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EFFECT OF NITROGEN AND BIOFERTILIZATION ON YIELD AND QUALITY OF SUGAR BEET UNDER DRIP IRRIGATION IN NEWLY RECLAIMED SANDY SOILS

Abd El-Rahman E.A. Omar[1*] and Hanan Y. Mohamed[2]

1. Agron. Dept., Fac. Agric., Zagazig Univ., Egypt

2. Sugar Crops Res. Inst., Agric. Res. Center, Giza, Egypt

ABSTRACT

The present study was conducted in the Experimental Farm, El-Khattara region, Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt during 2009/2010 and 2010/2011 seasons. The study aimed to investigate the effect of nitrogen fertilizer levels (50, 75, 100 and 125 kg N/fad.) and biofertilization treatments (control, cerialine, potassiomag as well as cerialine + potassiomag) on yield and its attributes as well as juice quality of sugar beet under drip irrigation in sandy soils. Nitrogen fertilizer level had significant effect on all traits in the two seasons and their combined analysis. Increasing N fertilizer levels from 50 to 125 kg N/fad., caused significant increase in root dimensions (length and diameter), fresh top weight/plant, fresh root weight/plant, Na%, K%, sugar loss in molasses percentage (SLM%) and root yield/fad. Top and recoverable sugar yields were responded only to 100 kg N/fad. The highest averages of sugar%, purity% and extractable sugar % were produced from using low nitrogen levels (either 50 or 75 kg N/fad.). Biofertilization treatments had significant effect on root length, fresh top weight/plant, fresh root weight/plant, Na%, K% as well as top and root yields/fad. However, root diameter, sucrose%, alpha amino N%, purity%, SLM% and alkaline coefficient (AC) did not significantly influenced by applying biofertilizers. The highest recoverable sugar yield/fad., could be obtained by using either cerialine alone or in combination with potassiomag. The interaction between studied factors revealed significant effect on fresh root weight/plant, sucrose%, Na% and extractable sugar%.

Key words: Sugar beet, nitrogen levels, biofertilizers, sandy soils, yield and its attributes, juice quality.

INTRODUCTION

Sugar beet (*Beta vulgaris,* L.) has acquired more importance in Egypt and occupied the second source of sugar after sugar cane. This is because sugar beet is well adopted to grow in poor and saline soils, especially in reclaimed lands. Furthermore, for it's limited water requirements and it is better in water use efficiency as compared with sugar cane.

Nitrogen is the most important fertilizer element to be added under sandy soil conditions. Proper nitrogen nutrition in sugar beet production is crucial. Lack of nitrogen will result in significant reduction in root yields, while excess nitrogen will promote significant decrease in sucrose content of root and excessive leaf growth. Because of the significant effects of nitrogen on root yield and yield quality, the goal of nitrogen management in sugar beet is to supply enough nitrogen during beginning and middle part of the growing seasons to ensure optimal crop growth and canopy development and to exhaust soil nitrogen reserves toward the end of the growing season to obtain optimal yield quality (Blumentbal, 2002). Kandil *et al.* (2002) indicated that raising nitrogen level from zero to 20, 40, 60 and 80 kg N/fad., showed significant increase in root length, root diameter, root fresh weight/plant, foliage fresh weight/plant as well

* **Corresponding author: Tel. :** + 201005135701
E-mail address: omaromar1971@yahoo.com

as root, top and sugar yields/fad. On the contrary, they added that, highest averages of sucrose and purity percentages were obtained from the control treatment in both seasons. Ramadan *et al.* (2003) reported that sucrose and purity percentages as well as recoverable sugar content significantly decreased with increasing N application from 0 to 150 kg N/fad., in sandy soil. On the other hand, they found that impurity attributes (Na, K and alpha amino nitrogen) and sucrose loss to molasses, significantly increased with raising N level up to 150 kg N/fad. Geweifel *et al.* (2006) pointed out that, increasing nitrogen level from 96 to 210 kg N/ha caused significant increase in top, root and sugar yields and decreased sucrose % under sandy soil conditions in Egypt. Increasing nitrogen fertilizer levels caused significant differences in yield, yield components and quality of sugar beet (Seadh *et al.,* 2007; Seadh, 2008; Stevens *et al.,* 2008; Abdel-Motagally and Attia, 2009; Nemeat-Alla *et al.,* 2009 ; El-Hosry *et al.,* 2010 and Sarhan *et al.,* 2012). Furthermore, Gobarah *et al.,* (2010) reported that increasing N level from 60 to 150 kg N/fad., was associated with significant increase in root yield, yield components, Na, K and alpha amino nitrogen contents. The highest sugar yield (7.07 t/fad.) was produced from using nitrogen fertilizer up to 90 kg N/fad., in both seasons. Abashady *et al.,* (2011) found that, increasing nitrogen fertilizer level from 75 to 90 and 105 kg N/fad., caused significant increase in root, sugar and top yields as well as Na, K, alpha amino nitrogen content and sugar loss in molasses in both seasons. On the contrary, they reported that sucrose, purity, sugar extractable, extractability percentages and alkaline coefficient recorded low averages in both seasons. Osman (2011) indicated that increasing N level up to 120 kg N/fad., gave high averages of root length, root diameter, fresh weight/plant, root and sugar yields/fad., while a gradual reduction in sucrose % and purity % has been detected with increase nitrogen level over 80 kg N/fad. El-Sarag and Moselhy (2013) found that increasing N level from 105 to 211 kg N/ha caused significant increase in root, top and sugar yields/ha.

