Yield and Quality of Sugar Beet in Response to Levels and Times of Nitrogen Application and Foliar Spraying of Urea

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Abstract:

Effects of N levels (120, 168 and 216 kg N ha^{-1}), times of N application (½ N dose before the first irrigation (BFI) + ½ N dose before the second irrigation (BSI); ½ N (BFI) + ½ N before the third irrigation (BTI); $^{1}/_{3}$ N (BFI) + $^{1}/_{3}$ N (BSI) +$^{1}/_{3}$ N(BTI) and foliar spraying of urea (0, 1 and 2% concentrations) on root yield and quality of sugar beet "cv. Kawamira" were evaluated. Increasing N levels from 120 to 216 kg N ha^{-1} enhanced root yield and its components, while it resulted in marked reduction in yield quality (total soluble solids, sucrose and purity %). Timing of N application significantly affected most of yield characters. Adding nitrogen in two equal portions, 1/2 before the first irrigation (BFI) +1/2 N before the second irrigation (BSI), gave the highest root, top and sugar yields/ha^{-1}. Foliar spraying of urea at 2 % concentration gave marked increases in root, top and sugar yields/ha^{-1}. Application 216kg N ha^{-1} in two equal doses (1/2 N BFI + 1/2 N BSI) produced the highest root and sugar yields/ha^{-1}. However, the addition of 216kg N ha^{-1} and foliar application of urea at 2 % solution produced the highest top yield ha^{-1}.

Generally, it can be concluded that soil application of nitrogen at the rate of 216 kg N ha^{-1} in two equal portions, i.e. (1/2 N BFI + 1/2 N BSI) and foliar nutrition by urea (46% N) at 2 % was the recommended treatment for raising root and sugar yields of sugar beet under study conditions.

Key words: Nitrogen levels, time of N application, urea, foliar spraying, concentration, root yield, sugar percentage, sugar yield.

Introduction

Sugar beet (*Beta vulgaris* L.) has a great ability to be successfully grown in the newly reclaimed lands. The irrigation water requirements are relatively low compared with many field crops particularly sugar cane. Nitrogen fertilizer is considered one among these factors affecting growth, yield and quality of sugar beet. It is usually applied as soil application. Few attempts were done to examine N efficiency when applied as foliar nutrition. Rates, times and methods of nitrogen application play an important role in sugar beet growth, production and quality. Badawi (1989a and b), Kamel *et al*. (1989), El-Kassaby and Leilah (1992), and Seaadh (1998) reported that increasing nitrogen rates up to 60 kg N fad^{-1} (fad = faddan = 4200 m^{2} = 0.42 ha) resulted in desirable effects on sugar beet yields and their attributes. El-Kassaby *et al*. (1991) and Sharief *et al*. (1997) stated that raising nitrogen level up to 70 kg N fad^{-1} significantly increased root and sugar yields fad^{-1}. Mahmoud *et al*. (1999) found that the maximum root and sugar yields were produced with the addition of 80 kg N fad^{-1}. Sorour *et al*. (1992) stated that increasing nitrogen rates from 60 to 120 kg N fad^{-1} increased root length, root diameter as well as root and sugar yields fad^{-1}. Ghonema and Sarhan (1994) and Badawi *et al*. (1995) indicated that 75 kg N fad^{-1} was the best nitrogen rate for sugar beet fertilization. The addition of N up to 100 kg N fad^{-1} substantially improved length, diameter and weight of sugar beet roots (Mahmoud *et al*., 1999). On the other hand, TSS, sucrose % and juice purity markedly decreased as nitrogen level increased (Sorour *et al*. 1992; Mahmoud *et al*. 1999).

Split application of N in two equal portions (pre the first and second watering) caused a positive response in sugar beet growth and root yield (Badawi, 1989a; Zalat, 1993; El-Hennawy *et al*.1998). Sarhan and Ismail (2003) found that applying nitrogen fertilizer dose at two equal portions after thinning and one month later produced the highest values of fresh and dry yields of fodder beet roots. Finally, Mousa (2004) stated that adding nitrogen in three equal portions, before the first, second and third irrigations, significantly increased root length and diameter, root, top and sugar yields fad^{-1}, sucrose and purity percentages.

