J. Agric. Sci. Mansoura Univ., 27(3): 1943 - 1953, 2002

SUGAR BEET RESPONSE TO ZINC-APPLICATION UNDER DIFFERENT WATER REGIMES IN NORTHERN DELTA SOILS

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Field experiment was conducted at Sakha Agricultural Res. Station to study the effect of zinc application (2, 4 and 6 kg fed^{-1}) under different amounts of irrigation water (3317.6, 2792.6, and 2267.6 m^3 fed^{-1}).

The obtained results could be summarized as follows:

- Root yield and sugar yield (ton fed^{-1}) were significantly increased as irrigation amounts and zinc application rates were increased.
- Sucrose percentage, impurities (Na, K, αN) in the roots decreased and purity increased with increasing irrigation water amounts, while the application rate of zinc had no significant effect on these characteristics up to 4 kg Zn fed^{-1}.
- Root diameter was increased significantly as water amount increased and not affected by application of Zn.
- Root length was increased significantly as water amount decreased and zinc fertilization level increased.
- Root yield, sugar yield, root diameter, sucrose percentage , root length as well as the purity were significantly affected by the interaction between studied treatments irrigation regime and zinc fertilization. The highest values of 44.72, 8.8 ton fed^{-1} and 12.31 cm root and sugar yields and root diameter, respectively were obtained by treatment (I_1 x Zn_3) while the highest values (20.86%, 43.73 cm and 85.13%) for sucrose %, root length, and purity were recorded by treatments (I_3 x Zn_2), (I_3 x Zn_1) and (I_1 x Zn_2), respectively.
- The values of water consumptive use and the moisture uptake from the surface layer were increased with increasing the amount of water applied to the soil and vice versa.
- The values of seasonal KC were 0.82, 0.75, and 0.68 (using modified Penman equation) for treatments I_1, I_2, and I_3, respectively while its values were 0.87, 0.79 and 0.72 (using Radiation equation) for treatment I_1, I_2, I_3, respectively. Using Modified Blaney equation the KC values were 1.3, 1.19 and 1.08 from treatments I_1, I_2 and I_3, respectively.
- Water utilization efficiency (W.Ut.E.) for root yield was calculated to be 12.78, 13.79 and 10.10 kg/m^3 for treatments I_1, I_2 and I_3, respectively while they were found to be 2.52, 2.72 and 2.07 kg/m^3 for sugar yield, respectively.
- The values of W.U.E. were 17.53, 17.36 and 11.40 kg/m^3 for root yield and 3.45, 3.43 and 2.34 kg /m^2 for sugar yield, with using treatments of I_1, I_2 and I_3, respectively.
- Treatment I_3 recorded the highest value of water application efficiency (88.55%). While the lowest value (72.89%) was recorded with I_1 treatment.

استجابة بنجر السكر للتسميد بالزنك تحت كميات رى مختلفة فى أراضى شمال الدلتا

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أجريت تجربة حقلية بمحطة البحوث الزراعية بسخا عام ١٩٩٨/١٩٩٩م لدراسة تأثير كميات مختلفة من ماء الرى: ٣٣١٧,٦ ، ٢٧٩٢,٦ ، ٢٢٦٧,٦ م٣ للفدان ، والتسميد بالزنك بمعدلات ٢ ، ٤ ، ٦ كيلو جرام زنك/للفدان.

ويمكن تلخيص النتائج المتحصل عليها كالآتى:

١- زيادة محصول الجذور ومحصول السكر بالطن/فدان معنويا بزيادة كميات الماء المضافة ومعدل التسميد بالزنك.

٢- زيادة نسبة السكر والمواد غير النقية فى الجذور ونقص النقاوة بنقص كمية ماء الرى المضافة بينما لم يتضح تأثير التسميد بالزنك على هذه المكونات حتى ٤كجم زنك/للفدان.

٣- زيادة قطر الجذور بالسم معنويا مع زيادة كميات ماء الرى بينما لا يوجد تأثيرا معنويا للتسميد بالزنك.

٤- زيادة طول جذر البنجر (بالسم) معنويا بنقص كمية ماء الرى وزيادة معدلات التسميد بالزنك.