In the present time, great attention has been given to biofertilization as management tool for increasing crop production. Application of biofertilizers aims to minimize the environmental pollution of mineral fertilizers and to save its cost (Ouda, 2007). Sultan *et al.* (1999) and Bassal *et al.* (2001) indicated that inoculation of sugar beet seeds with azobacterin significantly increased sucrose %, purity %, root dimensions, root and sugar yields/fad. Abu El-Fotoh *et al.* (2000) reported that addition of biofertilizers (microbin + phosphorin) combined with NPK chemical fertilizers at the level of 50% of the recommended dose, produced significantly higher root and sugar yields and had positive effect on juice quality such as Na, K, alpha amino N, extractable sugar and total sugar percentages. Sugar beet seed biofertilization and / or N-fertilization significantly increased root, top and sugar yields/ha (Hassanein and Hassouna, 2000). Biofertilization treatments caused significant effect on root, top and sugar yields/fad., (Kandil *et al.,* 2002; Ramadan *et al.,* 2003; Badawi *et al.,* 2004; Amin, 2005; Ouda, 2007 and El-Hosry *et al.,* 2010). Abou Zeid and Osman (2005) and Aly *et al.,* (2009) reported that biofertilization treatments had no significant effect on root quality of sugar beet. El-Sayed and Abou Shady (2011) indicated that application of biofertilizer (Potassiomag) caused a significant increase in root length, root diameter, root weight/plant as well as N,P and K content compared with control while, sucrose % and purity % did not significantly affected by application of biofertilizer. Sarhan (2012) found that application of mixture of microbin + rhizobacterin + phosphorien produced the highest averages of root length, root diameter, root fresh weight, top fresh weight, sucrose %, purity % as well as root and sugar yields/fad., compared with using each biofertilizer alone. Therefore, this study aimed to investigate the effect of N fertilizer levels and biofertilization on yield attributes, yield and juice quality of sugar beet under newly reclaimed sandy soil conditions using drip irrigation system.

MATERIALS AND METHODS

Two field experiments were carried out in Agricultural Research Station, Faculty of Agriculture, Zagazig University at El-Khattara region, Sharkia Governorate, Egypt during the two successive seasons 2009/2010 and 2010/2011. The study aimed to investigate response of sugar beet to nitrogen levels and biofertilization on yield and its attributes as well as quality of sugar beet under drip irrigation system. The soil of the experimental site is sandy in texture where it has a particle size distribution of 92.45, 4.33 and 3.22% for sand, silt and clay, respectively. The soil had an average pH of 8.1 and organic matter content of 0.11%. The average available N, P and K contents were 12.3, 4.2 and 70 ppm, respectively. A split plot design with three replicates was used. The main plots assigned to four nitrogen fertilizer levels (50, 75, 100 and 125 kg N/fad.). Nitrogen fertilizer was applied in the form of ammonium sulphate (20.5% N), each level was spilt into four equal doses, the first was applied after thinning and the others were applied at 2-weeks interval after the first application. While, the subplots were devoted to the following four biofertilization treatments *i.e.* control (without adding biofertilizers), cerialine, potassiomag as well as cerialine + potassiomag.