Foliar nutrition with urea is considered a new direction to raise nitrogen use efficiency through minimizing the applied rate of nitrogen, particularly under the reverse soil conditions. Lamb and Moraghan (1993) stated that the addition of nitrogen as foliar application did not affect root yield and extractable sugar in one season, while it resulted in a marked increase in root yield in the other season. Barsoum and Zeinab-Nassar (1995) revealed that foliar application of urea at 4 % concentration produced the highest root length, diameter and fresh weight as well as top and root yields fad^{-1}.

For the combined effects of soil and foliar nitrogen application, Badawi (1996) indicated that urea as foliar nutrition had an active role in enhancing growth and yield of sugar beet. He also added that the interaction between soil N-levels and foliar concentration of urea had marked effects on root fresh weight, sucrose % as well as root and sugar yields fad^{-1}. Podlaska and Artysza (1995) reported that adding nitrogen fertilization at a rate of 120 kg N ha^{-1} before sowing, or 80 kg N ha^{-1} before sowing + foliar spray of 40 kg N ha^{-1} as 6 % urea solution gave higher root and top yields ha^{-1}.

Materials and Methods

This investigation was carried out at the Experimental Station, Faculty of Agriculture, Mansoura University, during 1995/96 and 1996/97seasons. The purpose was to study the effect of levels and times of nitrogen application, foliar spraying of urea and their combinations on yield and quality of sugar beat (*Beta vulgaris* L.). A split-split plot design with four replicates was used. The main plot treatments consisted of three nitrogen levels (120, 168 and 216 kg N ha^{-1}). The sub plot treatments were assigned to three times of nitrogen application (½ N before the first irrigation (BFI) + ½ N before the second irrigation (BSI); ½ N BFI + ½ N before the third irrigation (BTI) and $^1/_3$ N (BFI) + $^1/_3$ N BSI +$^1/_3$ N BTI. Nitrogen fertilization in the from of urea (46 % N) was side dressed as a previously mentioned rates and times of application. The sub-sub plot treatments were assigned to three foliar spray concentrations of urea, i.e. 0, 1 and 2 %. Each sub-sub plot was 3.0 × 3.5 m and consisted of 5 ridges with 0.60 m spacing between ridges. The preceding summer crop was maize (*Zea mays* L.) in both seasons.

Soil samples were randomly taken from the soil surface of 0 - 30 cm in the experimental sites before soil preparation. Results of chemical and mechanical analysis of the experimental site soil, according to Piper (1950) are listed in Table (1). The experimental site area was fertilized with calcium super phosphate (15.5 % P_2O_5) at the rate of 240 kg ha^{-1}, which was added after ridging and before sowing irrigation. Potassium in the form of potassium sulphate (48 % K_2O) was added at the rate of 120 kg ha^{-1} in one dose before the first irrigation.

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

Characters	1995/96	1996/97
Clay (%)	41.7	40
Silt (%)	30.2	31.9
Fine sand (%)	24.3	23.6
Texture class	Clay	Clay
CaCo3 (%)	3.3	3.6
Organic matter (%)	1.8	1.7
Total nitrogen (%)	0.11	0.09
Available P (ppm)	11.8	10.9
Available K (ppm)	343.2	318.4

Seeding dates were 11th and 7th November in 1995 and 1996 seasons, respectively. Seed balls of sugar beet "cv. Kawamira" were hand sown as the usual dry sowing method on one side of the ridge in hills 20 cm apart at the rate of 2-3 balls/hill. Plots were irrigated immediately after sowing to soil saturation. To enhance the emergence of plants, a quick irrigation was applied at seven days after sowing. Plants were thinned twice and the later one was done to ensure one plant/hill (84000 plants ha^{-1}). Other agricultural practices were kept the same as normally practiced in growing sugar beet fields.