٥- تأثر محصول الجذور ومحصول السكر وقطر الجذر ونسبة السكروز% وطول الجذر والنقاوة تأثيرا معنويا بالتفاعل بين كمية الماء ومعدل التسميد بالزنك فأعلى قيم (٤٤,٧٢ طن/فدان ، ٨,٨ طن/فدان ، ١٢,٣١سم) لمحصول الجذر. ومحصول السكر وقطر الجذر أمكن الحصول عليها باستخدام المعاملة (I_1 X Zn_3) بينما أعلى القيم (٢٠,٨٦% ، ٤٣,٧٣سم ، ٨٥,١٣%) للسكروز وطول الجذر والنقاوة% أمكن الحصول عليها بالمعاملات (I_3 X Zn_2) و (I_3 X Zn_1) و (I_1 X Zn_3) على الترتيب.

٦- أتضح أن أعلى قيمة للأستهلاك المائى السنوى ٥٧,٥٨سم حصل عليها عندما روى النبات بـ ٢٦٢٥م٣/للفدان بينما أقل قيمة للأستهلاك المائى وجدت ٤٧,٨١سم عند الرى بـ ١٥٧٥م٣/للفدان.

٧- وجدت القيم العالية لأمتصاص الرطوبة من الطبقة السطحية كانت ٣٢,٨٤% ، ٣١,٨٣% ، ٣٣,٦١% للمعاملات I_3, I_2, I_1 على الترتيب.

٨- كانت قيم معامل المحصول السنوى ٠,٨٢ ، ٠,٧٥ ، ٠,٦٨ للمعاملات I_3, I_2, I_1 باستخدام معادلة Modified Penman بينما كانت قيم معامل المحصول السنوى هى ٠,٨٧ ، ٠,٧٩ ، ٠,٧٢ للمعاملات I_3, I_2, I_1 باستخدام معادلة الإشعاع Radiation وباستخدام معادلة Modified Planey-Cridd أمكن الحصول على قيم معامل المحصول ١,٣ ، ١,١٩ ، ١,٠٨ للمعاملات I_3, I_2, I_1 على الترتيب.

٩- وجد أن قيمة الكفاءة الإستعمالية للمياه كانت ١٢,٧٨ ، ١٣,٧٩ ، ١٠,١٠كجم/م٣ لمحصول الجذور وكانت ٢,٥٢ ، ٢,٧٢ ، ٢,٠٧كجم/م٣ لمحصول السكر مقابل معاملات الماء I_3, I_2, I_1 على التوالى.

١٠- وجد أن قيم كفاءة استخدام المياه (W.U.E.) كانت ١٧,٥٣ ، ١٧,٣٦ ، ١١,٤كجم/م٣ لمحصول الجذور وكانت ٣,٤٥ ، ٣,٤٣ ، ٢,٣كجم/م٣ لمحصول السكر مقابل معاملات الماء I_3, I_2, I_1 على الترتيب.

١١- وفيما يتعلق بكفاءة الرى التطبيقية (W.A.E.) وجد أن أعلى القيم (٨٨,٥٥%) أمكن الحصول عليها بإضافة٢٢٦٧,٦ م٣/فدان.

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is considered one of the important economic crops in Egypt and was found to be the most suitable ancillary source of sugar compared to sugar cane. The total amount of sugar produced from sugar beet in 1999 season was 317470 tons and represents about 25% of the total amount (1242587 tons). Egyptian policy aims to increase the amount of sugar from beet to reach 500 000 tons by using proper varieties, irrigation and fertilizations Sobh (1985). Sugar beet is reasonably drought tolerant with yield roughly proportional to total water use (Carter *et al.,* 1980, Miler and Aarstad, 1976, Nicholson *et al.,* 1974, and Winter, 1980).

Water stress in almost cases decrease fresh root weight (Winter, 1980, Sobh, 1985, Gouda *et al.,* 1993, Abd El-Wahab *et al.*, 1996 and Emara, 1996). Foliar application of 0.6 kg Zn/ha increased roots and sugar yields (Stratieva *et al.,* 1990). Besheit *et al.* (1992) reported that soaking sugar beet seeds before sowing in 40 ppm of Zn gave the maximum fresh and dry weights of leaves and roots. Also, zinc application to soil increased dry matter accumulation and sugar content in roots (Sun *et al.,* 1994).

On the other hand, zinc uptake increased as application Zn rate increased but this increase was not affected on root yield (Sofronovskaya, 1998). Sucrose concentration in a fresh weight can be increased due to water stress (Loomis and Worker, 1963; Carter *et al.,* 1980;I Abd El-Wahab *et al.,* 1996).

