EFFECT OF SOIL AND FOLIAR APPLICATION OF NITROGEN FERTILIZATION ON SUGAR BEET

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ABSTRACT

The present investigation was carried out at the Experimental Farm of Sakha Agricultural Research Station, Agricultural Research Center, at Kafr El- Sheikh Governorate, Egypt during 1999/2000 and 2000/2001 seasons. Two field experiments were conducted to study the effect of three nitrogen rates i.e., 40, 65 and 90 kg N/fed. (as soil application) and five treatments of foliar spraying with urea at the rate of (50 g/l) i.e., cont., one, two, three and four foliar on yield, yield components and quality of sugar beet as well as to minimizing costs of fertilization and environmental pollution. The experimental design was strip- plot design with four replications. The main results of this investigation could be summarized as follows:

Increasing nitrogen fertilizer as soil application up to 90 kg N/fed. and repeating foliar application with urea solution significantly increased root length and diameter, dry matter accumulation/plant, root and top yields/fed. as well as sugar yield/fed. in both seasons. The inverse was true in TSS, sucrose and juice purity percentages. Whereas, raising soil application of nitrogen from 40 to 90 kg N/fed. and foliar spraying with urea caused a marked decrease in the previously mentioned traits.

Generally, it can be concluded that soil application of nitrogen fertilizer at the rate of 65 kg N/fed. and foliar spraying sugar beet plants three times with urea solution at the rate of (50 g/l) could be recommended for optimum root and sugar yields per unit area as well as decreasing fertilizer costs under the condition of the present study.

INTRODUCTION

Sugar beet (*Beta vulgaris,* L.) is the second source for sugar production after sugar cane. The Egyptian Government encourages sugar beet growers to increase the cultivated area with sugar beet for decreasing the gab between sugar production and consumption. Improvement of sugar beet production can be achieved through optimizing the cultural practices.

Nitrogen is an essential nutrient for sugar beet plants, decidedly the amount and method of nitrogen application required to produce the maximum root and sugar yields. Soil application of fertilizers is the oldest and most common method practiced throughout the world for all crops. It was based on the fact that primary function of the root is to absorb plant nutrients from the soil. Nitrogen application as soil fertilizer increased length and diameter of roots (Gnative, 1989; El-Kassaby and Leilah, 1992; Besheit *et al*., 1995; Nemeat Alla 1997 and Azab *et al*., 2000); dry matter accumulation/plant (Mahmoud *et al.*, 1990; Sorour *et al*., 1992 and Nemeat Alla, 1997); root and top yields/fed. (Lamb and morghan 1993; Sherif and Eghlal, 1994; El-Hawary, 1999 and Azab *et al*., 2000); sugar yield/fed. (Besheit *et al*., 1995; Nemeat Alla, 1997 and Azab *et al*., 2000). On the other hand, TSS, sucrose and juice purity percentages were decreased by increasing nitrogen rates (Carter and

Traveller, 1981; Sorour *et al*., 1992; Nemeat Alla, 1997 and Azab *et al*., 2000).

Under certain conditions the application of nutritive elements as foliar spray has more advantages as compared to soil application. The foliar feeding of such elemnts is applied in small quantities as a result of higher efficiency of its absorpation by leaf surface and this saves large amount of fertilizers applied as soil application, minimizing costs and environmental pollution. Increasing number of foliar spraying with urea increased root length and diameter (Badawi, 1996; El-Maghraby, *et al*., 1997 and Azab *et al*., 2000); dry matter accumulation/plant (Saif, 1991); root, top and sugar yields/fed. (Besheit *et al*., 1995, El-Maghraby, *et al*., 1997; Fahmi, 1999 and Azab *et al*., 2000), however it decreased TSS, sucrose and juice purity percentages (Lamb and Moraghan, 1993, El-Maghraby, *et al*., 1997 and Azab *et al*., 2000).

This investigation was designed to study the effect of soil and foliar application of nitrogen fertilization on yield, yield components and quality of sugar beet as well as to reducing fertilizer costs and environmental pollution.

MATERIALS AND METHODS

Two field experiments were conducted on a clay soil at at the Experimental Farm of Sakha Agricultural Research Station, Agricultural Research Center, at Kafr El- Sheikh Governorate, Egypt during 1999/2000 and 2000/2001 seasons. Treatments were arranged in a strip-plot design with four replications. The vertical plots were devoted to the three soil application of nitrogen fertilizer rates i.e., 40, 65 and 90 kg N/fed., while the horizontal plots were assigned to the five foliar spraying treatments with urea at the rate of (50 g/l) i.e., foliar spraying with water (control), one foliar at 45 days after sowing (DAS), two foliar at 45 and 60 DAS, three foliar at 45, 60 and 75 DAS and four foliar at 45, 60, 75 and 90 DAS. The mechanical and chemical analysis of the experimental soil are showen in Table (1).