At harvest, random samples of five plants were uprooted from each sub-sub plot to estimate the following characters: Root length (cm), root diameter (cm), root fresh weight (g), foliage fresh weight (g) and root /top ratio. Total soluble solids (TSS %) in roots was measured in juice of fresh roots using Hand Refractometer. Sucrose percentage was determined polar metrically on lead acetate extract of fresh macerated roots according to the method of Le-Docte (1927). Apparent purity (%) was determined as a ratio between sucrose % and TSS % of roots.

Plants in the two inner ridges of each sub-sub plot were collected and cleaned, thereafter, roots and tops were separated and weighted in Kilograms and converted to estimate root and top yields (ton ha^{-1}). Gross sugar yield (ton ha^{-1}), was calculated by multiplying root yield by root sucrose percentage. Harvesting index (HI) was estimated using the following formula. HI= Root yield / Biological yield (root + foliage)

Data analysis: Statistical analyses were performed using SAS for Windows Release 6.12 (SAS Institute, 1997). The SAS procedures used for the ANOVA and normality tests were GLM (general linear model) and UNIVARIATE, respectively. Protected ANOVA LSD test was used to assess the differences between treatment means (Gomez and Gomez, 1984).

Results and Discussion

N level Effects: Results of the statistical analysis show that nitrogen fertilizer levels exerted significant effects on all estimated characters in both seasons, except purity percentage in the second season only (Tables 2, 3, 4 and 5). Increasing nitrogen levels from 120 to 168 and 216 kg N ha^{-1} was associated with significant increases in root yield and its component variables, i.e. root length, root diameter and root weight. The highest values of aforementioned characters were obtained with the addition of 216 kg N ha^{-1}. Meanwhile, the lowest means of these previously mentioned traits were obtained with the addition of the lowest N level (120 kg N ha^{-1}). Foliage fresh weight was also increased with each increase in nitrogen level up to the highest rate (216 kg N ha^{-1}). Maximum root/top ratio (2.36) in the second season (1996/97) and top yield (26.0 t ha^{-1}) in the first season (1995/96) was found with the addition of 168 kg N ha^{-1}. On the contrast, the highest level of nitrogen resulted in marked reduction in yield quality, i.e. total soluble solids (TSS) and sucrose % in both seasons and purity % in the first season. Harvest index was also significantly affected by nitrogen levels in both seasons and significantly increased as nitrogen level increased.

Table 2
Length, diameter and fresh weight of roots as affected by N levels, times of N application and foliar application of urea.

Characters	Root length (cm)		Root diameter (cm)		Root fresh weight (g)	
Treatments	95/96	96/97	95/96	96/97	95/96	96/97
A: Nitrogen levels:						
120 kg N ha^{-1}	34.1	33.8	8.27	7.98	493.3	593.1
168 kg N ha^{-1}	37.0	37.4	9.74	9.84	857.6	943
216 kg N ha^{-1}	43.6	44.6	10.72	11.03	920.3	971
LSD (5%)	1.4	0.9	0.53	0.23	48.2	45.1
B: Application time:						
1/2BFI+1/2BSI	39.9	40.1	9.91	9.92	806.8	898.6
1/2BFI+1/2BTI	38	38.5	9.56	9.6	755	824.3
1/3BFI+1/3BSI+1/3BTI	36.8	37.3	9.27	9.34	709.4	784.2
LSD (5%)	0.4	0.3	0.05	0.05	14.1	26.2
C: Foliar nutrition:						
Water	36.8	36.8	9.24	9.22	721.9	803.2
Urea at 1%	38.1	38.6	9.59	9.65	757.4	832.8
Urea at 2%	39.8	40.5	9.9	9.99	791.9	871.2
LSD (5%)	0.2	0.3	0.06	0.06	7.3	10.1

Table 3
Foliage fresh weight, root/top ratio and total soluble solids (TSS) % as affected by N levels, times of N application and foliar application of urea

