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SUGAR - BEET YIELDS AND CROP COEFFICIENT AS AFFECTED BYNITROGEN FERTILIZER APPLICATION UNDER DIFFERENT IRRIGATION SYSTEMS

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ABSTRACT

Two years successful field experiments (2001/2002 and 2002/2003) were carried out at Banger El- Soukar (Burg El- Arab Sector) under newly reclaimed land conditions to study the response of Sugar - beet crop (yield and quality) and attributed parameters to nitrogen fertilizer scheduling under different irrigation systems. To perform and analyze the methodology of the study, three parameters were considered. Irrigation systems: I (modified furrow irrigation, I_1 and sprinkler irrigation, I_2; two sources of nitrogen, N (ammonium sulphate, N_1 and ammonium nitrate, N_2; with four application rates D (40, 60, 80, and 100 kg N/fed) and three application times, T (two, three and four equal portions). The statistical split-split plot design with four replicates was adopted for this study. Results indicate that sprinkler irrigation system has the maximum sugar- beet crop yield and quality, as well as inhabited attributed growth parameters and rationalized water applications. However, with respect to growth parameters, sprinkler irrigation system has improved both root diameter/length ratio; root weight per plant and root yield by about 11.91, 21.16 and 15.16% comparing with modified furrow irrigation system respectively. With regard to the total observed yield and extracted sugar, data reveal that sprinkler irrigation system has obtained the highest value of 5.22 Mg/fed. and 20.86% respectively. Also, results indicate that, sprinkler irrigation system has rationalized the water application, water use efficiency and nitrogen use efficiency for both root and sugar yield by about 37.47 and 58.18, 71.42 and 16.8, 22.30% respectively comparing with modified furrow irrigation system, under newly reclaimed conditions of Banger- El- Soukar district. With point of view on fertilizer sources and application amounts, results show that applying ammonium nitrate by 100 kg/fed. in four equal portions (35, 50, 65 and 80 days after sowing), is more effective for improving sugar- beet yield, comparing with ammonium sulphate under sprinkler irrigation system. Concerning the quality parameters, the highest value of gross sugar of 20.86 % was obtained by sprinkler irrigation comparing with 18.81% by furrow irrigation. The highest values of (T.S.S.) of 24.82 and 23.06% were obtained with ammonium nitrate and ammonium sulphate at 100 kg N/fed. respectively under sprinkler irrigation system. The highest. values of K, Na and α-amino-N of 7.51, 3.18 and 3.5-meq/100g were accompanied to the application of ammonium sulphate at 40 kg N/fed. The average value of seasonal Sugar - beet crop coefficient (K_c) for the two growing seasons was 0.845 and the highest K_c value of 1.06 was in March

__Key words__: Sugar-beet, Sprinkler irrigation, Furrow irrigation, Nitrogen fertilization.

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INTRODUCTION

Sugar-beet is a strategic commodity in many countries worldwide, wherever it ranked after wheat from the importance point of view in Egypt. The total cultivated area of Sugar - beet in Egypt has increased from 16.9 thousand feddans in 1982 to 140.9 thousand feddans in 2004. The total expected sugar production in Egypt in 2004 was estimated as 1.5 teragrams; however, the expected local consumption of sugar is about 2.2 teragrams. Therefore, only 69.7% self sufficiency is achieved and about 30% has to be imported (Egyptian Society of Sugar Technologists, 2004).

Sugar – beet is characterized by short growing season, consumes less water than cane (about two- thirds) and it may also grows under a wide variety of soil and climatic conditions. (Abou- Shieshaa, 2001).

Irrigation and fertilization methods are considered as the most important factors affecting yield and quality of Sugar-beet. Doorenbos and Kassam (1986) indicated that water requirements of Sugar - beet ranged from 550 to 750 mm, moreover, they added that irrigation increased yield but decreased sugar content.

Modern or modified irrigation systems can apply water continuously with the desired amounts compared with traditional furrow irrigation. Christiansen and Davis (1967) recommended that sprinkler irrigation can be used on all soils of widely different topography and slops for many crops, and it is especially desirable for soils having high infiltration rates. Allam (1997) found that the water consumptive use for Sugar - beet yield under sprinkler and furrow irrigation systems were 69.4cm (2914.8 m^3/fed) and 92.8cm (3897.6 m^3/fed) during the growing season 1993-1994, while were 72.4cm (3040.8 m^3/fed) and 95.7cm (4019.4 m^3/fed) during the growing season 1994-1995 respectively. Badr (1987) found that the total water applied for Sugar - beet in Nubaria (sandy soil) was 5271 m^3/fed with furrow irrigation and 3364 m^3/fed with sprinkler irrigation. Awad et al. (2003) mentioned that the average water consumptive use during two successive growing seasons (1993 to1995) for Sugar - beet yield at Elbostan (Nubaria Sector) was 2982 m^3 /fed. and 3958 m^3 /fed. for sprinkler and furrow irrigation respectively. They added that sprinkler irrigation system resulted in higher root yield of 25.81 Mg/fed. compared to 20.94 Mg/fed. with surface irrigation system. Also, for both irrigation systems, increasing the nitrogen fertilizer level up to 60 kg N/fed. resulted in a significant increase in sugar yield and water use efficiency. In the other hand sugar yield decreased as the nitrogen fertilizer level increased to 75 kg N/fed. Metwally et al. (2003) reported that the maximum Sugar - beet root's yield, minimum water consumptive use and maximum field water use efficiency of 33.78 Mg/ fed, 1646.2 m^3/fed. and 0.021 Mg/ m^3 respectively were obtained with the ridge irrigation methods (double furrows) at 50 m furrow length and 0.06% laser leveling. El Tntawy and El Shafi (2004) reported that land leveling using laser technique; conveying and distributing irrigation water using perforated pipes connecting with PE pipes in Sugar -

beet production lead to save water and decrease both of accumulative advance time, water recession time and infiltration opportunity time. Furthermore, roots yield and grain yield increased by about 27% and 71% respectively compared to traditional furrow irrigation.