Table (1): Mechanical and chemical analysis of the experimental soil.

Season	Sand %	Silt %	Clay %	Texture	Organic matter %	p^H	Total N (ppm)	Cations meq/l.				Anions meq/l			
								Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^-	CO_3^{--}	SO_4^{--}
1999/2000	12.3	26.9	60.8	Clay	1.81	8.2	85.0	16.2	0.30	5.2	2.9	9.2	2.8	0.0	13.6
2000/2001	12.2	26.7	61.1	Clay	1.89	8.0	86.0	16.3	0.35	5.1	2.6	9.4	2.9	0.0	13.3

Each sub-plot included six ridges each 50 cm apart and 7 m. long. Sowing took place on October 20 th and 28 th in 1999 and 2000 seasons, respectively. Seed of multigerm cultivar “Top” were sown in hills 20 cm apart on one side ridges at rate of 3-4 seeds per hill. Plant were thinned to one plant per hill at 4 true leaves stage in both seasons. The nitrogen fertilizer in the form of Urea (46.5 % N) as soil application was applied in two split applications; one half after thinning and the second half after 30 days later.

At maturity, the area of 14 m2 of each plot were harvested to determined root and top yields. Ten guarded plants were taken at random to estimate root dimensions (length and diameter) as well as dry matter accumulation/plant. Total soluble solids percentage (TSS%) was determined by a hand refractometer, while sucrose percentage was determined according to Le-Docte (1927). Juice purity percentage was calculated by dividing sucrose percentage by TSS %. Sugar yield/fed. was calculated from root yield/fed. multiplied by sucrose percentage.

The analysis of variance was carried out according to Gomez and Gomez (1984). Treatment means were compared by Duncan’s Multiple Range Test (Duncan, 1955). All statistical analysis was performed using analysis of variance technique by means of “M state” computer software package.

RESULTS AND DISCUSSION

1. Root dimensions:

Data in Table (2) indicate that root dimensions (root length and diameter at harvest) significantly increased by increasing nitrogen fertilizer levels from 40 to 90 kg N/fed. in both seasons, except the root length in the first season. The longest and thickest roots were resulted from application of 90 kg N/fed., while the shortest and thinest roots were produced by applying 40 kg N/fed. The increase in root length and diameter with increasing nitrogen rate may be attributed to the role of nitrogen in increasing division and elongation of root cells led to increasing root dimensions. Similar results were obtained by El-Kassaby and Leilah (1992), Besheit *et al.* (1995) and Nemeat Alla (1997).

Root diameter of sugar beet plants was significantly influenced by foliar application of urea, while root length was not affected in both seasons (Tabl 2). It is evident that spraying sugar beet plants with urea three or four foliar sprayings were effective to increase root diameter in the two seasons compared to the other treatments. These results were in acordance with those of Gnative (1989); Badawi (1996); Nemeat Alla (1997); El-Maghraby *et al*. (1997) and Azab *et al*. (2000).

The interaction between nitrogen rate and foliar application of urea had no significant effect on root length and diameter in both seasons.

2. Dry matter accumulation/plant:

Concerning dry matter accumulation/plant at harvest, the data presented in (Table 3) show that increasing nitrogen level up to 90 kg N/fed. as soil application significantly increased this triat in the two seasons. In the first season, each increament of applied nitrogen resulted in a significant increase in dry matter accumulation/plant. These observations were fairly true with those elucidated by Mahmoud *et al*. (1990); Sorour *et al*. (1992) and Nemeat Alla (1997).

Table (2): Root length and diameter as affected by the nitrogen fertilizer rate and foliar spraying with urea in 1999/2000 and 2000/2001 seasons.

