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YIELD ANALYSIS OF SOME SUGAR BEET CULTIVARS UNDER BIO AND MINERAL NITORGEN FERTILIZATION CONDITIONS

Assey, A.A.,[1] H.G.M. Geweifel[1], M.A. Gomaa[1] and Gehan, A. Amin[2]

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

2. Agron. Dept., National Res. Center, Dokki, Cairo, Egypt

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ABSTRACT : Two field experiments were carried out in the station of National Research Center at Shalkan, Kalubia, Egypt during 2002/2003 and 2003/2004 seasons to study the effect of bio and mineral nitrogen fertilization on sugar yield and yield components as well as quality of three sugar beet cultivars. The interrelationships between sugar yield and yield components were examined through correlation coefficients, path analysis and regression analysis. The main findings obtained from this study can be summarized as follows :

Gross sugar yield/fad was positive and highly significant correlated with each of root yield/fad, sucrose%, purity %, top yield/fad and root diameter. Also, a positive and significant correlation coefficient was found between gross sugar yield/fad and top/root ratio.

The results of path analysis indicated that root yield/fad and sucrose content as well as their interaction were the main sources of gross sugar yield/fad since, they contributed about 97.57% of the total sugar yield variation.

The regression analysis revealed that the response of gross sugar yield to application mineral nitrogen was of quadratic relationship for the three sugar beet cultivars under both treated and untreated plants with Rhizobacterin. The expected maximum sugar yield valued 4.504, 5.055 and 3.918 ton/fad for Baraka, Demapoly and Shemis cultivars, respectively under untreated plants. This was

theoretically the result of application 64.92, 97.50 and 71.50 kg N/fad. However, inoculation of Rhizobacterin reduced mineral nitrogen requirements to only 58.43, 58.70 and 67 kg N/fad for Barka, Demapoly and Shemis cultivars to achieve the highest gross sugar yield/fad of 5.249, 4.618 and 3.847 ton/fad, respectively.

It is recommended to use Baraka cultivar, inoculation of Rhizobacterin and application of about 60 kg N/fad to achieve the maximum sugar yield of about 5.250 kg sugar/fad.

Key words : Bio and mineral fertilization, cultivars, sugar beet.

INTRODUCTION

Sugar beet (*Beta vulgaris*, L.) is considered the second important sugar crop in Egypt after sugar cane. The Egyptian Government encourages decreasing the gab between sugar production and consumption. Applying proper cultural practices lead to increasing yield potentiality of sugar beet, especially this crop could be cultivated in the newly reclaimed lands and needs low water requirements.

Recently, under Egyptian conditions a great attention is being devoted to reduce the high rates of mineral fertilizers, the cost of production and environmental pollution via reducing doses of nitrogenous fertilizers by using biofertilization.

For successful breeding programs of sugar beet, a great deal work was done to search for the characters positively correlated with sugar yield on which selection must be done. In this connection, Ali (1978) found that correlation coefficients showed α definite interrelationship among root yield and each of gross sugar yield and top yield. The gross sugar trait was positively and highly significantly correlated with sucrose and total soluble solids while it was negatively and highly significant correlated with top/root ratio. Also, Eraky *et al.* (1982) found that sugar yield was positively and significantly correlated with root yield. Positive and significant correlations between root yield and each of root length, root diameter and top yield were reported by Ghanem and Gomaa (1985). Several workers such as Ouda, Sohier (1986); Basha and Gomma, (1994) and Sharief and Eghbal (1994) indicated that gross sugar yield was positive and highly significant correlated with each of T.S.S.%, root yield/fad, top/root ratio, root length and root diameter. Moreover, Rady *et al.*, (2000) found a positive correlation between top yield and each of root yield and sugar yield.

Regarding path analysis, Geweifel (1982) reported that root yield greatly acted on the gross sugar yield variation since path coefficient was 0.8443 and 0.9715 accounted for 71.28 and 94.34% of the total variation in the Autumn and Spring plantings, respectively. Similar results were obtained also by Ouda, Sohier (1986). Furthermore, the results of path analysis indicated that sucrose content, root yield /fad, and root weight/ plant as well as their interactions were the main sources of gross sugar yield since, they contributed with about 89.79% of the total yield variation.