Nitrogen fertilizer plays a significant and direct function on yield and quality of Sugar-beet roots, so it is necessary to use the appropriate method of irrigation and maximize the nitrogen efficacy for attaining the highest roots yield as well as the best quality. Koszanski et al. (1996) found that the water consumption increased by increasing the nitrogen fertilizer application, and found that the yield /mm irrigation water depth increased with increasing nitrogen application rate. They added that application of 100kg N/ha increased roots yield but application from 200 to 300kg N/ha resulted in little further increase. Zalat (1993) found that the late application of nitrogen after 40 and 70 days from sowing significantly increased sucrose%, T.S.S.% and juice purity% compared with early application at sowing. On the other hand, El-Essawy (1994) mentioned that, there were no significant differences in T.S.S. %, juice purity and sucrose% due to time of nitrogen application. He added that roots yield and sugar yield were significantly increased by application of nitrogen at sowing as full amount or half of nitrogen at sowing and another before the first irrigation. Many investigations have been focused on Sugar - beet in order to identify its most suitable production conditions to gain better quality and quantity of Sugar - beet yields, save water and minimize the pollution of the environment. To realize these goals lot of works still needed.

Therefore, the aims of this study are to study the effect of nitrogen applications under two different irrigation systems on yield characters and quality of sugar- beet as well as water consumptive use, water use efficiency and to asses sugar-beet crop coefficient (k_c) for Banger- El- Soukar district.

MATERIALS AND METHODS

Two successful years filed experiments (2001/2002 and 2002/2003) were carried out at Banger El- Soukar on newly reclaimed soils to study the effect of nitrogen applications on yields, water consumptive use, crop coefficient, and water use efficiency of Sugar - beet crop under sprinkler and modified furrow irrigation systems. Sugar - beet (Sophy cultivar) was sown in 14th and 16th October, and was harvested in 16th and 19th April for the first and the second growing seasons, respectively.

A portable (hand- moved) sprinkler irrigation system was used with 12 x 12m spacing. A centrifugal pump of 20Hp was used to provide sufficient water discharge of 45 m^3/h and pressure head of 0.35 MPa. A Sprinkler head (R B 30) with double nozzles (4 x 2.4mm) was used.

For modified furrow irrigation systems, the common land preparation practices included chiseling, disking using disc harrow, grading with a land plane, and furrowing using opener (spaced 60 cm apart). Each individual furrow (60 m long) was irrigated using 800 mm length and 60.14 mm in diameter P.V.C. spiles. The calibration of the spiles was carried out under field conditions using volume and time method. Good water intake control can be achieved either by adjusting the water level in the field channel, or by closing off individual spiles with plug or lid. Average discharge value of (2.10 l/s) was obtained when 11-13 cm water head above the spiles outlets was maintained constant. All other agronomic practices were identically applied according to the recommended practices for the Sugar - beet crop.

The statistical split –split design method with was adopted for this study. Wherever, three variables were considered in the analysis. The main plots represented by two irrigation methods, the sub main plots were incorporated by two nitrogen sources and four application rates and the sub-sub main plots represented by three application times. The effect of treatments and their interactions were identified. All treatments were fully randomized within each of four replicates. The treatments of the experiment were characterized as follows:

Irrigation systems (I):

I_1: Furrow irrigation system.

I_2: Portable sprinkler irrigation system.

Nitrogen fertilization (Sources, N and rates, D):

N_1: Ammonium sulphate (20.5%).

N_2: Ammonium nitrate (33.5%).

Nitrogen fertilization rates:

D_1: application of 40 kg N/fed.

D_2: application of 60 kg N/fed.

D_3: application of 80 kg N/fed.

D_4: application of 100 kg N/fed.

Time of application (T):

T_1: Two equal applications at 35 and 70 days after sowing.

T_2: Three equal applications at 35, 50 and 65 days after sowing.

T_3: Four equal applications at 35,50,65 and80 days after sowing.

Soil sampling:

Soil samples were taken to determine some physical and chemical properties of the experimental site. Values of these measurements at different soil depths are presented in Tables (1 and 2).

Table (1): Some soil physical characteristics of the experimental site.

Soil depth (cm)	Particle size distribution (%)			Texture class	Bulk density, Mg/m^3	Fc (%)	PWP (%)	Available water (%)
	Sand	Silt	Clay					
0-15	68.9	7.8	23.3	Sandy clay loam	1.32	24.3	13.3	11
15-30	70.73	8.15	21.12	Sandy clay loam	1.35	24.1	13.2	10.9
30-45	75.4	7.9	16.7	Sandy loam	1.35	23.8	12.75	11.05
45-60	77.48	8.32	14.2	Sandy loam	1.31	23.2	12.43	10.77

Table (2): Some soil chemical analysis of the experimental site.

Soil depth (cm)	EC dS/m	pH	Total CaCO3 (%)	O.M (%)	Soluble cations and anions (meq/L)						
					Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{-2}
0-30	1.63	8.51	26.3	0.451	8.95	3.80	5.39	4.62	6.48	4.53	2.71
30-60	1.05	8.12	28.14	0.703	9.38	2.15	4.11	4.00	4.71	3.38	3.23

Soil fertility (NPK):

Values of nitrogen, phosphorus and potassium elements in ppm were determined in soil samples. Results indicated that the soil was deficient in nitrogen, where nitrogen concentration was 10.5 ppm. P level was 8.5 ppm, while K concentration was 263 ppm.