Treatments	**1999/2000 season**		**2000/2001 season**	
N- level: (kg N/fed.):	**Root length (cm)**	**Root diameter (cm)**	**Root length (cm)**	**Root diameter (cm)**
40	29.70	9.38b	28.00b	11.01b
65.	29.73	11.57a	29.00b	11.06b
90	29.93	11.87a	31.14a	12.85a
F- test	NS	*	*	*
No. of urea spraying:				
Control	29.62	10.20b	28.62	11.00b
One	29.63	10.21b	29.05	11.03b
Two	29.99	10.20b	29.30	11.10b
Three	29.85	11.84a	29.83	12.50a
Four	29.86	12.24a	30.08	12.55a
F- test	NS	*	NS	*
Interaction:	NS	NS	NS	NS

***, ** and NS indicate P<0.05 and not significant, respectively. Means of each factor designated by the same latter are not significantly different at 5% level, using Dincan's multiple range test.**

The data in Table (3) reveal that the foliar application of urea exerted a significant influence on dry matter accumulation/plant in both seasons. Four times of foliar spraying with urea gave the highest dry matter /plant in the two seasons, without significant difference with three foliar sprayings in the second season. On the other hand, control and one foliar spraying of urea recorded the lowest dry matter/plant. These results are in good agreement with those obtained by Saif (1991).

The interaction between nitrogen level as soil application and foliar application of urea exerted a significant effect in dry matter/plant in the first season only (Table 3). The data in Table (4) show that the highest dry matter/plant was obtained when sugar beet plants were fertilized by 90 kg N/fed. and sprayed three or four foliar sprayings with urea during 75 or 90 days after sowing, respectively, wheares plants recived 40 kg N/fed. and sprayed with water recorded the lowest one.

3. Root and top yields/fed. :

The soil application of nitrogen fertilizer significantly increased root and top yields/fed. in both seasons (Table 3). The data also reveal that each increament of applied nitrogen resulted in significan increase in root and top yields/fed. This fact is true in both seasons. The increase in root and top yields caused by nitrogen application may be attributed to the favourable effects of nitrogen in building up the photosynthetic area of beet plants and consequently accumulation of more dry matter in roots and tops. This findings stand in conformity with those recorded by Lamb and Moraghan (1993); Kemp *et al*. (1994); Nemeat Alla (1997); El-Hawary (1999) and Azab *et al*. (2000).

Table (3): Dray matter accumulation/plant, root and top yields as affected by nitrogen fertilizer rate and foliar spraying with urea in 1999/2000 and 2000/2001 seasons.

Treatments	1999/2000 season			2000/2001 season		
N- level: (kg N/fed.):	Dry matter (g/plant)	Root yield (t/fed.)	Top yield (t/fed.)	Dry matter (g/plant)	Root yield (t/fed.)	Top yield (t/fed.)
40	180.67c	26.37c	9.11c	186.83b	24.94c	8.75c
65.	197.32b	29.75b	11.64b	200.45a	30.64b	13.19b
90	215.59a	31.83a	14.46a	204.43a	34.11a	15.32a
F- test	**	**	**	*	**	**
No. of urea spraying:						
Control	186.89c	25.76d	9.81c	185.97c	26.26d	10.04c
One	190.43c	28.38c	11.20b	190.92bc	29.10c	11.31b
Two	193.41c	29.53b	11.43b	195.63b	30.48b	11.44b
Three	204.70b	31.17a	12.80a	206.53a	31.42ab	14.35a
Four	213.88a	31.76a	13.45a	207.09a	32.21a	14.96a
F-test	*	**	**	*	**	**
Interaction:	**	**	NS	NS	**	NS

***, ** and NS indicate P<0.05 and not significant, respectively. Means of each factor designated by the same latter are not significantly different at 5% level, using Dincan's multiple range test.**

Foliar application of urea exerted a significant effect in root and top yields/fed. in both seasons. Three and four foliar sprayings with urea gave the highest values of root and top yields/fed., while sprayed sugar beet plants with water (control) resulted in the lowest values of these traits. This fact is true in the two seasons. This view is in agreement with that found by Lamb an Moraghan (1993); Kemp *et al*. (1994); Badawi (1996); El-Maghraby *et al*. (1997); Fahmi (1999) and Azab *et al*. (2000).

Highly significant interaction effect between nitrogen fertilizer level and foliar application times of urea on root yield/fed. were found in both seasons (Table 3). The highest root yield/fed. was obtained from blants fertilized with 90 kg N/fed. in combination with four foliar sprayings with urea without significant difference with those plants recived 65 kg N/fed. and sprayed three foliar sprayings with urea (Table 4).

4. TSS and juice purity percentages:

Concerning total soluble solids (TSS) and juice purity percentages, the available data in Table (5) reveal that nitrogen level as soil application decreased both traits, but the differences between nitrogen level on TSS in the first season as well as on juice purity percentage in the second season did not reach the level of significant. This results are in the same line with those of Carter and Traveller, 1981; Sorour *et al*., 1992; Nemeat Alla, 1997 and Azab *et al*., 2000.

