12****	**0.20****	**0.28****	**0.57****	**0.53****	**0.11****	**0.09****

Table.5 A matrix of simple correlation coefficient between gross sugar yield and other important traits estimated in 2012/13 season

	Character	1	2	3	4	5	6	7	8	9
1	**Gross sugar**	**1**								
2	**Root length**	**0.892****	**1**							
3	**Root diameter**	**0.859****	**0.902****	**1**						
4	**Root fresh wt.**	**0.891****	**0.846****	**0.872****	**1**					
5	**Top fresh wt.**	**0.826****	**0.787****	**0.698****	**0.794****	**1**				
6	**Root yield**	**0.951****	**0.837****	**0.817****	**0.828****	**0.707****	**1**			
7	**Top yield**	**0.886****	**0.817****	**0.738****	**0.806****	**0.908****	**0.847****	**1**		
8	**Gross sugar**	**0.931****	**0.832****	**0.787****	**0.848****	**0.871****	**0.774****	**0.827****	**1**	
9	**Purity (%)**	**0.538****	**0.703****	**0.502****	**0.548****	**0.639****	**0.478****	**0.564****	**0.523****	**1**

** Correlation coefficient is significant at $P \leq 0.01$

Table.6 A matrix of simple correlation coefficient between gross sugar yield and other important traits estimated in 2013/14 season

	Character	1	2	3	4	5	6	7	8	9
1	**Gross sugar**	**1**								
2	**Root length**	**0.727***	**1**							
3	**Root diameter**	**0.884***	**0.713***	**1**						
4	**Root fresh wt.**	**0.865***	**0.628***	**0.889***	**1**					
5	**Top fresh wt.**	**0.871***	**0.538***	**0.813***	**0.901***	**1**				
6	**Root yield**	**0.987***	**0.731***	**0.877***	**0.872***	**0.864***	**1**			
7	**Top yield**	**0.928***	**0.676***	**0.907***	**0.884***	**0.849***	**0.947***	**1**		
8	**Gross sugar**	**0.947***	**0.656***	**0.836***	**0.796***	**0.797***	**0.885***	**0.814***	**1**	
9	**Purity (%)**	**0.593***	**0.534***	**0.685***	**0.557***	**0.513***	**0.569***	**0.656***	**0.572***	**1**

** Correlation coefficient is significant at $P \leq 0.01$

Table.7 Correlation coefficient (r), coefficient of determination (R2) and standard error of the estimates (SEE) for predicting gross sugar yield in 2012/13 and 2013/14 seasons

Season	r	R^2	SEE	Sig.	Fitted equation
2012/13	**0.999**	**0.999**	**0.032**	***	Gross sugar yield = -6.930 + 0.195 root yield + 0.334 sucrose + 0.012 root length
2013/14	**1.000**	**1.000**	**0.019**	***	Gross sugar yield = -6.740 + 0.188 root yield + 0.310 sucrose + 0.710 top fresh wt. – 0.148 root fresh wt. + 0.009 purity + 0.003 root length