Actual evapotranspiration (ET_a):

Gravimetric soil samples were taken at sowing, just one day before and after each irrigation and at harvest to determine water consumptive use or the actual evapotranspiration (ET_a) of Sugar-beet crop. Water consumptive use (ET_a) were calculated according to the equation given by Israelson and Hansen (1962) as follows:

$$ET_a = \sum_{i=1}^{n} \left[(\theta_2 - \theta_1)_i / 100 \right] \times Pd_i \times d$$

where:

ET_a: actual evapotranspiration (cm),
i : soil layer,
n : total number of soil layer,
θ_1 : soil moisture content before irrigation for layer i (%),
θ_2 : soil moisture content after irrigation for layer i (%),
p_{di}: bulk density for layer i (g cm^{-3}) and
d :layer depth (cm).

Reference crop evapotranspiration (ET_o):

Reference crop evapotranspiration (ET_o) values for the two growing seasons were calculated by using CROPWAT computer model (Ver.7) according to Smith (1991). Meteorological data of Burg El- Arab Sector (Extensional Farm at Banger El- Soukar region) were employed for this purpose. The required input data were the relative humidity (%), wind speed (m/s), the average monthly values of maximum and minimum air temperatures (C^o), sun shin duration (hr) and the amount of rainfall (mm/month). ET_o values were calculated according to Penman- Monteith method (Allen et al., 1998) as follows:

$$ET_o = \frac{0.408\Delta\,(R_n - G) + \gamma \left(\frac{900}{T+273}\right) U_2 (e_a - e_d)}{\Delta + \gamma\,(1 + 0.34U_2)}$$

where:

ET_o :reference crop evapotranspiration (mm day^{-1}),
R_n :net radiation at the crop surface (M J $m^{-2}day^{-1}$),

G :soil heat flux density ($M J m^{-2} day^{-1}$),

T :average daily air temperature at 2 m height (C^o),

U_2 :wind speed at 2m height ($m s^{-1}$),

e_a :saturation vapor pressure (kPa),

e_d :actual vapor pressure (kPa),

e_a-e_d : vapor pressure deficit (kPa),

Δ : slope of vapor pressure and temperature curve (kPa C^{o-1}),

γ : psychrometric constant (kPa C^{o-1}) and

900 : conversion factor.

Water use efficiency (WUE):

Water use efficiency (WUE) values were calculated according to Jensen (1983) as follows:

$$WUE = \frac{\text{Sugar beet root yield or Sugar yield (Mg/fed.)}}{\text{Applied irrigation water } (m^3/\text{fed.})} \quad (Mg/m^3)$$

Nitrogen use efficiency (NUE):

Nitrogen use efficiency (NUE) values were calculated as follows:

$$NUE = \frac{\text{Sugar beet root yield or Sugar yield (Mg/fed.)}}{\text{Nitrogen (kg/fed.)}} \quad (Mg/\ kg\ N)$$

Sugar - beet crop coefficient (K_c):

Sugar - beet crop coefficient (K_c) values at (Banger- El- Soukar district) were calculated by using the actual evapotranspiration (ET_a) and potential evapotranspiration (ET_o) values according to the relation described by James (1993) as followings:

$$K_c = \frac{ET_a}{ET_o}$$

Statistical analysis:

Obtained data for the two growing seasons were subjected to proper statistical analysis using (SAS) software package, (2000). The treatment's means were compared using the least significant difference (LSD) test at 5% probability level. Water consumptive use and water use efficiency were considered in the analysis.

RESULTS AND DISCUSSION

1-Plant characters:

Results of plant characters at harvest as affected by irrigation system, nitrogen sources and levels and time of nitrogen application, as well as their interactions are shown in Table (3).

i- Plant height (cm):

Data in Table (3) show that there were no significant effects due to irrigation methods on the plant height character. Average values of plant height are ranged between 30.63 and 30.76 cm, for furrow and sprinkler irrigation systems, respectively. However, the effects of nitrogen sources and rates on the plant height were highly significant. The maximum plant height value of 36.72 cm was obtained with ammonium nitrate at 100 kg N/fed. While the minimum plant height value of 23.17 cm was with ammonium sulphate at 40 kg N/fed. Also, the effects of nitrogen application time on the plant height character were highly significant. The maximum plant height value of 32.32 cm was obtained with four time of application. Considering the interactions between treatments, the interaction between nitrogen source, rate and irrigation methods affected significantly on plant height character. The general trend of plant height character reflected the effect of nitrogen source; fertilization rate and application time was more than the effect of irrigation system.

ii- Roots characters (diameter/ length ratio, weight /plant (gm/plant) and yield (Mg/fed.):

Data in Table (3) show significant effects between different treatments, wherever, there were direct effects of all treatments on roots diameter/ length ratio, root, weight/plant, and roots yield (Fig.1). Sprinkler irrigation system has improved both root diameter/length ratio; root weight per plant and root yield by about 11.91, 21.16 and 15.16% comparing with modified furrow irrigation system respectively. Also, the maximum roots length, diameter, root weight/plant and root yield values of 40.81, 14.13cm, 1233.5 g and 32.83 Mg/fed. were obtained with ammonium nitrate at 100 kg N/fed., respectively. While the minimum root length, diameter, root weight/plant and root yield (Mg/fed.) values of 23.0 cm, 9.63 cm, 545 g and 15.13 Mg/fed., respectively were obtained with ammonium sulphate at 40 kg N/fed., respectively. Applying nitrogen in four equal portions (35,50, 65 and 80 days after sowing) recorded the highest values of roots length; diameter, root weight and root yield of 33.14 cm, 12.21cm, 958.61 g and 26.13 Mg/fed., respectively. Obtained results illustrated that the effect of nitrogen source and rates is more than the effect of both irrigation system and application time.

iii- Number of leaves /plant, foliage weight/plant (g) and leaves yield (Mg/fed.):