Characters	Foliage fresh wt. (g)		Root/top		TSS (%)	
Treatments	95/96	96/97	95/96	96/97	95/96	96/97
A: Nitrogen levels:						
120 kg N ha^{-1}	308.4	320.2	1.6	1.85	26.36	26.18
168 kg N ha^{-1}	483.4	404.1	1.78	2.36	26.26	26.07
216 kg N ha^{-1}	507.7	513.5	1.82	1.89	26.08	25.93
LSD (5%)	18.1	27.3	0.07	0.23	0.07	0.07
B: Application time:						
1/2BFI+1/2BSI	450.7	434.8	1.77	2.09	26.37	26.24
1/2BFI+1/2BTI	432.6	413	1.73	2	26.24	26.06
1/3BFI+1/3BSI+1/3BTI	415.3	390	1.69	2.01	26.09	25.89
LSD (5 %)	7.2	6.2	0.04	0.06	0.03	0.03
C: Foliar nutrition:						
Water	409.9	392.3	1.74	2.05	25.96	25.78
Urea at 1%	435.3	414.8	1.72	2.02	26.26	26.09
Urea at 2%	453.4	430.8	1.73	2.03	26.48	26.32
LSD (5 %)	5.3	4.0	N.S	N.S	0.06	0.04

N.S: Not significant (P>0.05)

Table 4
Sucrose %, purity % and root yield (t ha^{-1}) as affected by N levels, times of N application and foliar application of urea

Characters	Sucrose %		Purity %		Root yield (t ha^{-1})	
	95/96	96/97	95/96	96/97	95/96	96/97
A: Nitrogen levels:						
120 kg N ha^{-1}	18.36	18.04	69.65	68.91	26.466	31.749
168 kg N ha^{-1}	18.17	17.74	69.23	68.04	46.410	50.884
216 kg N ha^{-1}	17.67	17.66	67.76	68.09	49.718	52.431
LSD (5%)	0.18	0.2	0.72	N.S	1.666	0.857
B: Application time:						
1/2BFI+1/2BSI	18.24	17.97	69.17	68.5	43.364	48.195
1/2BFI+1/2BTI	18.05	17.8	68.82	68.32	40.936	44.458
1/3BFI+1/3BSI+1/3BTI	17.91	17.66	68.65	68.22	38.318	42.388
LSD (5%)	0.07	0.06	0.29	N.S	0.976	1.452
C: Foliar nutrition:						
Water	17.94	17.68	69.14	68.57	39.199	43.435
Urea at 1%	18.08	17.81	68.88	68.29	40.936	44.792
Urea at 2%	18.17	17.94	68.63	68.18	42.483	46.838
LSD (5%)	0.03	0.04	0.17	0.16	0.738	0.762

N.S: Not significant (P>0.05)

Table 5
Averages top and sugar yields (t ha^{-1}) and harvest index as affected by N levels, times of N application and foliar application of urea.

Characters / Treatments	Top yield (t ha^{-1}) 95/96	Top yield (t ha^{-1}) 96/97	Sugar yield (t ha^{-1}) 95/96	Sugar yield (t ha^{-1}) 96/97	Harvest Index 95/96	Harvest Index 96/97
A: Nitrogen levels:						
120 kg N ha^{-1}	16.446	17.065	4.855	5.736	0.62	0.62
168 kg N ha^{-1}	25.871	21.729	8.449	9.020	0.63	0.64
216 kg N ha^{-1}	25.752	27.394	8.782	9.258	0.64	0.66
LSD (5%)	0.833	1.166	0.452	0.214	0.01	0.01
B: Application time:						
1/2BFI+1/2BSI	23.990	23.134	7.902	8.663	0.64	0.64
1/2BFI+1/2BTI	22.729	22.158	7.378	7.902	0.63	0.64
1/3BFI+1/3BSI+1/3BTI	21.349	20.896	6.831	7.473	0.62	0.64
LSD (5%)	0.857	0.357	0.190	0.262	0.01	N.S
C: Foliar nutrition:						
Water	21.111	21.015	7.021	7.664	0.63	0.65
Urea at 1%	22.681	22.110	7.378	7.973	0.63	0.64
Urea at 2%	24.252	23.038	7.711	8.401	0.63	0.63
LSD (5%)	0.571	0.452	0.143	0.148	N.S	0.01

N.S: Not significant (P>0.05)

The highest value of harvest index was obtained with the addition of 216 kg N ha^{-1} (Table 5). The increase in root weight and dimension with the increase in nitrogen levels might be due to the role of nitrogen as nutrient element in chlorophyll formation and encouragement the growth of canopy, so it helps photosynthetic practice and hence increasing root weight and dimension (length and diameter). These results are similar to those reported by Mahmoud *et al*. (1990 a and b) and Shahr-Zad (1999).