Foliar spraying of urea (one to four foliar sprayings) significantly decreased TSS and juice purity percentages in the two seasons, except juice purity percentage in the first season (Table 5). Control sugar beet plants gave the higher values of TSS and juice purity percentages compared to other treatments of foliar application of urea. The data show also that increasing the amount of nitrogen fertilizer accompanied by substantial decrease in both characters, because the highest rate of nitrogen gave higher rate of photosynthetic, which need a large amount of sucrose to consist the root and foliage of sugar beet plants. These results are agreement with those found by Lamb and Moraghan (1993); El-Maghraby *et al*. (1997) and Azab *et al*. (2000).

There were no significant interaction effects between nitrogen level and foliar application of urea on TSS and juice purity percentages in both seasons.

Table (4): Dry matter accumulation/plant, root and sugar yields/fed. in two seasons as affected by the interaction between nitrogen fertilizer rate and foliar spraying with urea.

N- level as soil application	No. of urea spraying				
	Cont.	One	Two	Three	Four
Dry matter accumulation (g/plant) in 1999/2000 season					
40 kg N/fed.	181.76f	181.28f	180.99f	190.96e	204.37c
65 kg N/fed.	174.71f	190.87e	192.86de	201.27c	212.91b
90 kg N/fed.	202.20c	199.13cd	206.38bc	221.87a	224.35a
Root yield (t/fed.) in 1999/2000 season					
40 kg N/fed.	21.26i	25.52h	26.61h	28.93fg	29.54efg
65 kg N/fed.	25.44h	28.43g	30.05def	32.11ab	32.72a
90 kg N/fed.	30.57cde	31.19bcd	31.93abc	32.48ab	33.01a
Root yield (t/fed.) in 2000/2001 season					
40 kg N/fed.	20.04h	23.19g	25.61f	27.22ef	28.63df
65 kg N/fed.	25.16fg	30.39cd	31.82bc	32.75ab	33.07ab
90 kg N/fed.	33.59ab	33.73ab	34.01ab	34.29ab	34.91a
Sugar yield (t/fed.) in 1999/2000 season					
40 kg N/fed.	3.53i	4.08h	4.23h	5.34cd	5.60bc
65 kg N/fed.	4.16h	4.43gh	4.67fg	5.68abc	5.99a
90 kg N/fed.	5.06de	4.91ef	4.94ef	5.60bc	5.94ab
Sugar yield (t/fed.) in 2000/2001 season					
40 kg N/fed.	3.35h	3.48gh	3.89fg	4.94de	5.36cd
65 kg N/fed.	4.19f	4.64e	4.83e	5.70bc	6.04ab
90 kg N/fed.	5.45c	5.41c	5.38c	5.94ab	6.27a

Means designated by the same latters are not significantly different at 5% level, using Dincan's multiple range test.

5. Sucrose percentage and sugar yield/fed.:

From data presented in Table (5) it can be see that increasing nitrogen level caused a significant decrease in sucrose percentage in both seasons. As beneficial effect of nitrogen on increasing root yield/fed., increasing level of nitrogen fertilizer recorded a significant increase in sugar yield/fed. in the two seasons. The decrease in sucrose and juice purity percentages related to the increase in rates of nitrogen may be due to the role of nitrogen in increasing non sucrose substance such as proteins, amino acids and other substance, which led to decreasing juice purity percentage.

Table (5): Total soluble solids (TSS), sucrose and juice purity percentages and sugar yield (t/fed.) as affected by the nitrogen fertilizer rate and foliar spraying with urea in 1999/2000 and 2000/2001 seasons.

Treatments	1999/2000 season				2000/2001 season			
	TSS	Sucr-ose	Juice purity	Sugar yield t/fad	TSS	Sucr-ose	Juice purity	Sugar yield t/fad
	%				%			
N- level: (kg N/fed.):								
40	22.00	17.5a	80.4a	4.26c	24.7a	17.5a	69.7	4.08b
65	21.75	16.6b	77.0b	4.58b	23.7b	16.5b	69.7	5.14a
90	21.52	16.5b	75.3b	5.99a	23.6b	16.4b	70.2	5.75a
F- test	NS	*	*	**	*	*	NS	*
No. of urea spraying:								
Control	23.0a	18.0a	78.2	4.25b	24.8a	17.7a	72.7a	4.33c
One	21.6b	16.7b	78.2	4.47b	24.2ab	16.6b	68.4b	4.51c
Two	21.5b	16.7b	77.5	4.61b	24.0bc	16.7b	68.2b	4.70bc
Three	21.4b	16.6b	77.1	5.54a	23.6c	16.5b	70.1b	5.53ab
Four	21.3b	16.4b	76.8	5.84a	23.4c	16.4b	69.8b	5.89a
F- test	*	*	NS	*	*	*	**	**
Interaction:	NS	NS	NS	*	NS	NS	NS	*

***, ** and NS indicate P<0.05 and not significant, respectively. Means of each factor designated by the same latter are not significantly different at 5% level, using Dincan's multiple range test.**

This findings are in harmony with those obtained by El-Kassaby and Leilah (1992); Besheit *et al*. (1995); Smit *et al*. (1995); Nemeat Alla (1997) and Azab *et al*. (2000).