The influences of irrigation systems and nitrogen fertilization treatments on number of leaves /plant, foliage weight/plant and leaves yield were tabulated in Table (3). Results indicate that the effect of irrigation system on number of leaves /plant, foliage weight/plant and leaves yield had significant effect between sprinkler and furrow irrigation. The average values of number of leaves /plant, foliage weight/plant and leaves yield are 24.46, 366.42 g and 11.1 Mg /fed., respectively under sprinkler irrigation system compared to 21.60, 332.1g and 9.03 Mg/fed. with furrow irrigation. Furthermore, data in Table (3) showed a significant differences between nitrogen types and application rate in number of leaves /plant, foliage weight/plant and leaves yield. Increasing nitrogen fertilizer from 40 up to 100 kg of N/fed. caused significant increases in number of leaves /plant, foliage weight/plant and leaves yield. Each increase in nitrogen levels resulted in significant increase in number of leaves /plant, foliage weight/plant and leaves yield. The highest mean values of the leaves/plant number were 35.0 and 29.4 with ammonium nitrate at 100 kg of N/fed. and ammonium sulphate at 100 kg of N/fed., respectively, while were 475.06 and 418.71 g for foliage weight/plant, and were 11.66 and 10.98 Mg/fed. for leaves yield at the same conditions. Also number of leaves /plant, foliage weight/plant and leaves yield influenced significantly by the nitrogen application time. Beet plants received nitrogen in four and three equal portions inhabited the greatest values of number of leaves /plant, foliage weight /plant and leaves yield of (25.34 and 25.05), (372.7 and 351.03 g) and (9.66 and 8.77 Mg/fed.) respectively compared to that received nitrogen in two equal portions 23.21, 324.0 g and 8.2 Mg/fed., respectively. Results of the interaction between treatments showed highly significant effect on the number of leaves per plant.

iv- Sugar yield (Mg/fed.)

Data of sugar yield as presented in Table (3) and Fig. (2) indicated that the irrigation systems affected significantly on sugar yield. Sprinkler irrigation system occupied the higher sugar yield of 3.55 Mg/fed. comparing with 2.91 Mg/fed under furrow irrigation. Nitrogen sources and levels influenced significantly sugar yield. There are significant differences between all treatments. In general, the highest values of sugar yield of 5.22 and 4.37 Mg/fed. were obtained with ammonium nitrate at 100kg N/fed. and ammonium sulphate at 100 kg N/fed. respectively. Nitrogen application time significantly influenced sugar yields. Beet plants received nitrogen in four equal portions at 35,50,65 and 80 days after sowing produced the highest sugar yield of 3.58 Mg/fed. These results verified the effect of nitrogen source and levels on sugar yield than irrigation system and application time.

Generally, increasing nitrogen fertilizer rate from 40 to 100 kg N/fed. caused proportional increases in plant characters. Furthermore, beet plants received nitrogen in four equal portions at 35,50,65 and 80 days after sowing and in three equal portions at 35,50 and 65 days after sowing produced the highest values of plant characters. While those received nitrogen in two equal portions at 35dayes and 70 days after sowing produced the lowest ones. These results are agreed with Tawfik (2000), and Hassn (2000). Also, applying nitrogen at any time with furrow irrigation was less effective in yield characters than applying nitrogen with sprinkler irrigation system.

2- Quality parameters:

i- Gross sugar (%), white sugar (%) and juice purity (%):

Results of gross sugar, white sugar and juice purity as affected by irrigation systems and nitrogen sources, levels and time of application as well as their interactions are presented in Table (4). Irrigation system affected significantly on gross sugar. The highest value of gross sugar of 20.86% was obtained by sprinkler irrigation compared to 18.81% with furrow irrigation. Concerning white sugar and juice purity, the effect of irrigation systems was insignificant. These results are agreed with Allam (1997). Nitrogen sources and levels significantly affected gross sugar and white sugar. The beet plants fertilized by ammonium nitrate produced the highest values of gross sugar and white sugar, while those fertilized by ammonium sulphate produced the lowest ones. As well as, increasing nitrogen level from 40 to 60,80, and 100 kg N/fed. significantly increased gross sugar and white sugar percentage. Application time of nitrogen substantially affected gross sugar, white sugar percentage. Concerning juice purity percentage, the results clearly showed that purity percentage was not affected by irrigation systems, nitrogen sources as well as by application time.

ii- Total soluble solids percentage (T.S.S.):

Data in Table (4) illustrate the influence of irrigation systems and nitrogen fertilizers on T.S.S. Irrigation systems showed significant effect on T.S.S. Sprinkler irrigation system had the highest T.S.S. value of 24.62% compared to 22.16% by furrow irrigation. Furthermore, nitrogen sources, levels and application times affected significantly on T.S.S. There are significant differences between all treatments. Increasing nitrogen fertilizer levels resulted in significantly increase in T.S.S. in root juice. The highest values of T.S.S. of 24.82% and 23.00% were obtained with 100 kg N/fed. of ammonium nitrate and ammonium sulphate, respectively. Also, Adding nitrogen fertilizer in four equal doses resulted in higher T.S.S. value of 23.93% compared to 21.8% and 20.19% with three and two portions of nitrogen, respectively.

iii- Potassium (K), sodium (Na) , alpha- amino - nitrogen contents (α-amino-N) and alkalinity coefficient:

Effects of irrigation systems and nitrogen sources, levels, and application times on soluble non-sugars or impurities (K, Na and α-amino-N) and alkalinity coefficient in root juice of Sugar - beet plant were summarized in Table (4). Obtained results showed insignificant effect of irrigation systems on (α-amino-N). Meanwhile, irrigation systems affected significantly both of K, Na and alkalinity coefficients. Nitrogen sources and application levels influenced significantly K, Na, α-amino-N and alkalinity coefficient in root juice. Application of ammonium nitrate decreased the concentration of K, Na, α -amino-N and alkalinity coefficient in root juice compared with application of ammonium sulphate. The highest values of K, Na and α-amino-N of 7.51,3.18 and 3.5-meq/100g, respectively were accompanied to the application of 40 kg N/fed. ammonium sulphate . Increasing the application levels up to 100 kg N/fed. decreased K, Na, α-amino-N and alkalinity coefficient values in lots of treatments. Also application time affected significantly on K, Na, α-amino-N and alkalinity coefficient in root juice. Application of nitrogen in four equal portions at 35,50,65 and 80 days after sowing resulted in inferior values of K, Na, α-amino-N and alkalinity coefficient in root juice. These results disagree with El-Shafei (1991). They mentioned that increasing of nitrogen increased the impurity components. While, obtained results are in agreement with Sobhy et al. (1999) and Awad et al. (2003).