The effects of irrigation on purity not well understood, Bauer *et al.,* 1975; Reichman *et al.,* 1977; Sobh, 1985; Attia and Sultan, 1987 and Abdel-Wahab *et al.,* 1996.

Monthly and seasonal consumptive water use were increased as the irrigation water amounts increased (Doorenbos *et al.,* 1979; Sobh 1985 and Abdel Wahab *et al.,* 1996).

The objective of this research is to determine the influence of zinc fertilization and the amount of seasonal irrigation water on sugar beet crop and its water consumptive use in Northern Delta soils.

MATERIALS AND METHODS

The effect of zinc fertilization and irrigation treatments on sugar beet during growing season 1998/1999 was tested in a split plot design three levels of seasonal irrigation water amounts used the main plots I_1 = 3317.6, I_2 = 2792.6, and I_3 = 2267.6 m^3/fed. these amounts including planting irrigation and effective rain off. Three levels of zinc fertilizer (Zn_1 = 2 kg fed^{-1}, Zn_2 = 4 kg Zn fed^{-1}, and Zn_3 = 6 kg Zn fed^{-1}) were added to the sub plots by soil application before the second irrigation. Both N-fertilizer (80 kg N/fed.) as urea (46.5% N) and K fertilizer in the form of K-sulfate (48% K_2O) at rate of 48 kg fed^{-1} K_2O were applied for all plots in two equal doses at the thinning time and before the second irrigation P-fertilizer as superphosphate (15.5% P_2O_5) was added during tillage operation with the rate of 15 kg P_2O_5/fed. Sugar beet (Cawamera) variety was sown on 15 November. Plot area was 20 m^2 (4 x 5 m).

The soil characteristics of the experimental site (were determined according to Black (1965) and presented in Table (1).

The climatological data of the studied area during the growing season are recorded in (Table 2). The plants were harvested on May 31 and the following parameters were recorded:

1. Sugar beet yield (root and sugar ton/fed.).
2. Yield component (root length and diameter).
3. Yield quality [sucrose %, impurities (K, Na, αN) and purity] was determined in Delta Sugar Company Limited Laboratories at Kafr El-Sheikh Governorate.

Soil water relations were determined as follows:

A) Water consumptive use (Cu) in each irrigation was calculated according to (Hansen *et al.,* 1979). as follows:

$$Cu = \sum \frac{Pw_2 - Pw_1 \text{ x BDi x Di}}{100}$$

Where:

Cu = Water consumptive use (cm) for the effective root zone (0-60 cm).

i = Number of soil layers.

Pw_2-Pw_1 = Percentage of soil moisture content 48 hours after irrigation and before irrigation for the specified soil layer.

BDi = Bulk density for specified layer.

Di = Depth of layer (15 cm).

B) The amounts of water applied to each plot was measured using small siphon according to FAO (1974).

C) Water efficiencies:

1. Water utilization efficiency (W.Ut.E) was calculated according to Doorenbos and Pruitt (1975) as follows:

$$\text{W.Ut.E.} = \frac{\text{Root or sugar yield in kg fed}^{-1}}{\text{Total water applied in m}^3\text{ fed}^{-1}}$$

2. Water use efficiency (W.U.E.):

$$\text{W.U.E.} = \frac{\text{Root or sugar yield in kg fed}^{-1}}{\text{Actual evapotranspiration m}^3\text{ fed}^{-1}}$$

3. Water application efficiency (W.A.E.):

$$\text{W.A.E.} = \frac{\text{Total water stored in root zone}}{\text{Total water applied}} \text{ x 100}$$

D) Crop coefficient (KC):

It was calculated according to Doorenbos and Pruitt (1975) as follows:

$$KC = \frac{\text{Actual evapotranspiration ETA}}{\text{Potential evapotranspiration ETP}}$$

ETP was calculated by using, modified Penman, Radiation and Modified Blany-Criddle equations.

Statistical analysis was carried out according to Snedecor and Cochran (1967), and treatment means were compared by least significant differences (L.S.D.) at the levels of 1% and 5% probability.

Table (1): Mechanical and chemical analysis of experimental soil (0-60 cm)*.

Particle size distribution			Texture	E.C	pH	Available nutrients ppm			
Sand %	Silt %	Clay%	class	dSm^{-1}	1: 2.5	N	P	K	Zn
17.53	30.34	49.95	Clayey	1.32	7.86	58.83	9.84	416.0	1.08

*** Mechanical analysis was determined according the International Method Piper, (1950).**
Available N, and K according to Black (1965)
Available P according to Olsen *et al.* (1954)
Available Zinc was determined according to Lindsay and Norvell (1978).