Cerialine and potassiomag as commercial products were produced by Biofertilizer Unit, Agriculture Research Centre (ARC) Giza, Egypt, which included free-living bacteria able to fix atmospheric nitrogen and potassium in the rhizosphere of soil. Biofertilization treatments were done before sowing directly by mixing the recommended dose of each biofertilizer with sand as side-dress near from hills. The subplots area (15 m^2) included 5 rows of 5 m length and 60 cm apart. In both seasons, the preceding crop was sesame. Seeds of sugar beet variety "Panther" was planted at distance of 20 cm between hills on mid of October in the two growing seasons. Thinning was done after 35 days from planting to obtain one plant/hill (35000 plants/fad.). Phosphorus fertilizer was added during seed bed preparation at level of 31 kg P_2O_5/fad., in the form of calcium superphosphate (15.5% P_2O_5), while potassium fertilization was applied at level of 48 kg K_2O/ fad., as potassium sulphate (48% K_2O) in two equal doses, the first at seed bed preparation and the second after thinning. The other agronomic practices were carried out as recommended. On harvesting date (195 days from planting), a random sample of five guarded plants were taken from the second row to determine the yield attributes and juice quality as following: (a) yield attributes: 1- Root length (cm) 2- Root diameter (cm) 3- Top fresh weight (g/plant) 4- Root fresh weight (g/plant). (b) Juice quality: 1- Sucrose percentage (%) was determined using polarimeter on a lead acetate extract of fresh macerate root according to Le-Docte (1927). 2- Purity percentage (%) was calculated according to the following equation (Devillers, 1988): Purity% = 99.36 – [14.27 (Na+K+alpha amino nitrogen)/sucrose%]. 3- Impurities (Na, K and alpha amino nitrogen) were determined according to AOAC (2005). 4- Sugar loss to molasses percentage (SLM%) = 0.14 (Na+K) + 0.25 (alpha amino nitrogen) + 0.50 (Devillers, 1988). 5- Extractable sugar percentage (%) = sucrose % - SLM – 0.60 (Dexter *et al.,* 1967). 6- Alkalinity coefficient (AC) was determined as described by Harvey and Dutton (1993) as follows AC = K + Na / alpha amino nitrogen.

Thereafter, a bulk sample which included all sugar beet plants of the third and fourth central rows of each plot (6 m^2) was taken to estimate top and root yields (t/fad.) as well recoverable sugar yield (t/fad.) by multiplying root yield x extractable sugar %.

Data were analyzed according to Gomez and Gomez (1984). Treatment means were compared using Least Significant Differences (L.S.D.) test at 0.05 level of probability (Waller and Duncan, 1969). The error mean squares of split-split plot design were homogenous (Bartlett's test), the combined analysis was calculated for all the studied characters in both seasons. Statistical analysis was performed by using analysis of variance technique of (MSTAT-C 1991) computer software package.

In interaction tables, capital and small letters were used to compare rows and columns means, respectively.

RESULTS AND DISCUSSION

Yield Attributes

Effect of nitrogen fertilizer levels

Results presented in Table 1 show that N fertilizer level had significant effect on all yield attribute traits in both seasons and their combined analysis. Increasing N fertilizer level from 50 to 125 kg N/fad., was associated with significant increase in root length, root diameter, fresh top weight/plant and fresh root weight/plant in both seasons and their combined analysis, while the response of root length, fresh top weight/plant and fresh root weight/plant responded only to application of 100 kg N/fad., in the second season. These results confirm the role of nitrogen in division as well as building organic metabolites which in turn translocated to be stored in sugar beet roots (Gobarah *et al.,* 2010). These favorable effects for nitrogen fertilizer application were rather expected since the soil was sandy poor fertile one. The positive effect of N application on yield attributes was also reported by many workers (Ramadan *et al.,* 2003; Geweifel *et al.,* 2006; Stevens *et al.,* 2008; Abdel-Motagally and Attia, 2009; El-Hosry *et al.,* 2010 and Sarhan *et al.,* 2012).

Effect of biofertilization

Results presented in Table 1 indicate that biofertilization treatments significantly affected root length, fresh top weight/plant and fresh root weight/plant, while root length in the second season and root diameter in both seasons and their combined analysis were not significantly affected by applying biofertilizers. It was clear that addition either cerialine alone or in combination with potassiomag were associated with the highest averages of fresh root weight/plant in the second season and combined analysis. However, application of potassiomag recorded highest averages of fresh top weight/ plant in the first season and combined analysis. Furthermore, all biofertilizer treatments were at par and surpassed the control treatment (without biofertilizer application) in root length according to first season and combined analysis. These results are in harmony with those obtained by Sultan *et al.* (1999), Bassal *et al.* (2001), Kandil *et al.* (2002), Amin (2005), Ouda (2007), El-Sayed and Abou Shady (2011) and Sarhan (2012).