Timing of N application effects: Time of nitrogen application significantly affected all estimated characters in the two seasons and only purity percentage in the first season. Root characters (length, diameter, fresh weight and root/top ratio) increased with the split application of nitrogen in two equal portions, 1/2 before the first irrigation (BFI) +1/2 N before the second irrigation (BSI). Meanwhile, adding N into three equal portions 1/3 before the first irrigation (BFI) + 1/3 N before the second irrigation (BSI) + 1/3 N before the third irrigation (BTI) gave the lowest values of root characters. Top, root and sugar yields as well as harvest index were markedly affected by time of nitrogen application. Adding nitrogen in two equal portions (before the first and second irrigation) gave the highest root and sugar yields as well as harvest index. Sugar beet quality (Sucrose, TSS and Juice purity in roots %) was markedly affected by timing of N application. Adding nitrogen in two equal portions (1/2 before the first irrigation (BFI) +1/2 N before the second irrigation (BSI)) resulted in the greatest sugar %. Meanwhile, adding nitrogen in three equal portions 1/3 before the first irrigation (BFI) +1/3 N before the second irrigation (BSI) + 1/3 N before the third irrigation (BTI) recorded the lowest means. The increase in root and sugar yields with the split application of nitrogen might be attributed to the increase in nitrogen use efficiency, because of the reduction in N loss to low limit with the split addition, beside the continuous supply of plants from nitrogen. Similar results were stated by El-Hennawy *et al.* (1998) and Shahr-Zad (1999).

Foliar nutrition effects: Data in Tables (2, 3, 4 & 5) show that foliar nutrition of urea had significant effects on all estimated characteristics in the two seasons, except root/top ratio. Root dimensions (root length, root diameter, root weight), foliage weight were increased with foliar spraying of urea at 2 % concentration. Root, sugar and top yields as well as harvest index were increased with urea foliar nutrition compared to the control. Urea at 2 % gave the highest root and sugar yields ha^{-1} as well as harvest index. Sugar percentage increased with the addition of urea at 2 % concentration. Meanwhile, spraying with tap water recorded the lowest means of this trait. Badawi (1996) came to similar results.

Interaction effects: The interaction between nitrogen fertilizer levels and time of its application had significant effects on root and sugar yields ha^{-1} in 1996/97 season. Application of nitrogen at 216 kg ha^{-1} in two equal portions, 1/2 before the first irrigation (BFI) +1/2 N before the second irrigation (BSI), produced the highest root and sugar yields ha^{-1}. On the other side, the lowest root and sugar yields ha^{-1} were produced with the lowest level of N application (120 kg N ha^{-1}) in case of its addition in three equal portions, $^{1}/_{3}$ N BFI + $^{1}/_{3}$ N BSI +$^{1}/_{3}$ N BTI, as shown in Fig. (1 and 2).

The interaction between N levels and urea concentrations had a significant effect on top yield ha^{-1}. The soil application of 216 kg N ha^{-1} and foliar spraying urea at 2 % concentration produced the highest top yield ha^{-1}, while the lowest top yield was obtained with the addition of 120 kg N ha^{-1} without urea foliar spraying (Fig. 3).

Generally, it can be concluded that addition nitrogen at the rate of 216 kg ha^{-1} in two equal portions i.e. 1/2 before the first irrigation (BFI) +1/2 N before the second irrigation (BSI) and foliar nutrition by urea at 2 % was the recommended treatment for higher yields of sugar beet under the conditions of this study.