Table (2): Meteorological data of Sakha Agriculture Research Station 1998/1999.

Month	Temperature, ºC		Relative humidity %		Wind. sp., km/hr	Rain, mm
	Max.	Min.	Max.	Min.		
Nov. 1998	26.0	12.0	75.4	42.5	73.0	-
Dec. 1998	21.30	8.2	72.20	41.9	109.9	3.6
Jan. 1999	19.33	8.8	69.83	46.69	60.90	7.8
Feb. 1999	17.73	6.73	67.46	46.00	98.11	11.8
March 1999	21.13	10.71	67.84	44.90	109.23	-
April 1999	25.43	9.22	73.57	45.77	124.30	5.1
May 1999	29.27	15.5	70.06	41.42	141.13	-

RESULTS AND DISCUSSION

1) Root yield (ton fed^{-1}):

Data in Table (3) indicated that root yield was significantly increased with increasing the amounts of irrigation water and the maximum yield (42.39 ton fed^{-1}) was obtained when 3317.6 m^3 water per feddan was added to the soil. The magnitude of the increase was 85.1% as compared to the treatment received 2267.6 m^3 water per feddan that gave the lowest value of root yield (22.90 ton fed^{-1}). This may be due to the direct effect of the availability of soil water in the effective root zone. These results are in agreement with those obtained by Sobh (1985) Gaber *et al.* (1986); Cucci and Caro (1986); Emara (1990, 1996) and Abd El-Wahab *et al.* (1996). With respect to zinc effect on the root yield. Data in Table (3) showed that zinc fertilization treatments gave significant synergistic effect on root yield. The maximum root yield 35.82 ton

Table (3): Effect of irrigation and zinc fertilization on sugar beet characteristics.

Treatment	Root quality						Root component		Root yield ton fed^{-1}	Sugar yield ton fed^{-1}
	Sucrose pol. %	Impurities (mg/100 g).				Purity				
		K	Na	αN	$\frac{K+Na}{N}$	%	Root diameter cm	Root length cm		
A. irrigation m^3 fed^{-1}										
I_1 =3317.6	19.69	6.38	1.52	2.21	3.54	84.55	12.16	32.57	42.39	8.31
I_2 =2792.6	19.74	7.05	1.88	2.72	3.34	82.03	12.14	41.40	38.50	7.60
I_3 =2267.6	20.50	6.66	1.69	2.73	3.08	82.54	9.71	43.47	22.90	4.70
L.S.D.	**	**	*	*	*	**	**	**	**	**
B. Zinc fer. kg fed^{-1}										
Zn_1 =2	20.04	6.67	1.69	2.49	3.37	82.93	11.46	38.34	32.76	6.57
Zn_2 = 4	20.05	6.80	1.77	2.56	3.34	83.17	11.39	39.07	35.82	7.18
Zn_3 = 6	19.80	6.61	1.63	2.62	3.25	83.03	11.17	40.03	35.22	6.97
L.S.D.	**	**	**	n.s	n.s	n.s	n.s	**	**	**

fed^{-1}, using 4 kg Zn fed^{-1} while the lowest yield was recorded with 2 kg Zn fed^{-1}. (32.76 ton fed^{-1}) which achieved an increment of 9.4%.

These results are in harmony with those obtained by Stratieva *et al.* (1990); Besheit *et al.* (1992) and Sun *et al.* (1994).

2. Gross sugar yield (ton fed^{-1}):

Sugar yield per unit area is the main goal of sowing any sugar crop and it is the sum product of sugar extractable % and root yield per unit area. Data in Table (3) revealed that decreasing the amounts of irrigation water applied to the soil (3317.6 to 2267.6 m^3 water fed^{-1}) resulted in 76% decrease in gross sugar yield may be due soil moisture stress as shown before. These results supported the results obtained by Carter *et al.* (1980); Roberts *et al.* (1980); Sobh (1985); Cucci and Caro (1986) and Abd El-Wahab (1996).

Dealing with the effect of zinc fertilization on gross sugar yield, data clarify that gross sugar yield was significantly increased with increasing zinc levels applied to the soil up to 4 kg Zn fed^{-1} which gave the maximum yield 7.18 ton fed^{-1} compared with 6.57 and 6.97 ton fed^{-1} given by of 2 and 6 kg Zn fed^{-1}, respectively. These results are in agreement with those obtained by Sun *et al.* (1994).