3- Amounts of applied irrigation water:

Monthly average values of applied irrigation water in (mm) for Sugar - beet crop under sprinkler and furrow irrigation systems were presented in Table (5). Average amounts of applied irrigation water with sprinkler irrigation system were 708.5 mm (2975.70 m^3/fed) while were 974 mm (4090.80 m^3/fed) with modified furrow irrigation method. The maximum values of applied irrigation water of 136 and 159 mm occurred during March by sprinkler and furrow irrigation systems, respectively. Above discussed results demonstrated that the sprinkler irrigation system inhabited the highest yields, as shown in Table (3). This can suggest that using sprinkler irrigation system will save at least 1100 m^3/fed of water.

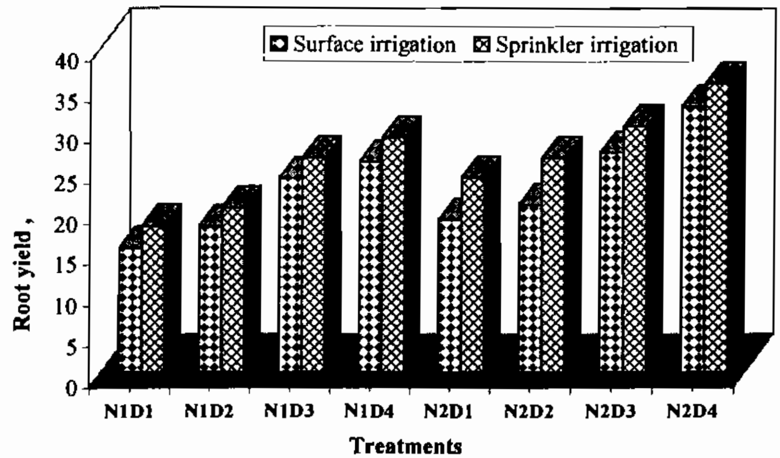

Fig.(1): Effect of irrigation methods and nitrogen applications on root yield (Mg/fed.)

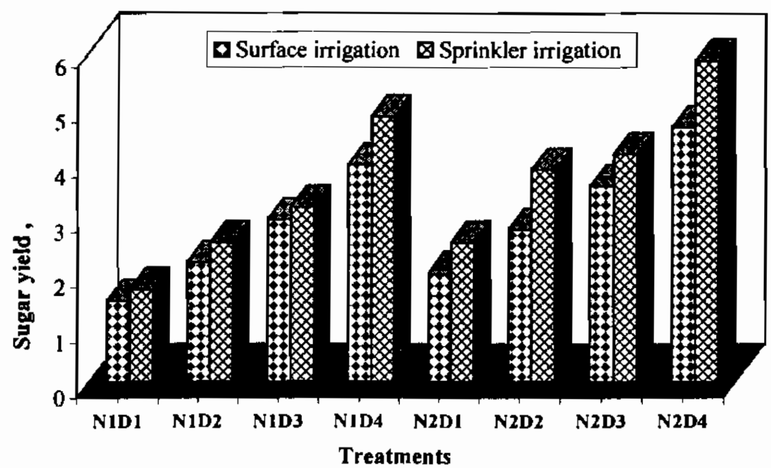

Fig.(2): Effect of irrigation methods and nitrogen applications on sugar yield (Mg/fed.)

i-Water consumptive use (ET_a):

Results of water consumptive use of Sugar - beet as affected by irrigation treatments and nitrogen applications were presented in Table (6). The average water consumptive use value under sprinkler irrigation system was 453.25 mm, while was 530 mm under furrow irrigation system. Increasing nitrogen level from 40 to 60, 80 and 100 kg N/fed. resulted in an increase in water consumptive use values regardless irrigation system and nitrogen sources.

ii- Water use efficiency (WUE):

Results of WUE considering roots and sugar yields as affected by irrigation systems and sources, levels and application times of nitrogen fertilizer were presented in Table (4). Irrigation system affected significantly on WUE. Sprinkler irrigation system had the highest water use efficiency values of 0.0087 and 0.0012 Mg/m^3 for root and sugar yields respectively compared to 0.0055 and 0.0007 Mg/m^3 with furrow irrigation system. Considering nitrogen sources and levels, the highest values of WUE for roots and sugar yields of 0.0093 and 0.00148 Mg/m^3 were obtained by ammonium nitrate at rate of 100 kg N/fed. Furthermore, nitrogen application in four equal portions resulted in the highest values of WUE of 0.0074 and 0.001 Mg/m^3 for roots and sugar yields, respectively, compared to 0.0069 and 0.0009 Mg/m^3 and 0.0064 and 0.0084 Mg/m^3 by three and two equal portions, respectively. Obtained results demonstrated that the effect of nitrogen sources and rates as well as irrigation systems is