Interaction effect

Results in Table 1-a indicate that fresh root weight/plant was significantly affected by the interaction between N fertilizer levels and biofertilization treatments in both seasons and their combined analysis. According to combined analysis, it is clear that sugar beet control plants which did not receive any biofertilizers application, responded significantly to each increment in nitrogen fertilizer level. However, plants fertilized with cerialine alone or cerialine + potassiomag were responded to 100 and 125 kg N/fad, respectively. Under low levels of N (50 and 75 kg N/fad.), all biofertilizers treatments surpassed the control ones. Furthermore, under high levels of N (100 and 125 kg N/fad.), the highest fresh root weight/ plant was recorded by applying either cerialine alone or in combination with potassiomag. Finally, the highest fresh root weight/ plant (1297.83 g) could be obtained by applying 125 kg N/fad., and using combination of cerialine and potassiomag, while the lowest value (831.17 g) was recorded by applying 50 kg N under control treatment (without adding biofrtilizers).

Juice Quality

Effect of nitrogen fertilizer levels

Results presented in Tables 2 and 3 show that N fertilizer levels had significant effect on all juice quality traits (sucrose%, Na%, K%, alpha amino N%, purity%, extractable sugar%, SLM% and alkaline coefficient in both seasons and their combined analysis, except K% in the first season and alkaline coefficient in the second season where the differences did not reach the level of significance. High levels of nitrogen (100 and 125 kg N/fad.) significantly increased impurities parameters (Na%, K% and alpha amino N%) and SLM% and decreased sucrose%, purity% and extractable sugar% compared with the low levels of nitrogen (50 and 75 kg N/fad.). These results could be attributed to the reason that high levels of nitrogen fertilizer increased non-sugar substances such as protein, amino acids and other substances (impurities) which lead to decreasing purity%, extractable sugar% and sugar loss to molasses (Draycott, 1993 and Gobarah *et al.,* 2010). However, sugar beet plants which received 50 kg N/fad., gave highest values of alkaline coefficient in the first season and combined analysis. These results are in agreement with those obtained by Ramadan *et al.* (2003), Geweifel *et al.* (2006), Nemeat-Alla *et al.* (2009), Abashady *et al.* (2011), Osman, (2011) and Sarhan *et al.* (2012) who found that increasing N levels had a significant negative effect on sugar beet quality. On the other hand, Ouda (2007) found that increasing N level caused significant increase in sucrose%, while purity% was not affected by application of nitrogen.

Table 1. Influence of N levels and biofertilization on root length, root diameter, fresh top weight/plant and fresh root weight/plant of sugar beet during both growing seasons and their combined

Main effects and interactions	Root length (cm)			Root diameter (cm)			Fresh top weight/plant (g)			Fresh root weight/plant (g)		
	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
Nitrogen levels (kg/fad.), N												
50	21.03c	21.21c	21.12d	10.67c	12.05b	11.36c	332.50c	270.17c	301.33c	1136.83c	905.33c	1021.08d
75	22.02b	21.70b	21.86c	11.46b	12.52b	11.99b	364.75b	322.42b	343.58b	1253.42b	999.92b	1126.67c
100	22.15b	22.51a	22.33b	11.71b	12.39b	12.05b	363.33b	332.67ab	348.00b	1273.83b	1101.58a	1187.71b
125	22.83a	22.69a	22.76a	12.37a	13.10a	12.73a	391.83a	336.83a	364.33a	1372.17a	1138.50a	1255.33a
F-test	**	**	**	**	*	**	**	**	**	**	**	**
L.S.D. 0.05	0.38	0.46	0.27	0.40	0.54	0.30	16.42	11.77	9.00	44.46	51.29	30.22
Biofertilization, B												
Control	20.84b	21.54	21.19b	11.35	12.22	11.79	339.17c	284.33b	311.75c	1135.17b	988.42c	1061.79c
Cerialine	22.43a	22.08	22.26a	11.38	12.66	12.02	347.50bc	319.50a	333.50b	1306.33a	1099.92a	1203.12a
Potassiomag	22.23a	22.26	22.25a	11.56	12.43	11.99	401.75a	330.75a	366.25a	1280.75a	1008.25bc	1144.50b
Cerialine + Potassiomag	22.52a	22.22	22.37a	11.92	12.75	12.33	364.00b	327.50a	345.75b	1314.00a	1048.75ab	1181.37a
F-test	**	N.S.	**	N.S.	N.S.	N.S.	**	**	**	**	**	**
L.S.D. 0.05	0.76	-	0.52	-	-	-	18.78	20.43	13.50	42.03	58.88	35.22
Interaction												
NxB	N.S.	N.S.	N.S.	N.S	N.S	N.S.	N.S.	N.S.	N.S.	**	**	**(1-a)

*, ** and N.S. indicate significant at 0.05, 0.01 and insignificant, respectively.