Fig.2

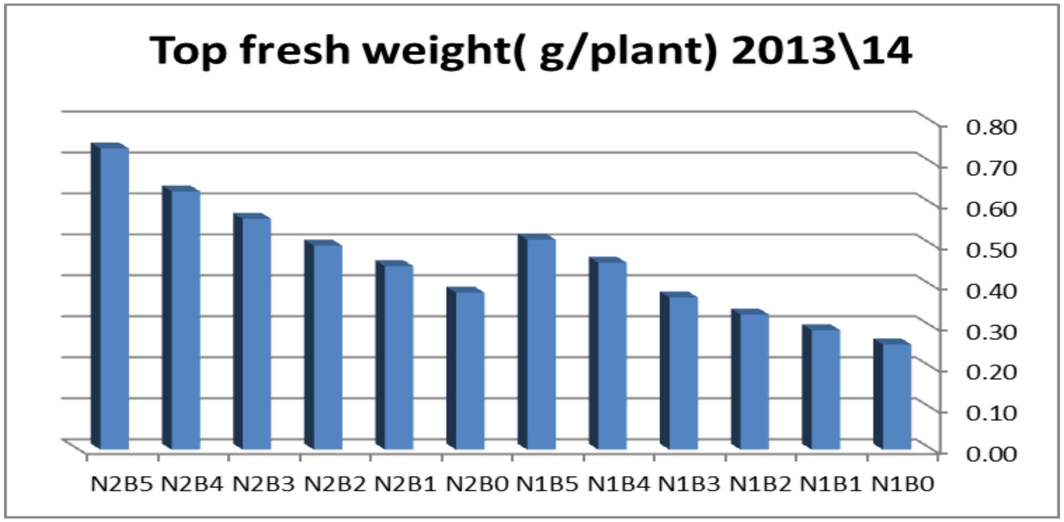


Fig.3

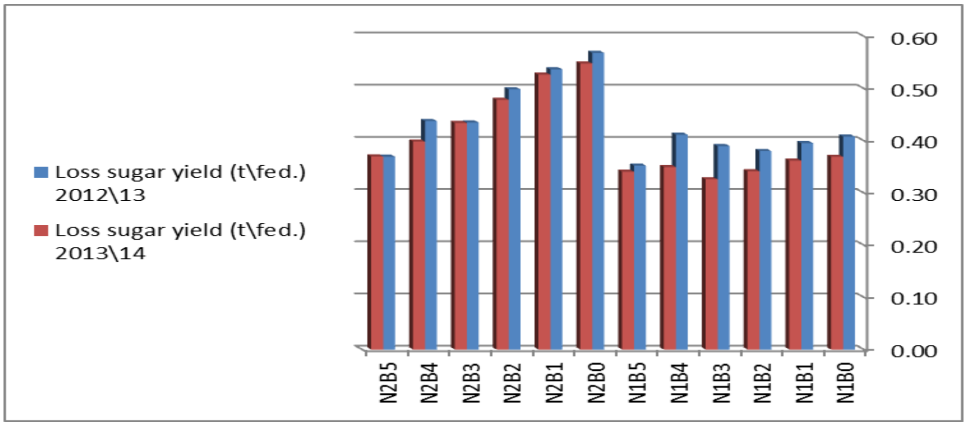


Fig.4

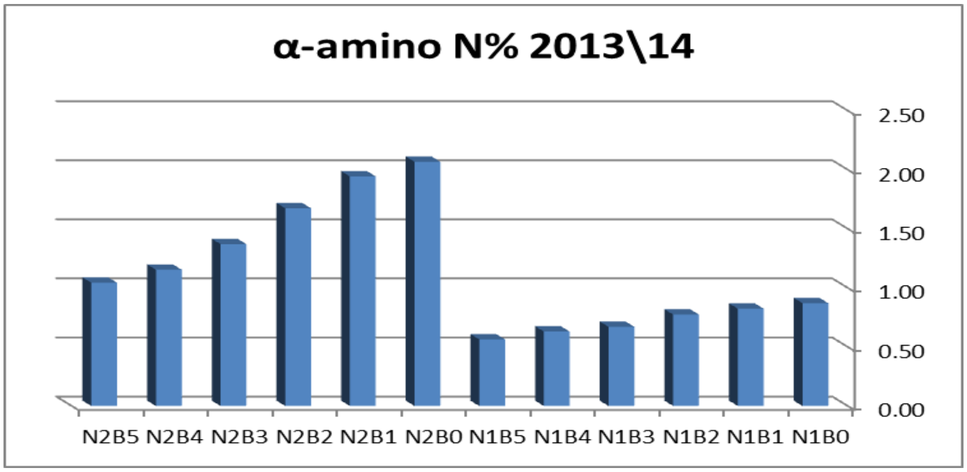


Fig.5

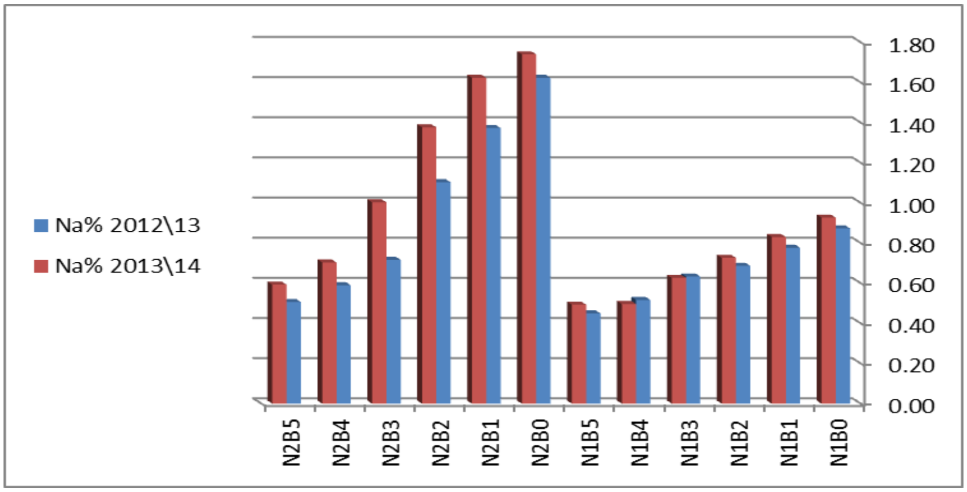


Fig.6

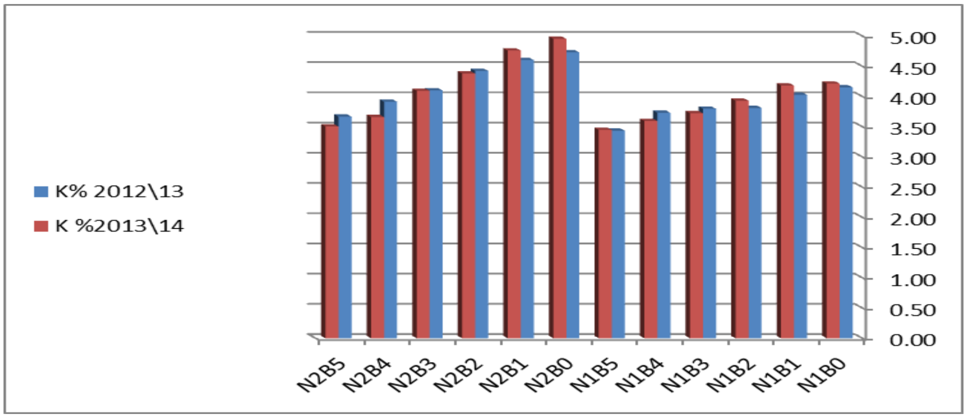


Fig.7

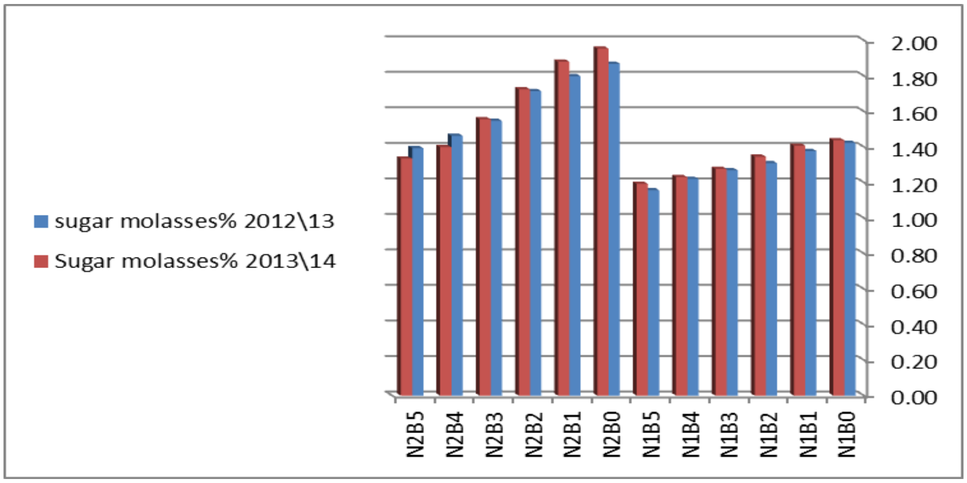
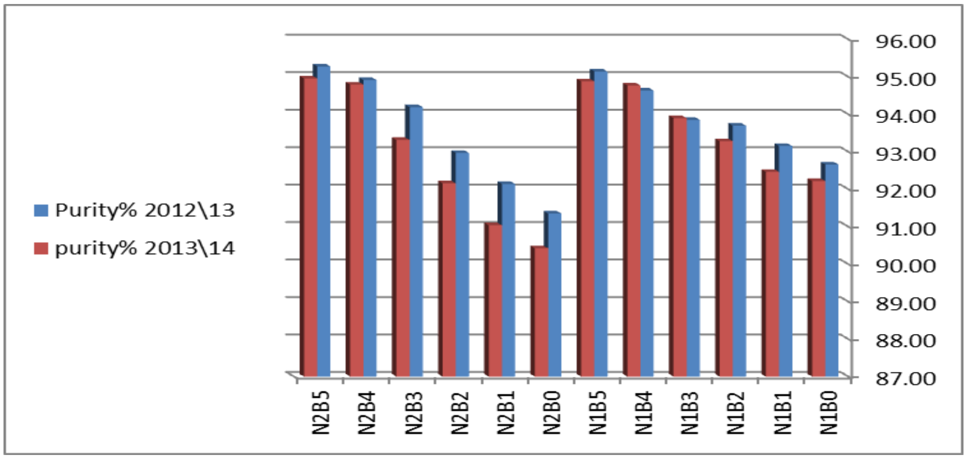


Fig.8



On the other hand, the highest values of loss sugar %, loss sugar yield and impurities in terms of (α- amino- N, Na and K) were recorded due to the interaction between 100 (N_1) kg N /fed and 0 (B_0) ppm boron. It could be recommended that to maximize sugar beet yields and root quality, 140 (N_2) kg N /fed together with 120 (B_4) and 150 (B_5) ppm boron should be applied.

Yield analysis study

Correlation coefficient: The correlation coefficients in Tables 5 and 6 between gross sugar yield and each of root length and diameter, root and top fresh weight, root and top yield, gross sugar and purity (%) were computed in order to throw light on the relationship of effectual traits interest. Positive and highly significant ($P \leq 0.01$) correlations were obtained between gross sugar yield and each of root yield in 1st season r = 0.951** and in 2nd season r = 0.987**, as well as gross sugar (%) in 1st season r = 0.931** and in 2nd season r = 0.947**. Also, positive and highly significant correlation coefficient were seen between root yield and top yield in 1st season r = 0.847** and in 2nd season r = 0.947**, as well as between root yield and gross sugar (%) in 1st season r = 0.774** and in 2nd season r = 0.885**. Positive and highly significant correlations were obtained between gross sugar yield and each of purity (%) in 1st season r = 0.538** and in 2nd season r = 0.5933**. The results obtained in Table 7 clarify that there are three traits *i.e*. root yield, gross sugar (%) and root length in 2012/13 season and six ones *i.e*. root yield, gross sugar (%), top fresh weight, root fresh weight, purity (%) and root length in 2013/14 season were significantly ($P \leq 0.001$) contributed to variation in gross sugar yield.

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