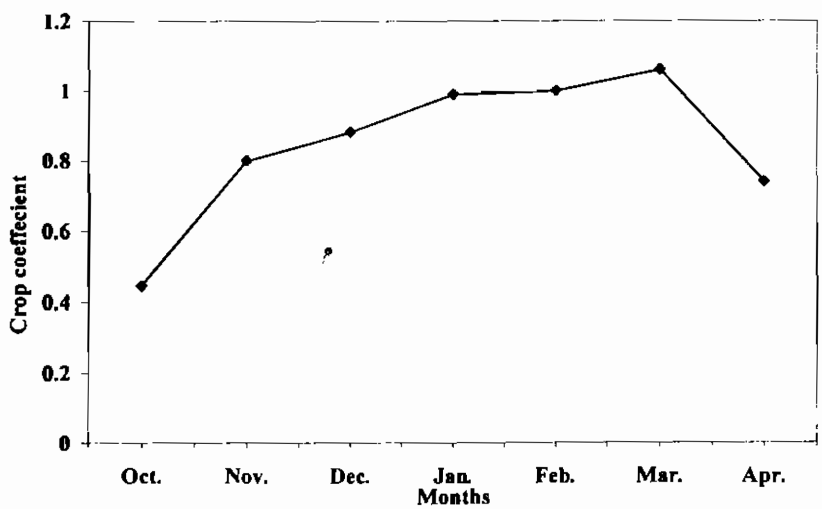

Fig. (3): Sugar beet crop coeffecient (kc) for Banger -ElSoukar district

more dominant on WUE than the effect of nitrogen application time. These results are in accordance with Sultan et al. (1996) and Metwally et al. (2003).

iii- Nitrogen use efficiency (NUE):

The response of nitrogen use efficiency (NUE) of sugar-beet considering roots and sugar yields to irrigation systems and nitrogen applications was significant as demonstrated in Table (4). Irrigation systems affected significantly on NUE. Sprinkler irrigation system had the highest nitrogen use efficiency values of 0.336 and 0.051 Mg/kg N for root and sugar yields respectively compared to 0.287 and 0.0417 Mg/ kg N with modified furrow irrigation system. Considering nitrogen sources and levels, ammonium nitrate had the highest value of NUE for root and sugar yield of 0.394 and 0.0559 Mg/ kgN at rate of 40 kg N/fed. compared to 0.325 and 0.0391 Mg/ kg N with ammonium sulphate at the same application rate, respectively. Obtained results demonstrated that the effect of nitrogen rates and sources as well as irrigation systems is more dominant on NUE than the effect of nitrogen application time.

iii-Potential evapotranspiration (ET_0) and crop coefficient (K_c): Values of potential evapotranspiration (ET_o) and Sugar - beet crop coefficient (Kc) are presented in Table (7) and Fig. (3). The maximum monthly value of ET_o occurred during March in the two growing seasons. The crop coefficient (K_c) values were calculated according to the monthly actual evapotranspiration (ET_o) derived from treatment of sprinkler irrigation system with nitrogen fertilizer of 80kg N/fed. Crop coefficient values were low at the beginning of growing season and increased gradually to reach its maximum value during March, and then decreased after that. The average value of crop coefficient for the two growing seasons was 0.845.

CONCLUSIONS

Obtained results could be summarized as follows:

1-The application of ammonium nitrate nitrogen fertilizer at rate of 80-100kg N/fed., added in four equally portions under sprinkler irrigation system, increased significantly the quantity and quality of sugar - beet yields.

2-The average amount of applied irrigation water and water consumptive use of sugar - beat under sprinkler irrigation system were 708.5 mm and 453.25mm, respectively. While, were 974 mm and 530 mm under the modified furrow irrigation.

3-The maximum values of water use efficiency and nitrogen use efficiency in relation to root and sugar yields were 0.0093 and 0.00148 $Mg/m^3$and 0.394 and 0.0559 Mg/kg N, respectively under sprinkler irrigation.

4-The average value of Sugar - beet crop coefficient (K_c) at Burg El- Arab Sector was 0.845, while the maximum value was 1.06 and occurred in March.

5-It can be recommended that using sprinkler irrigation system will save a significant amount of irrigation water without any significant decrease on Sugar -beet yields compared to the modified furrow irrigation system.

Table (3): Plant characters as affected by sources, levels and application times of nitrogen fertilizer under different irrigation systems.

Characters / Treatments	Plant height (cm)	Root length (cm)	Root diameter (cm)	No. of leaves/plant	Foliage weight (g/plant)	Leaves yield (Mg/fed.)	Root weight (g/plant)	Root yield (Mg/fed.)	Sugar yield (Mg/fed.)
Irrigation: I									
I_1	30.63a	30.66b	10.96b	21.60b	332.10b	9.03b	810.58b	22.62b	2.91b
I_2	30.76a	31.53a	12.57a	24.46a	366.42a	11.10a	982.09a	26.05a	3.55a
Fertilization: F									
N_1D_1	23.17g	23.00g	9.63 f	14.45 f	244.15g	5.77h	545.00 g	15.13h	1.56h
N_1D_2	28.78e	25.97f	10.68e	21.54d	292.52e	7.57f	718.70 e	20.29f	2.33f
N_1D_3	32.72c	29.94d	11.60d	24.43 c	350.20d	8.98d	923.58 c	25.78d	3.04e
N_1D_4	34.36b	37.31b	13.26b	29.4 b	418.71b	10.98b	1087.54b	30.47b	4.37b
N_2D_1	24.87f	27.31e	10.52e	18.74 e	279.10f	7.13g	690.96 f	18.21g	2.23g
N_2D_2	30.86d	29.98d	11.65d	23.95 c	348.20d	8.81e	880.50 d	23.69e	3.29d
N_2D_3	34.10b	34.43c	12.66 c	28.78 b	406.00c	10.10c	1090.92b	27.77c	3.83c
N_2D_4	36.72a	40.81a	14.13 a	35.00 a	475.06a	11.66a	1233.5 a	32.83a	5.22a
App. Time:T									
T_1: 2 portions	28.75c	29.15c	11.36c	23.21b	324.00c	8.20c	838.07c	22.60c	2.90c
T_2: 3 portions	31.02b	30.98b	11.73b	25.05a	351.03b	8.77b	892.33b	24.35b	3.22b
T_3: 4 portions	32.32a	33.14a	12.21a	25.34a	372.70a	9.66a	958.61a	26.13a	3.58a
Interactions.									
F x I	**	Ns	**	**	*	**	**	**	**
T x I	Ns	Ns	Ns	**	*	**	**	Ns	Ns
T x F	Ns	**	Ns	**	Ns	Ns	Ns	Ns	Ns
T x F x I	Ns	Ns	Ns	**	Ns	Ns	Ns	Ns	*

Means within each column followed by the same letter are insignificant at 0.05 level of probability.