Concerning regression analysis, Ouda, Sohier (1986) indicated that the regressions of gross sugar yield on nitrogen fertilization were quadratic relationship. Also, Sharief *et al.*, (1997) found that root yield was the most important variable contributing toward sugar yield/fad followed by sucrose percentage. Finally, Saif, Laila (2000) obtained similar results where root fresh weight yield/fad. and sucrose% were the most variables contributing to sugar yield directly and indirectly.

The present investigation aimed to study the interrelationships between sugar beet yield/fad and yield attributes through correlation coefficients, path analysis and regression analysis.

MATERIALS AND METHODS

This investigation was conducted in the station of National Research Center at Shalkan, Kalubia in 2002/2003 and 2003/2004 seasons. This was aimed to study the effect of biofertilization and nitrogen on growth, yield and quality of three sugar beet cultivars.

Each experiment included 18 treatments which were combinations of three sugar beet cultivars, two biofertilization treatments and three N-fertilization levels.

1. Sugar beet cultivars

a. Baraka

b. Demapoly

c. Shemis

2. Biofertilization (B)

a. Untreated

b. Treated with Rhizobacterin

3. N-fertilization level (N)

a. Zero kg N/fad (control)

b. 50 kg N/fad

c. 100 kg N/fad

A split – split plot design with four replications was used where the main plots were assigned to three cultivars, the sub-plots were devoted to biofertilization, whereas the sub-sub-plots were occupied by N-fertilization rates.

In both seasons preceding crop was corn. The sub-sub plot area was 10.5 m^2 i.e. 1/400 fad (5 ridges of 3 m long and 0.7 m a part). The spacing within ridges were 20 cm between hills. Sowing date was 27^{th} October in the two seasons. Calcium super phosphate (15.5% P_2O_5) at a rate of 100 kg/fad and potassium sulphate (50% K_2O) at a rate of 50 kg/fad were added before sowing. The studied nitrogen fertilizer levels in form of ammonium sulphate (20.5% N) were applied according to each level in two sequel splits in both seasons after thinning and before the third irrigation. Beet plants were thinned in two times i.e. 25 and 35 days after sowing to let one plant/hill.

The normal cultural treatments of growing sugar beet crop were practiced. Rhizobacterin as commercial products were produced by Biofertilizer Unit, Agriculture Research Center (ARC) which included some free living bacteria able to fix atmospheric nitrogen in the rhizosphere of some root crops such as maize, wheat and sugar beet.

The biofetilizer (seed inoculation) was done before sowing directly, by soaking seed in running water for one hour and then air dried.

Concerning the aim of soaking seed in water, usually, seeds of sugar beet treated with some fungicides to protect them from diseases and can not be inoculated with bacterium.

RESULTS AND DISCUSSION

Yield Analysis

The combined data of yield attributes and yield were subjected to simple correlation, path coefficient and regression analysis and calculated according to Svab (1973) as follows :

$$r_{ij} = \frac{SP_{ij}}{\sqrt{SS_i \times SS_j}}$$

$$r_{yi} = \frac{SP_{yi}}{\sqrt{SS_y \times SS_i}}$$

$$P_i = bi \sqrt{\frac{SS_i}{SS_y}}$$

$$r_{yi} = P_i + \Sigma P_i r_{ij}$$

$$R^2 = P_i^2 + \Sigma 2P_iP_j r_{ij}$$

$$Y = a + bX + cX^2$$

where :

i = in r_{yi}, index of independent variable.

j = index of the other independent variable.

y = index of dependent variable.

1. Correlation coefficients between yield and yield attributes

The correlation coefficients in Table 1 show the relationships between gross sugar yield and each of root yield/fad, sucrose %, T.S.S%, purity%, top yield/ fad, top/root ratio, number of leaves/plant, root length and root diameter.

Positive and highly significant correlation coefficients were obtained between gross sugar yield and each of root yield/fad (r = 0.879**); sucrose % (r = 0.689**); purity % (r = 0.655**); top yield/fad (r = 0.634**); number of leaves/plant (r = 0.508**) and root diameter (r = 0.604**). Also, positive and significant correlation coefficient appeared between gross sugar beet and top/root ratio i.e. r = 0.335**. Similar results were obtained by Ali (1978) and Eraky *et al.*, (1982), Geweifel (1982), Ouda, Sohier (1986), Basha and Gomma (1994) and Sharief and Eghbal (1994).

However, the correlations between gross sugar yield and the other characters i.e. T.S.S% and root length were not significant as shown in Table 1.