Table 1-a. The interaction effect between N fertilizer levels and biofertilization on fresh root weight/plant (combined analysis of two seasons)

Nitrogen levels (kg N/fad.) \ Biofertilization	Control	Cerialine	Potassiomag	Cerialine + Potassiomag
	C	A	B	B
50	831.17 d	1143.67 b	1057.00 b	1052.50 c
	B	A	A	A
75	1025.50 c	1144.17 b	1160.00 a	1177.00 b
	B	A	B	AB
100	1146.00 b	1251.17 a	1155.50 a	1198.17 b
	BC	AB	C	A
125	1244.50 a	1273.50 a	1205.50 a	1297.83 a

Capital and small letters were used to compare means of rows and columns, respectively.

Effect of biofertilization

It is clear from Tables 2 and 3 that biofertilization treatments had no significant effect on sucrose%, alpha amino N%, purity%, SLM% and alkaline coefficient in both seasons and their combined analysis. However, there was a significant difference between biofertilization treatments in K%, Na% (only first season) and extractable sugar% (only combined analysis). According to results from combined analysis, applying potassiomag biofertilizer caused significant increase in Na% compared with either control (without biofertilizer application) or cerialine, while applying cerialine caused significant decrease in K% compared with other biofertilizaion treatments which did not differed significantly. Concerning extractable sugar% in the combined analysis, it is clear that applying either cerialine alone or in combination with potassiomag had positive increase in extractable sugar% compared with potassiomag alone but, without significant differences from control. In this regard, many workers reported that biofertilization treatments caused positive effect on juice quality (Sultan *et al.,* 1999; Abu El-Fotoh *et al.,* 2000; Kandil *et al.,* 2002 Badawi *et al.,* 2004 and Sarhan, 2012). On the other hand, Ramadan *et al.* (2003), Abou Zeid and Osman (2005) and Aly *et al.* (2009) found that bacterial inoculation of sugar beet seeds caused insignificant effect on juice quality. Also, Amin (2005), Ouda (2007) El-Sayed and Abou Shady (2011) concluded that biofertilization treatments had no significant effect on purity%.

Interaction effect

The interaction between the two main factors under study showed significant impact on sucrose % (combined analysis), Na% (first season and combined analysis) and extractable sugar % (combined analysis). Tables 2-a, 2-b and 3-a show the interaction effects according to the combined analysis on sucrose%, Na% and extractable sugar%, in respective order. The similar trends were obtained concerning sucrose% and extractable sugar%. It is clear that highest averages of sucrose% (17.79) and extractable sugar% (15.59) could be obtained by applying 50 kg N/fad., and using combination of cerialine and potassiomag, but without significant differences with either control or cerialine alone. However, plants fertilized with the highest level of nitrogen (125 kg N/fad.) significantly decreased in sucrose% and extractable sugar% compared with the lowest level (50 kg N/fad.) under application biofertilization or without application.

Table 2. Influence of N levels and biofertilization on root sucrose percentage and impurities content (Na, K and alpha amino nitrogen) of sugar beet during both growing seasons and their combined

Main effects and interactions	Sucrose percentage (%)			Na (%)			K (%)			Alpha amino N (%)		
	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
Nitrogen levels (kg/fad.), N												
50	16.93a	17.91a	17.42a	1.70b	1.57b	1.63c	4.61	5.20bc	4.91bc	0.98c	1.11b	1.04c
75	16.53ab	17.59ab	17.06a	1.82ab	1.69b	1.75bc	4.52	5.16c	4.84c	1.04bc	1.26ab	1.15bc
100	16.07b	17.13bc	16.60b	1.86a	1.76ab	1.81b	4.57	5.42ab	5.00ab	1.22ab	1.32a	1.27ab
125	16.09b	16.82c	16.46b	1.95a	1.96a	1.96a	4.56	5.60a	5.08a	1.29a	1.42a	1.36a
F-test	*	*	**	*	*	**	N.S.	*	*	*	*	**
L.S.D. 0.05	0.75	0.61	0.43	0.15	0.26	0.13	-	0.24	0.15	0.22	0.21	0.14
Biofertilization, B												
Control	16.29	17.50	16.89	1.73b	1.73	1.73b	4.43b	5.63a	5.03a	1.02	1.26	1.14
Cerialine	16.49	17.54	17.01	1.79b	1.74	1.77b	4.37b	5.23b	4.80b	1.20	1.25	1.22
Potassiomag	16.17	17.11	16.64	1.91a	1.83	1.87a	4.63ab	5.40ab	5.01a	1.21	1.30	1.25
Cerialine + Potassiomag	16.68	17.30	16.99	1.90a	1.68	1.79ab	4.83a	5.13b	4.98a	1.12	1.31	1.21
F-test	N.S.	N.S.	N.S.	**	N.S.	*	*	**	*	N.S.	N.S.	N.S.
L.S.D. 0.05	-	-	-	0.11	-	0.10	0.34	0.28	0.18	-	-	-
Interaction												
NxB	N.S.	N.S.	*(2-a)	N.S.	*	*(2-b)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*, ** and N.S. indicate significant at 0.05, 0.01 and insignificant, respectively.