I_1: Furrow irrigation I_2: Sprinkler irrigation N_1: Ammonium sulphate. N_2: Ammonium nitrate.

D_1: D_4: Application levels. T_1: T_3: Application times Ns: non- significant.

*, ** : significant at 0.05 and 0.01 levels of probability , respectively.

Table (4): Quality characters and water use efficiency as affected by sources, levels and application time of nitrogen fertilizer under different irrigation systems.

Characters / Treatments:	Gross sugar (%)	White sugar (%)	Juice purity (%)	T.S.S. (%)	Sodium (meq/100g)	Potassium (meq/100g)	Alpha-amino-N (meq/100g)	Alkalinity coefficient	Water use efficiency (Mg/m^3)		Nitrogen use efficiency (Mg/kg N)	
									Root yield	Sugar yield	Root yield	Sugar yield
Irrigation: I												
I_1	18.81b	15.05a	83.87a	22.16b	2.42b	6.74a	2.84a	3.23a	0.0055b	0.0007b	0.287b	0.0417 b
I_2	20.86a	14.90a	84.15a	24.62a	2.55a	6.54b	2.86a	3.00b	0.0087a	0.0012a	0.336a	0.0510 a
Fertilization: F												
N_1D_1	16.23f	11.95g	84.10a	19.07h	3.18a	7.51a	3.50a	2.80e	0.0043h	0.0004h	0.325c	0.0391f
N_1D_2	17.43e	13.46f	83.97a	20.68f	2.72b	7.14b	3.01c	3.16b	0.0057f	0.0006f	0.249h	0.0390f
N_1D_3	18.46d	14.81e	83.88a	21.22e	2.51c	6.64c	2.63e	3.35a	0.0073d	0.0008e	0.280f	0.0381g
N_1D_4	20.15b	16.55b	83.79a	23.00b	2.40d	6.08d	2.61e	3.19b	0.0086b	0.0012b	0.265g	0.0437e
N_2D_1	17.76e	13.68f	84.15a	20.39d	2.73b	7.05b	3.35b	2.90d	0.0052g	0.0006g	0.394a	0.0559a
N_2D_2	18.90c	15.16d	83.92a	21.92c	2.27e	7.06b	2.74d	3.25b	0.0067e	0.0009d	0.343b	0.0549 b
N_2D_3	20.10b	15.96c	83.87a	22.16c	2.09f	6.05d	2.54f	3.22b	0.0079c	0.0011 c	0.300d	0.0479 d
N_2D_4	21.67a	18.21a	83.75a	24.82a	1.96g	5.62e	2.46g	3.06c	0.0093a	0.0014a	0.288e	0.0518 c
App. Time: T												
T_1 2 portions	18.42c	14.37c	83.90a	20.19c	2.51a	6.86b	2.69c	3.09b	0.0064c	0.0008c	0.263c	0.0393c
T_2 3 portions	18.76b	14.87b	84.00a	21.80b	2.51a	6.78a	2.97a	3.25a	0.0069b	0.0009b	0.367b	0.0452b
T_3: 4 portions	19.33a	15.68a	84.05a	23.93a	2.43b	6.40c	2.90b	3.00c	0.0074a	0.0010a	0.394a	0.0523a
Interactions.												
F x I	Ns	**	Ns	**	**	**	**	**	**	**	**	**
T x I	Ns	Ns	Ns	**	**	**	**	**	**	**	**	**
T x F	Ns	Ns	Ns	Ns	**	Ns	*	**	**	**	*	*
T x F x I	Ns	Ns	Ns	**	**	Ns	*	**	**	**	*	*

Means within each column followed by the same letter are insignificant at 0.05 level of probability.

I_1: Furrow irrigation I_2: Sprinkler irrigation N_1: Ammonium sulphate. N_2: Ammonium nitrate.

D_1: D_4: Application levels. T_1: T_3: Application times Ns: non- significant.

*, ** : significant at 0.05 and 0.01 levels of probability, respectively.

Table (5): Monthly average values of applied irrigation water in (mm) for Sugar - beet crop under sprinkler and furrow irrigation systems

Month	Sprinkler irrigation		Average	Furrow irrigation		Average
	2001/02	2002/03	(mm)	2001/02	2002/03	(mm)
Oct.	64	73	68.5	113	115	114
Nov.	88	84	86	136	142	139
Dec.	102	104	103	141	144	142.5
Jan.	110	110	110	146	149	147.5
Feb.	122	124	123	149	156	152.5
Mar.	134	138	136	157	161	159
Apr.	80	84	82	122	117	119.5
Total	700	717	708.5	964	984	974

Table (6): Monthly average WCU values (mm) of Sugar - beet crop as affected irrigation systems and nitrogen applications.