The root yield/fad was positively and highly significantly correlated with top yield/fad (r = 0.639**); number of leaves/plant (r = 0.679**) and root diameter (r = 0.688**). But, the correlation coefficients between root yield/fad and both of purity% (r = 0.321*) and root length (r = 0.320*) were significant. These results are generally in agreement with those obtained by Rady *et al.* (2000).

The positive and highly significant correlation coefficients

Table 1 : Simple correlation coefficients between gross sugar yield (ton/fad) and its attributes (combined)

Characters	2	3	4	5	6	7	8	9	10
1. Gross sugar yield (ton/fad)	0.879**	0.689**	0.193	0.655**	0.634**	0.335*	0.508**	0.207	0.604**
2. Root yield (ton/fad)	-	0.272	-0.022	0.321*	0.639**	0.265	0.679**	0.320*	0.688**
3. Sucrose%		-	0.449*	0.848**	0.336*	0.298*	0.064	-0.080	0.181
4. T.S.S%			-	-0.088	0.016	0.023	-0.178	-0.267	-0.150
5. Purity%				-	0.364*	0.312*	0.198	0.065	0.280*
6. Top yield (ton/fad)					-	0.896**	0.536**	0.211	0.337*
7. Top/root ratio						-	0.351*	0.107	0.108
8. Number of leaves/plant							-	0.346*	0.569**
9. Root length								-	0.522**
10. Root diameter									-

were obtained between sucrose % and each of T.S.S.% (r = 0.449*) and purity% (r = 0.848**). However, it was positively and significant correlated with top yield/fad (r = 0.336*) and top/root ratio (r = 0.298*).

Purity% was found to be positively and significantly correlated with top yield (r = 0.364*), top/root ratio (r = 0.312*) and root diameter (r = 0.280*).

Positive and highly significant relationship appeared between top yield /fad on one hand and top/root ratio (r = 0.896**) and number of leaves/ plant (r = 0.536**). Whereas, it was positively and significant correlated with root diameter (r = 0.337*).

Furthermore, simple correlation coefficient was positive and significant between number of leaves/plant and each of root length (r = 0.346*) and root diameter (r = 0.569**).

Finally, root length was positively and highly significant correlated with root diameter (r = 0.522**).

2. Path analysis

The method of path coefficients included the three yield components i.e. root yield/fad, sucrose percentage and purity percentage. Path analysis was practiced in order to find the relative importance of these three characters in contributing gross sugar yield.

The effects of direct and indirect path coefficients of root yield/fad, sucrose% and purity% on gross sugar yield are shown in Table 2.

These effects were computed by partitioning the simple correlation coefficient into its components. Root yield/fad proved to have a high direct effect of gross sugar yield followed by sucrose% while the direct effect of purity% was very low. Since direct effects were 0.7457, 0.4760 and 0.0120 for root yield/fad, sucrose% and purity%, respectively. Likewise, the indirect effects of both purity% through root yield/fad and sucrose% showed great values of 0.2394 and 0.4037, respectively.

The results of contributions of the direct effects of root yield/fad, sucrose% and purity% as well as their interactions on gross sugar yield as recorded in percentage of the variation are presented in Table 3 and illustrated graphically in Fig. 1.

Table 2 : Direct and joint effects of gross sugar yield components presented as a percentage of variation of sugar beet. (combined data of both seasons)

Source	C.D.	%
Root yield (ton/fad)	0.5560	55.60
Sucrose%	0.2266	22.66
Purity%	0.0001	0.01
Root yield (ton/fad) x Sucrose%	0.1931	19.31
Root yield (ton/fad) x Purity%	0.0057	0.57
Sucrose% x Purity%	0.0097	0.97
R^2	0.9913	99.13
Residual	0.0087	0.87
Total	0.10000	100.00