Table 3. Influence of N levels and biofertilization on purity percentage, extractable sugar percentage, sugar loss in molasses and alkaline coefficient of sugar beet during both growing seasons and their combined

Main effects and interactions	Purity percentage (%)			Extractable sugar percentage (%)			SLM (%)			Alkaline coefficient		
	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
Nitrogen levels (kg/fad.), N												
50	93.20a	93.08a	93.14a	14.70a	15.58a	15.14a	1.63c	1.72c	1.68c	6.64a	6.18	6.41a
75	92.98ab	92.77ab	92.88a	14.28ab	15.21ab	14.75a	1.65bc	1.77c	1.71c	6.14ab	5.50	5.82b
100	92.54bc	92.26b	92.40b	13.76b	14.70bc	14.23b	1.71ab	1.84b	1.77b	5.37b	5.54	5.45b
125	92.44c	91.73c	92.08b	13.76b	14.31c	14.03b	1.73a	1.91a	1.82a	5.21b	5.52	5.36b
F-test	*	**	**	*	*	**	*	**	**	*	N.S.	**
L.S.D. 0.05	0.53	0.52	0.33	0.77	0.64	0.44	0.08	0.07	0.05	0.96	-	0.57
Biofertilization, B												
Control	93.05	92.31	92.68	14.07	15.05	14.56ab	1.62	1.84	1.73	6.20	5.99	6.09
Cerialine	92.98	92.66	92.82	14.23	15.15	14.69a	1.66	1.79	1.72	5.34	5.71	5.52
Potassiomag	92.51	92.24	92.37	13.86	14.68	14.27b	1.72	1.84	1.78	5.58	5.70	5.64
Cerialine + Potassiomag	92.62	92.63	92.62	14.36	14.92	14.64a	1.72	1.78	1.75	6.25	5.34	5.80
F-test	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
L.S.D. 0.05	-	-	-	-	-	0.30	-	-	-	-	-	-
Interaction												
NxB	N.S.	N.S.	N.S.	N.S.	N.S.	*(3-a)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*, ** and N.S. indicate significant at 0.05, 0.01 and insignificant, respectively.

Table 2-a. The interaction effect between N fertilizer levels and biofertilization on sucrose percentage (combined analysis of two seasons)

Nitrogen levels (kg N/fad.) \ Biofertilization	Control	Cerialine	Potassiomag	Cerialine + Potassiomag
	AB	AB	B	A
50	17.35 a	17.44 a	17.10 a	17.79 a
	A	A	A	A
75	17.03 ab	16.97 a	17.07 a	17.16 b
	B	A	B	B
100	16.42 c	17.28 a	16.24 b	16.47 c
	A	AB	B	AB
125	16.77 bc	16.36 b	16.16 b	16.54 c

Capital and small letters were used to compare means of rows and columns, respectively.

Table 2-b. The interaction effect between N fertilizer levels and biofertilization on Na percentage (combined analysis of two seasons)

Nitrogen levels (kg N/fad.) \ Biofertilization	Control	Cerialine	Potassiomag	Cerialine + Potassiomag
	A	A	A	B
50	1.67 ab	1.72 a	1.73 b	1.42 c
	A	A	A	A
75	1.74 ab	1.69 a	1.84 ab	1.73 b
	B	AB	A	A
100	1.65 b	1.80 a	1.93 a	1.87 b
	B	B	AB	A
125	1.85 a	1.86 a	1.97 a	2.14 a

Capital and small letters were used to compare means of rows and columns, respectively.

Table 3-a. The interaction effect between N fertilizer levels and biofertilization on extractable sugar percentage (combined analysis of two seasons)

Nitrogen levels (kg N/fad.) \ Biofertilization	Control	Cerialine	Potassiomag	Cerialine + Potassiomag
	AB	AB	B	A
50	15.07 a	15.13 a	14.78 a	15.59 a
	A	A	A	A
75	14.70 ab	14.72 a	14.75 a	14.82 b
	B	A	B	B
100	14.06 c	14.94 a	13.83 b	14.09 c
	A	AB	B	AB
125	14.41 bc	13.96 b	13.70 b	14.06 c

Capital and small letters were used to compare means of rows and columns, respectively

Regarding Na%, it is evident from Table 2-b that the lowest value of Na% (1.42) was obtained by applying 50 kg N/fad., and using combination of cerialine and potassiomag, while the highest value of Na% (2.14) was obtained by applying 125 kg N/fad., and combination of cerialine and potassiomag. It could be concluded that applying combination of cerialine and potassiomag with 50 kg N/fad., had favorable effect through improving sugar beet juice quality as expressed herein in increasing each of sucrose and extractable sugar percentages and decreasing Na%.