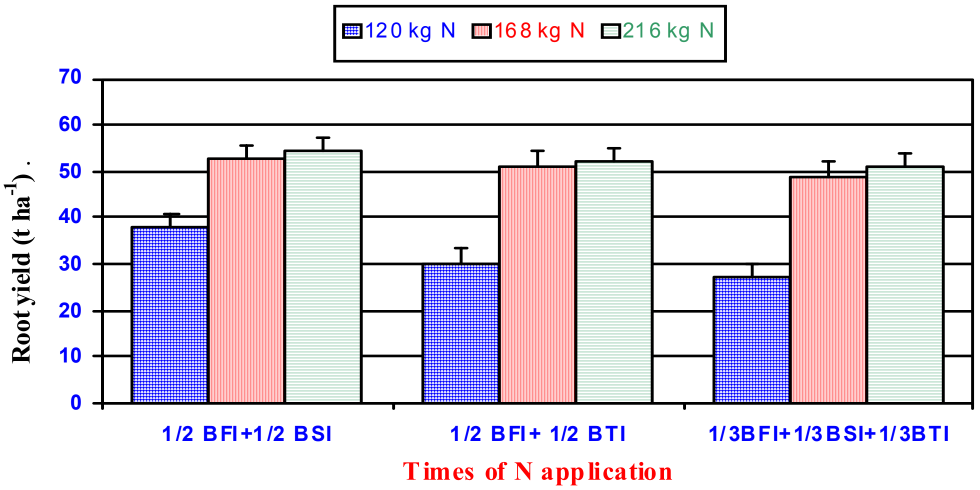

Fig. 1: Root yield (ton ha^{-1}) as affected by the interaction between nitrogen levels and times of its application in 1996/97. Bars = LSD (5%)

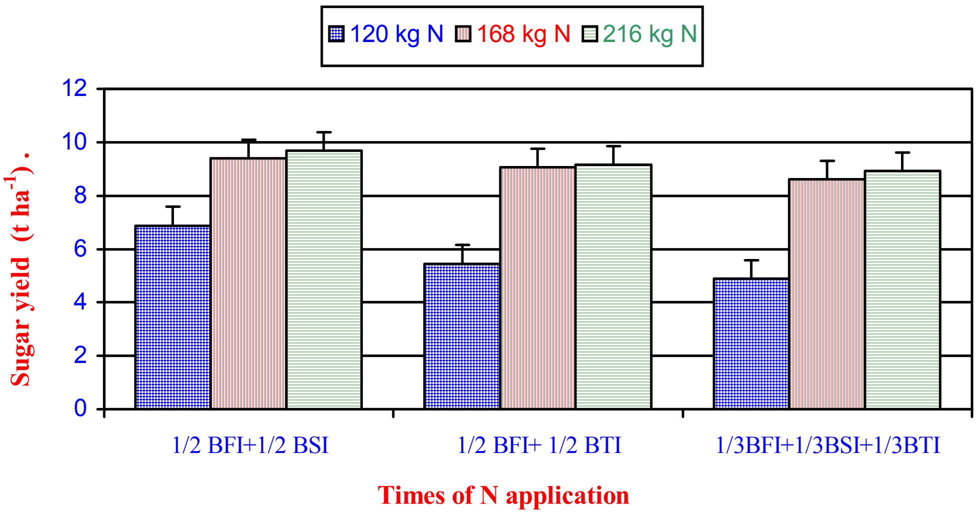

Fig. 2. Sugar yield (ton ha^{-1}) as affected by the interaction between nitrogen levels and times of its application in 1996/97. Bars = LSD (5%).