C.D. = Coefficient of determination

% = Percentage contributed

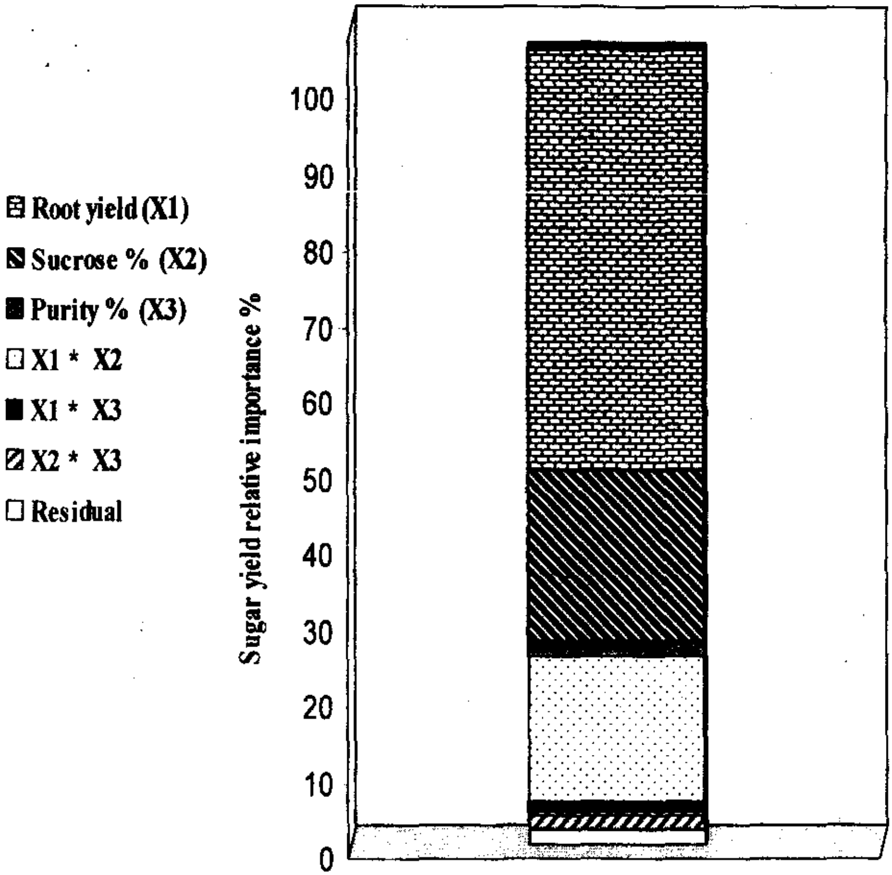

Fig.1: Components (direct and indirect effects) in gross sugar yield/fad variation of sugar beet.

Table 3 : Partioning of simple correlation coefficients between gross sugar yield (ton/fad) and its components of sugar beet (combined data of both seasons)

Source	Values
Root yield (ton/fad)	
Direct effect	0.7457
Indirect effect via sucrose%	0.1295
Indirect effect via purity%	0.0038
Total (ry_1)	0.8790
Sucrose %	
Direct effect	0.4760
Indirect effect via purity%	0.2028
Indirect effect via root yield (ton/fad)	0.0101
Total (ry_2)	0.6890
Purity%	
Direct effect	0.0120
Indirect effect via root yield (ton/fad)	0.2394
Indirect effect via sucrose%	0.4037
Total (ry_3)	0.6550

Path analysis revealed that the direct effect for root yield/fad was 55.60% being higher than that of sucrose% which was 22.66% then that of purity% which was only 0.01% of the gross sugar yield variation. The superiority of root yield/fad in its contribution on gross sugar yield/fad was proved also by Geweifel (1982) and Ouda, Sohier (1986).

The indirect path coefficient of these three characters was 20.85% of the gross sugar yield variation. Also, it is obvious that contribution of the residual effect to gross sugar yield in this study amounted to 0.87%.

Also, it is clear from the results in Table 2 that root yield, sucrose% and purity% contributed much to gross sugar yield since R^2 was 99.13% of the total gross sugar yield variation. Other direct and indirect effects for the rest of the studied characters were negligible and showed very slight contribution to sugar yield. Similar results were obtained by Basha and Gomma (1994).

3. Regression analysis

Parameters of regression analysis between mineral nitrogen and gross sugar yield/fad of the three sugar beet cultivars when untreated or treated with Azotobacterin are presented in Table 4 and illustrated graphically in Figures 2 and 3.

Data recorded showed that, the response of gross sugar yield under the three studied cultivars i.e. Baraka, Demapoly and Shemis was similar indicating quadratic relationship with nitrogen fertilization. This picture was true under both untreated and treated beets with biofertilization.