Top, Root and Sugar Yields

Effect of nitrogen fertilizer levels

Results presented in Table 4 show that nitrogen fertilizer levels had significant effect on top, root and recoverable sugar yields (t/fad.) in both seasons and their combined analysis. It is clear that root yield was responded positively to each N increment. The highest root yield was obtained by application 125 kg N/fad., in the second season (32.369 t/fad.) and combined analysis (34.682 t/fad.). Top and recoverable sugar yields (t/fad.) significantly increased with increasing N fertilizer level up to 100 kg N/fad., in both seasons and their combined analysis. The response of root yield to N application could be attributed to the increase in root dimensions (length and diameter) as well as fresh root weight/plant (Table 1) with increasing N level up to 125 kg N/fad. These results indicated the vital role of N in building up metabolites, activating enzymes and enhanced growth of sugar beet root which reflected in increasing root yield per unit area. The obtained results indicated that 100 kg N /fad., could be adequate to obtain high gross sugar yield where the differences between 100 and 125 kg N/fad., were not significant. Although, root yield and it's attributes responded to the high level of N (125 kg N/fad.), the recoverable sugar yield responded only to 100 kg N/fad. These results could be attributed to the reduction in juice quality traits when sugar beet plants fertilized with 125 kg N/fad., *i.e.* impurities, purity%, extractable sugar% and SLM%. In this regard, Gobarah *et al.* (2010) reported that increasing N level up to 150 kg N/fad., caused significant increase in top and sugar yield, while recoverable sugar yield responded only to 90 kg N/fad. Confirmed results show that N level revealed significant influence on top, root and sugar yields as mentioned by Ramadan *et al.* (2003), Geweifel *et al.* (2006), Seadh *et al.* (2007), Seadh (2008), Nemeat-Alla *et al.* (2009), Abashady *et al.* (2011), Osman (2011), Sarhan *et al.* (2012) and El-Sarag and Moselhy (2013).

Effect of biofertilization

As shown in Table 4, application of biofertilizers increased significantly top, root and recoverable sugar yield (t/fad) in both seasons and their combined except top yield in the first season where the differences did not reach the level of significance. It is obvious that all biofertilizer treatments surpassed the control (without adding biofertilizers) in top and root yields/fad. Highest averages of top and root yields could be obtained by addition of any biofertilizer, where the differences between biofertilizers were not significant. Concerning recoverable sugar yield (t/fad.) it is clear from results that applying either ceraline alone or in combination with potassiomag caused positive increase in recoverable sugar yield compared with control or potassiomag alone (combined analysis). These results are confirmed with the same trend in fresh root weight/plant (Table 1) and extractable sugar% (Table 3). The increase in yield and its attributes as result of biofertilizers may be due to its role in nitrogen fixation *via* free living bacteria which reduce the soil pH which led to increase the availability of most essential macro and micro-nutrients as well as excretion some growth substances such as indole acetic acid (IAA) and gibrillin (GA3) which play an important role in formation a large and active root systems and therefore increasing nutrient uptake, which stimulating establishment and vegetative growth, hence increasing root and foliage fresh weights and total yields per unit area (Sarhan, 2012). Many investigators confirmed the positive effect of biofertilizers on top, root and sugar yields (Kandil *et al.,* 2002; Ramadan *et al.,* 2003; Amin, 2005; Ouda, 2007; El-Hosry *et al.,* 2010; El-Sayed and Abou Shady, 2011 and Sarhan *et al.,* 2012).

Interaction effect

The interaction between nitrogen levels and biofertilization treatments had no significant effects on top, root and recoverable sugar yields in both seasons and their combined analysis.

Table 4. Influence of N levels and biofertilization on top yield, root yield and gross sugar yield of sugar beet during both growing seasons and their combined