Month	Sprinkler irrigation				Modified furrow irrigation			
	Nitrogen rate (kg/fed)				Nitrogen rate (kg/fed)			
	40	60	80	100	40	60	80	100
Oct.	17	18	21	23	23	24	26	26
Nov.	44	48	55	56	55	59	66	71
Dec.	54	54	62	68	63	66	73	76
Jan.	62	65	75	79	77	82	93	98
Feb.	75	78	89	92	82	88	103	113
Mar.	103	106	115	119	115	119	125	128
Apr.	49	54	63	69	58	60	73	78
Total (mm)	404	423	480	506	473	498	559	590

Table (7): Average potential evapotranspiration (ET_o) values (mm/period) and crop coefficient (K_c).

Month	Season 2001/2002	Season 2002/2003	Average ET_o (mm)	Average K_c
	ET_o (mm)	ET_o (mm)		
Oct.	40	54.4	47.2	0.445
Nov.	69	68.3	68.65	0.801
Dec.	68.4	72.1	70.25	0.883
Jan.	76.2	75.3	75.75	0.99
Feb.	90.4	86.1	88.25	1.00
Mar.	106.1	110.7	108.4	1.06
Apr.	82.8	87.4	85.1	0.740
Average	76.13	79.18	77.66	0.845

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الملخص العربي

تأثير إضافة التسميد النيتروجيني علي محصول بنجر السكر و معامل المحصول تحت نظم الري المختلفة

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يهدف البحث إلى دراسة تأثير إضافة السماد النيتروجيني على إنتاجية وجودة محصول بنجر السكر وعلى معامل المحصول تحت نظامي الري بالرش والري في خطوط المطور في منطقة بنجر السكر ببرج العرب. لذلك تم إجراء تجارب حقلية خلال موسمي 2002/2001 و2003/2002 في منطقة بنجر السكر حيث تسود التربة الرملية الكلسيه. ولقد اشتملت التجارب على ثلاث متغيرات:

1- نظم الري : (ري سطحي مطور في خطوط - ري بالرش).

2- نوع السماد النيتروجيني: (سلفات الأمونيوم (20.5%)- نترات الأمونيوم (33.5%)) ويضاف يدويا وفقا للكميات التالية: (40-60-80- و 100 كجم/فدان).

3- موعد الإضافة: علي دفعتين متساويتين (35 و 75 يوم بعد الزراعة)، على ثلاث دفعات متساوية (35 –50 و65 يوم بعد الزراعة) وعلى أربعة دفعات متساوية (35 –50- 65 و 80 يوم بعد الزراعة).

تم تصميم التجربة إحصائيا باستخدام تصميم القطع المنشقة مرتين في أربع مكررات ووزعت المعاملات عشوائيا داخل المكررات. تم تحليل النتائج الخاصة بمكونات المحصول وجودته وكذلك كميات المياه المضافة ومعدل استهلاك المياه وكفاءة استخدامها منطقيا وإحصائيا وكانت أهم النتائج المتحصل عليها كالتالي:

1-كان هناك تأثيرا معنويا لمعاملات الري والتسميد علي خصائص النمو ومكونات وجودة المحصول حيث أدي استخدام نظام الري بالرش إلى تحسين نسب قطر إلى طول الجذور ووزن الجذور للنبات ومحصول الجذور بحوالي 11.91و 21.16و 15.16% مقارنة بنظام الري في خطوط وعلى الترتيب. بينما بلغ محصول السكر 5.22 ميجاجرام/فدان بالإضافة إلى 11.66 ميجاجرام/فدان محصول العرش مع التسميد بنترات الأمونيوم بمعدل 100 كجم/فدان وعلي أربع دفعات متساوية. كما لوحظ تفوق النباتات المسمدة بنترات الأمونيوم في نسبة المواد الصلبة الذائبة الكلية حيث بلغت 24.82% تحت نظام الري بالرش. ومما هو جدير بالذكر أن زيادة معدلات التسميد بنترات الأمونيوم قابلها زيادة معنوية في محتوي السكر ونسبة السكر الأبيض المستخلص تحت نظام الري بالرش أيضا وكانت أقصى قيمه لهما 21.67% - 18.21% علي الترتيب. كما لوحظ انخفاض درجة نقاوة العصير معنويا عند التسميد بسلفات الأمونيوم.

2- أدى استخدام نظام الري بالرش إلى ترشيد استهلاك مياه الري ورفع كفاءة استخدام كلا من مياه الري والسماد النيتروجيني بالنسبة إلى محصول الجذور والسكر بنسبة 37.47، 58.18 و 71.42 و 16.8 و 22.30 % علي الترتيب مقارنة بنظام الري في خطوط المطور. وكانت أعلى كفاءة لاستخدام مياه الري والسماد النيتروجيني لمحصول الجذور والسكر 0.0093 و0.00148 ميجاجرام /م^3 مياه و 0.394و 0.0559 ميجاجرام/كجم نيتروجين علي الترتيب تحت نظام الري بالرش

3- قدرت القيمة المتوسطة لمعامل النبات لمحصول بنجر السكر بمنطقة بنجر السكر بحوالي 0.845 وبلغت أقصاها في شهر مارس حيث بلغت 1.06.

هذا وقد خلص البحث إلى أن استخدام نظام الري بالرش أدي إلى زيادة في المحصول كما ونوعا والاقتصاد في استهلاك مياه الري. فاستخدام الري بالرش يوفر 1000 م^3/فدان على الأقل. وهنا يجب ألا نغفل أن استخدام الري في خطوط المطور يؤدي أيضا إلى التوفير في مياه الري مقارنة بالري في خطوط التقليدي ونوصي باستخدامه حين تعذر استخدام نظم الري الحديثة. كما توصي النتائج بإضافة السماد النيتروجيني في صورة نترات الأمونيوم بمعدل من 80-100 كجم/فدان وعلى أربعة دفعات متساوية (35-50-65و80 يوم بعد الزراعة) تحت ظروف الأراضي الرملية الكلسيه بمنطقة بنجر السكر بمدينة برج العرب والمناطق ذات الظروف الأرضية و الجوية المشابهة.

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