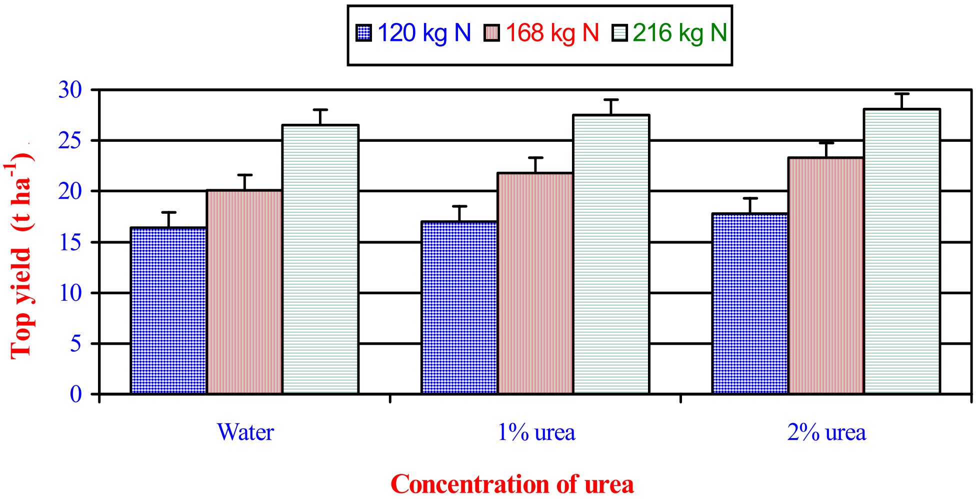

Fig. 3. Top yield (ton ha^{-1}) as affected by the interaction between nitrogen levels and concentration of urea foliar application in 1996/97. Bars = LSD (5%).

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المحصول والجودة في بنجر السكر واستجابته لمستويات ومواعيد إضافة النيتروجين والرش باليوريا

عبد الرحيم عبد الرحيم ليله، سمير السيد القلا، عوض طه القصبي
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قسم المحاصيل- كلية الزراعة – جامعة المنصورة
جمهورية مصر العربية

الملخص:

تم تقييم تأثير مستويات التسميد النيتروجيني (١٢٠، ١٦٨، ٢١٦ كجم ن/ هكتار) ومواعيد إضافته (نصف المعدل قبل الرية الأولى + نصف المعدل قبل الرية الثانية)، (نصف المعدل قبل الرية الأولى+ نصف المعدل قبل الرية الثالثة) و (ثلث المعدل قبل الرية الأولى+ ثلث المعدل قبل الرية الثانية+ ثلث المعدل قبل الرية الثالثة) وتركيزات الرش باليوريا كسماد ورقي (١٪ يوريا (١٠ جرام / لتر ماء) و ٢٪ يوريا(٢٠ جرام / لتر ماء)و الرش بالماء العادي (الكنترول) على نمو ومحصول بنجر السكر" كواميرا". وأشارت نتائج الدراسة إلى ما يلي:

- أدت زيادة مستويات النيتروجين من ١٢٠ إلى ١٦٨ و ٢١٦ كجم / هكتار إلى زيادة معنوية في محصول العرش والجذور والسكر، إلا أن زيادة معدل التسميد النيتروجيني حتى ٢١٦ كجم ن/هكتار قد أدت إلى نقص معنوي في صفات الجودة (نسبة المواد الصلبة الذائبة ونسبة السكر والنقاوة).
- أثر وقت إضافة السماد النتروجين معنويا على معظم الصفات بالدراسة، وقد أدى إضافة التسميد النيتروجيني على دفعتين متساويتين (٢/١ الكميه قبل الرية الأولى + ٢/١ قبل الرية الثانية) إلى زيادة معنوية في محصول الجذور والعرش والسكر/فدان.
- أدى الرش بمحلول اليوريا بتركيز ٢ ٪ إلى زيادة محصول الجذور والعرش والسكر/هكتار.
- أدت إضافة التسميد النيتروجيني بمعدل ٢١٦ كجم/هكتار على دفعتين متساويتين (قبل الرية الأولى والثانية مباشرة) إلى الحصول على أعلى محصول جذور وسكر/هكتار. كما بلغ محصول العرش/هكتار أقصاه بإضافة التسميد النيتروجيني بمعدل ٢١٦ كجم/ هكتار والتسميد الورقي بمحلول اليوريا بتركيز ٢٪.

- توصي الدراسة بإضافة التسميد النيتروجيني بمعدل ٢١٦ كجم/ هكتار على دفعتين متساويتين (قبل الرية الأولى والثانية مباشرة) والتسميد الورقي بمحلول اليوريا بتركيز ٢ ٪ لزيادة إنتاجيه محصول بنجر السكر تحت ظروف منطقة الدراسة.