Main effects and interactions	Top yield (t/fad.)			Root yield (t/fad.)			Recoverable sugar yield (t/fad.) †		
	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
Nitrogen levels (kg/fad.), N									
50	8.344c	7.131c	7.738c	27.929c	24.306d	26.117d	4.108c	3.788c	3.948c
75	9.357b	8.438b	8.898b	32.473b	27.795c	30.134c	4.637b	4.229b	4.433b
100	10.590a	9.295ab	9.943a	35.939a	30.941b	33.440b	4.949ab	4.544a	4.747a
125	10.872a	9.571a	10.221a	36.996a	32.369a	34.682a	5.090a	4.630a	4.860a
f-test	**	**	**	**	**	**	**	**	**
L.S.D. 0.05	0.859	1.038	0.600	1.347	0.880	0.716	0.390	0.219	0.199
Biofertilization, B									
Control	9.154	7.824b	8.489b	32.279b	27.263b	29.771b	4.532b	4.093b	4.313c
Cerialine	9.867	8.653a	9.260a	33.318ab	29.355a	31.337a	4.725ab	4.438a	4.581ab
Potassiomag	9.944	8.847a	9.395a	33.527a	29.082a	31.304a	4.629ab	4.253a	4.441bc
Cerialine + potassiomag	10.199	9.111a	9.655a	34.212a	29.710a	31.961a	4.899a	4.408a	4.653a
f-test	N.S.	*	**	*	**	**	*	*	*
L.S.D. 0.05	-	0.830	0.565	1.118	1.375	0.862	0.243	0.233	0.164
Interaction									
NxB	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*, ** and N.S. indicate significant at 0.05, 0.01 and insignificant, respectively.

† Recoverable sugar yield (t/fad.) was calculated by multiplying root yield x extractable sugar percentage.

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تأثير التسميد النيتروجينى والحيوى على محصول وجودة بنجر السكر تحت ظروف الرى بالتنقيط فى الأراضى الرملية المستصلحة حديثا

عبد الرحمن السيد أحمد عمر[١] – حنان يوسف محمد[٢]

١- قسم المحاصيل – كلية الزراعة – جامعة الزقازيق - مصر

٢- معهد بحوث المحاصيل السكرية – مركز البحوث الزراعية – الجيزة - مصر

أجريت تجربتان حقليتان فى المزرعة التجريبية التابعة لكلية الزراعة - جامعة الزقازيق بمنطقة الخطارة – محافظة الشرقية – جمهورية مصر العربية خلال الموسمين المتتاليين ٢٠١٠/٢٠٠٩ ، ٢٠١١/٢٠١٠ لدراسة تأثير أربعة مستويات من النيتروجين (٥٠، ٧٥، ١٠٠ و١٢٥ كجم ن/فدان) وأربعة معاملات للتسميد الحيوى (بدون إضافة، السيريالين، البوتاسيوماج والسيريالين + البوتاسيوماج) على المحصول ومساهماته وكذا صفات الجودة لبنجر السكر المنزرع تحت نظام الرى بالتنقيط فى الأراضى الرملية. ويمكن تلخيص أهم النتائج على النحو التالى: أدت إضافة النيتروجين إلى حدوث تأثيرات معنوية لجميع الصفات المدروسة فى كل من موسمى النمو والتحليل المشترك لهما. أدت زيادة مستويات النيتروجين من ٥٠ كجم ن/فدان وحتى ١٢٥ كجم ن/فدان الى حدوث زيادة معنوية فى أبعاد الجذر (الطول والقطر)، وزن العرش/نبات، وزن الجذر/نبات، محتوى الجذور من الصوديوم والبوتاسيوم، السكر المفقود بالمولاس ومحصول الجذور للفدان، بينما وصلت استجابة محصولى العرش والسكر المستخلص للفدان إلى ١٠٠ كجم ن/فدان فقط. تم التحصل على أعلى قيم لكل من نسب السكروز والنقاوة والسكر المستخلص بإضافة المعدلات المنخفضة من النيتروجين (٥٠ أو ٧٥ كجم ن/فدان). أثرت معاملات التسميد الحيوى معنويا على صفات طول الجذر، وزن العرش/نبات، وزن الجذر/نبات، محتوى الجذور من الصوديوم والبوتاسيوم ومحصول الجذور/فدان ، بينما لم تتأثر صفات قطر الجذر ، نسبة السكروز، نسبة النقاوة، السكر المفقود بالمولاس، ومعامل القلوية معنويا بمعاملات التسميد الحيوى. أمكن الحصول على أعلى محصول من السكر المستخلص للفدان بإضافة مخصب السيريالين منفردا أو مع مخصب البوتاسيوماج). أثر التفاعل بين مستويات النيتروجين ومعاملات التسميد الحيوى معنويا على صفات وزن الجذر/نبات، نسبة السكروز، نسبة الصوديوم و نسبة السكر المستخلصة.

المحكمـــــون:

١- أ.د. أحمـــد أبـو النجـا قنـديل	أستاذ المحاصيل – كلية الزراعة – جامعة المنصورة.
٢- أ.د. حمدي عبدالصادق باشا	أستاذ المحاصيل – كلية الزراعة – جامعة الزقازيق.