In the untreated plants, the quadratic regression curves for the three cultivars i.e. Barka, Demapoly and Shemis are presented by the equations :

Baraka : $Y = 1.976 + 0.0779\ X - 0.0006\ X^2$

Dimapoly : $Y = 2.203 + 0.0585\ X - 0.0003\ X^2$

Shemis : $Y = 1.873 + 0.0572\ X - 0.0004\ X^2$

With respect to the mentioned formulae, it could be found that the expected maximum gross sugar yield valued 4.504, 5.055 and 3.918 for Baraka, Demapdy and Shemis, respectively. It could be obtained by application of 64.92, 97.50 and 71.50 kg N/fad.

Table 4 : Parameters of regression analysis between nitrogen fertilization and gross sugar yield of three sugar beet cultivars under two biofertilization treatments (combined data of both seasons)

parameter	Untreated with Rhizobacterin			Treated with Rhizobacterin		
	Baraka	Demapoly	Shemis	Baraka	Demapoly	Shemis
a	1.976	2.203	1.873	2.859	2.895	2.500
b	0.0779	0.0585	0.0572	0.0818	0.0587	0.0402
c	-0.0006	-0.0003	-0.0004	-0.0007	-0.0005	-0.0003
R^2	0.9890	0.9989	0.9821	0.9199	0.9263	0.9624
X max (Kg N/fad)	64.92	97.50	71.50	58.43	58.70	67.00
Y max (Ton sugar/fad)	4.504	5.055	3.918	5.249	4.618	3.847

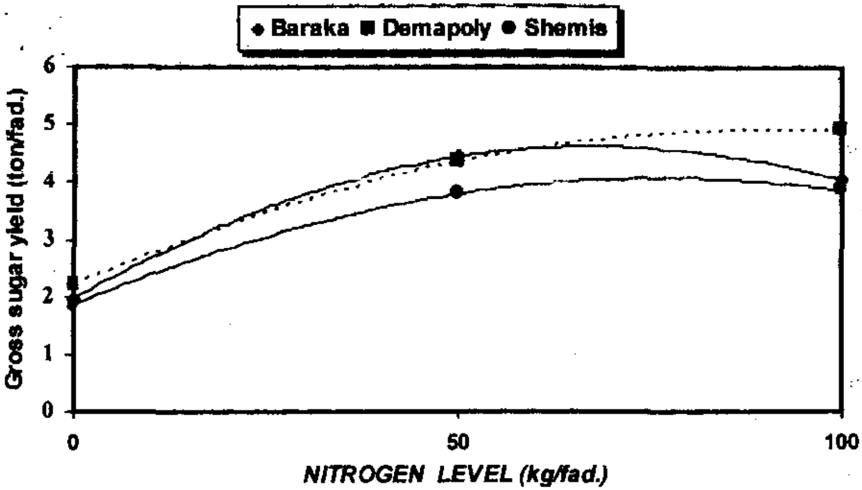

Fig. 2 : Response of gross sugar yield (ton/fad) of the three cultivars to different N fertilizer levels under untreated plants with Rhizobacterin (Combined data)

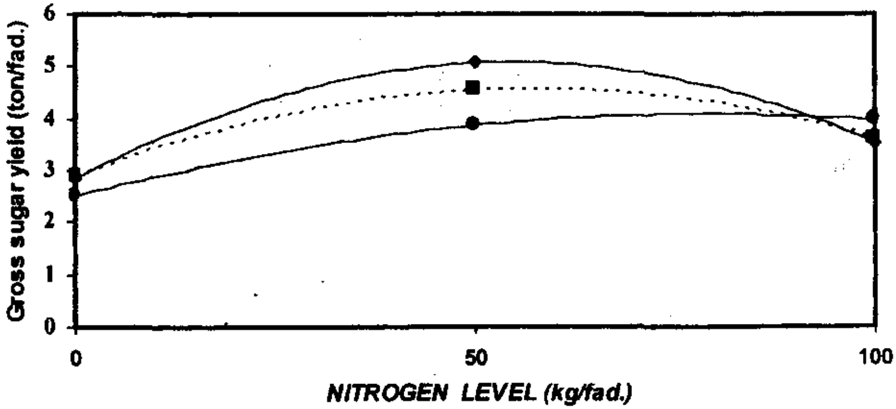

Fig. 3 : Response of gross sugar yield (ton/fad) of the three cultivars to different N fertilizer levels under treated plants with Rhizobacterin (Combined data)

Concerning the treated plants with Rhizobacterin, the quadratic regression curves are presented by the equations :

Baraka : $Y = 2.859 + 0.0818\ X - 0.0007\ X^2$

Dimapoly : $Y = 2.895 + 0.0587\ X - 0.0005\ X^2$

Shemis : $Y = 2.500 + 0.0402\ X - 0.0003\ X^2$

With respect to the forementioned formulae, it could be found that, the expected maximum gross sugar yield was 5.249, 4.618 and 3.847 ton/fad Theoretically, this was the result of adding mineral nitrogen up to 58.43, 58.70 and 67.00 kg N/fad for Baraka, Demapoly and Shemis cultivars, respectively.