Concerning to the effect of foliar application on sucrose percentage and sugar yield/fed., data clearly show that the lowest sucrose percentage was recorded with higher number of foliar application with urea in both season (Table 5). On the other hand, the highest sugar yield/fed. was obtained from foliar spraying three or four times with urea solution in the two seasons. The increase in root and sugar yields/fed. caused by foliar application of urea may be attributed to the active role of urea in enhancing growth of sugar beet plants i.e., root diameter and dry matter accumulation per plant, which led to increasing root and sugar yields. These results are in line with those concluded by Lamb and Moraghan (1993); El-Maghraby *et al*. (1997); Fahmi (1999) and Azab *et al*. (2000).

Results presented in Table (5) show that the interaction between nitrogen fertilizer rate and foliar application of urea exerted a significant influence on sugar yield/fed. in both seasons. The highest sugar yield/fed. was obtained from plants treated with 65 kg N/fed. in the first season and with 90 kg N/fed. in the second season in combination with three and four foliar sprayings of urea in the first and second seasons, respectively (Table 4). The data in the same Table indicate that application of 90 kg N/fed. increased sugar yield/fed. under all treatments of foliar spraying, without significant difference with 65 kg N/fed. in combination with three foliar sprayings of urea. This fact is true in both seasons.

It can be concluded that soil application of nitrogen fertilizer at the rate of 65 kg N/fed. and foliar spraying sugar beet plants three times with urea solution at the rate of (50 g/l) could be recommended for optimum root and sugar yields per unit area as well as decreasing fertilizer costs under the condition of the present study.

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تأثير إضافة السماد الأزوتى الى التربة أو بالرش الورقى على محصول بنجر السكر

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أجرى هذا البحث بالمزرعة البحثية لمحطة بحوث سخا بكفرالشيخ (مركز البحوث الزراعية) خلال موسمى ١٩٩٩/٢٠٠٠، ٢٠٠٠/٢٠٠١م. حيث أجريت تجربتين حقليتين لدراسة تأثير ثلاث مستويات من التسميد الأزوتى كسماد أرضى وهى ٤٠، ٦٥، ٩٠ كجم أزوت للفدان وخمسة معاملات من الرش بمحلول اليوريا بتركيز(٥٠ جم/لتر) وهى صفر (المقارنة)، رشة، رشتان، ثلاث رشات، أربع رشات على محصول بنجر السكر ومكوناته و جودته بالاضافة الى محاولة تقليل تكلفة الانتاج والمحافظة على البيئة من التلوث. أستخدم تصميم الشرائح المتعامدة فى أربعة مكررات.

وتتلخص أهم النتائج المتحصل عليها فيما يلى:

أدت زيادة مستوى التسميد الأزوتى كسماد أرضى حتى معدل ٩٠ كجم آزوت/فدان وتكرار الرش بمحلول اليوريا الى زيادة معنوية فى صفات طول وقطر الجزر، المادة الجافة المتجمعة لكل نبات، محصول الجذور والعرش للفدان وكذلك محصول السكر للفدان بكلا موسمى الدراسة. بينما كان لها تأثيرا عكسيا على النسبة المئوية لكل من المواد الصلبة الكلية الذائبة، السكروز وكذلك النقاوة. حيث أدت زيادة مستويات التسميد الأزوتى من ٤٠ الى ٩٠ كجم أزوت/فدان والرش بمحلول اليوريا بأى عدد من الرشات الى نقص واضح فى تلك الصفات المذكورة أخيرا.

وعامة يمكن أن نستخلص أن اضافة السماد الأزوتى بمعدل ٦٥ كجم أزوت للفدان مع الرش بمحلول اليوريا ثلاث مرات وبمعدل (٥٠جم/لتر) يمكن أن ينصح به للحصول على أعلى محصول من الجذور والسكر لوحدة المساحة وتقليل تكاليف التسميد تحت ظروف هذه الدراسة.