It is also interesting to note that the highest gross sugar yield of Baraka cultivar was 5.249 and could be achieved by adding about 58 kg N fad when plants were inoculated with Rhizobacterin.

The superiority of Baraka cultivar in gross sugar yield on the sugar beet cultivars was expected, since it was produced the highest growth characters as well yield and its attributes especially when its seeds were biofertilized with Rhizobacterin.

Finally, the quadratic response of sugar yield/fad to N fertilization was generally in agreement with some workers such as Geweifel (1982), Ouda, Sohier (1982), Sharief *et al.*, (1997) and Saif, Laila (2000).

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تحليل المحصول لبعض أصناف بنجر السكر تحت ظروف التسميد الحيوى والمعدنى

أحمد أحمد عاصى[1] – حسينى جميل محمد جويفل[1]

محمد عبد الكريم جمعة[1] – جيهان عادل أمين[2]

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

٢. قسم المحاصيل – المركز القومى للبحوث – الدقى – مصر

أقيمت تجربتان حقليتان بمزرعة المركز القومى للبحوث – شلقان – محافظة القليوبية خلال موسمى ٢٠٠٢/٢٠٠٣ ، ٢٠٠٣/٢٠٠٤ لدراسة تأثير التسميد الحيوى والنيتروجينى المعدنى على محصول السكر الخام ومكوناته وجودته فى ثلاثة أصناف من بنجر السكر. وتهدف الدراسة إلى دراسة سلوك هذه الأصناف لتحليل المحصول من خلال تحليل الارتباط البسيط وتحليل الانحدار وكذلك تحليل المرور لتحديد أكثر الصفات أهمية للمساهمة فى محصول السكر الخام.

ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى :

أظهرت نتائج تحليل الارتباط وجود علاقة طردية ومعنوية جداً بين محصول السكر الخام وكل من محصول الجذور/فدان ونسبة السكر ونسبة النقاوة ومحصول العرش/فدان وقطر الجذر بينما كانت العلاقة طردية ومعنوية مع نسبة العرش إلى الجذور.

أوضحت نتائج تحليل المرور أن المصادر الأساسية لإحداث التغير الناتج فى محصول السكر هى محصول الجذور/فدان ونسبة السكر والتفاعل بينهما حيث ساهمت هذه المكونات بمقدار ٩٧,٥٧% فى التباين الكلى لمحصول السكر للفدان.

دلت نتائج تحليل الانحدار المتعلقة باستجابة محصول السكر/فدان لإضافة التسميد النيتروجينى المعدنى وجود علاقة من الدرجة الثانية تحت ظروف إضافة وعدم إضافة السماد الحيوى Rhizobacterin لأصناف بنجر السكر الثلاثة تحت الدراسة وأن أعلى محصول سكر يمكن تحقيقه وصل إلى ٤,٥٠٤ ، ٥,٠٥٥ ، ٣,٩١٨ للأصناف Shemis, Demapoly, Baraka على التوالى وذلك عند إضافة ٦٤,٩٢ ، ٩٧,٥٠ ، ٧١,٥٠ كجم نيتروجين/فدان وعدم التلقيح بالسماد الحيوى ، بينما أدى استخدام السماد الحيوى إلى خفض احتياجات أصناف بنجر السكر من التسميد الأزوتى لتحقيق أعلى إنتاجية من السكر والتى وصلت إلى ٥,٢٤٩ ، ٤,٦١٨ ، ٣,٨٤٧ طن/فدان عند إضافة ٥٨,٤٣ ، ٥٨,٧٠ ، ٦٧,٠٠ كجم نيتروجين / فدان فقط.

وبناء على ذلك فإنه يوصى بزراعة الصنف Baraka مع معاملة البذور عند الزراعة بالسماد الحيوى Rhizobacterin والاكتفاء بإضافة حوالى ٦٠ كجم ن/فدان.