The impact of the interaction between irrigation and zinc levels on sugar beet yield (root and sugar yields) was clear. The optimum yield of root and sugar yields (44.14 and 8.59 ton fed^{-1}), respectively were obtained with application of 3317.6 m^3 water fed^{-1} and adding 4 kg Zn fed^{-1}.

3. Sucrose percentage:

Data in Table (3) demonstrate that there was a significant negative relation between sucrose % and the amount of water added to the soil consequently the maximum value 20.54% was given by 2267.6 m^3 water fed^{-1} (I_3). These results stand in the same line with those obtained by Carter *et al.* (1980), Roberts *et al.* (1980); Abd El-Wahab *et al.* (1996). In this regard Loomis and Hadock (1967) attributed the increase in sucrose percentage with increasing soil moisture stress to slower accumulations of dry matter and more rapid accumulation of sucrose.

As concerns zinc fertilization effect, data showed that sucrose % was not significantly affected by 2 or 4 kg zinc while it significantly affected by 6 kg Zn fed^{-1}.

4. Impurities (Na, K and αN):

Impurities in the roots were increased and the purity was decreased with decreasing irrigation water amounts applied to the soil (Table, 3). The highest values of the impurity and the lowest purity value were detected with 27926 m^3 water fed^{-1} (I_2). These results are in accordance with the findings of Winter (1980).

On the other hand, purity was not significantly affected by Zn, while there was a significant effect on alkalinity of sugar juice

The interaction between irrigation and zinc not significantly affected on αN and alkalinity while its effect was significant for Na and K contents and juice purity. The maximum purity value 85.13% was achieved by the combination between application of 3317.6 m^3 water (I_1) and 4 kg Zn fed^{-1}.

5) Root diameter (cm):

With respect to root diameter, data in Table (3) showed that decreasing the amounts of irrigation water added to the soil significantly decreased root diameter especially at the irrigation water level of 2267.6 m^3 water fed^{-1} (I_3) which gave the lowest diameter of 9.71 cm, the diameter 12.16 cm was recorded with 33176 m^3 water fed^{-1} (I_1). This may be due to the availability of soil water which had the direct effect on the growth of root. In this regard, Sorour (1995) attributed the reduction in root diameter at low soil moisture level to decreasing leaf area index which might decrease light interception and in turn decrease dry matter accumulation and root dimentions. These results are similar to those obtained by Attia and Sultan (1987); Emara (1990, 1996) and Abd El-Wahab (1996) For zinc effect where there was no significant effect on root diameter as zinc fertilizer applied to the soil.

The interaction between irrigation and zinc treatments recorded significant effect on root diameter and the best value of interaction was obtained by combination of 33176.6 m^3 water fed^{-1} (I_1) and 6 kg Zn fed^{-1} (Zn_3) (Table 4).

Table (4): Sugar beet characteristics as affected by irrigation and zinc fertilization interaction.

Treatment		Root quality						Root component		Root yield ton fed^{-1}	Sugar yield ton fed^{-1}
Water regime	Zn application	Sucrose pol. %	Impurities (mg/100 g).				Purity %	Root diameter cm	Root length cm		
			K	Na	αN	$\frac{K+Na}{N}$					
I_1	Zn_1	19.67	6.42	1.64	2.15	3.71	83.60	11.93	30.93	38.31	7.54
	Zn_2	19.47	6.52	1.49	2.21	3.53	85.13	12.25	31.88	44.14	8.59
	Zn_3	19.67	6.19	1.42	2.27	3.38	84.93	12.31	34.90	44.72	8.80
I_2	Zn_1	20.04	6.98	1.84	2.67	3.33	82.58	12.28	40.38	36.63	7.34
	Zn_2	19.82	7.02	2.04	2.68	3.38	81.43	12.10	41.79	39.29	7.79
	Zn_3	19.37	7.15	1.76	2.80	3.31	82.10	12.05	42.05	39.59	7.67
I_3	Zn_1	20.41	6.60	1.60	2.64	3.08	82.63	10.17	43.73	23.34	4.76
	Zn_2	20.86	6.86	1.78	2.78	3.10	82.95	9.83	43.54	24.02	5.01
	Zn_3	20.35	6.51	1.71	2.78	3.05	82.05	9.13	43.15	21.35	4.34
L.S.D. 0.01		**	**	**	n.s	n.s	**	**	**	**	**

6. Root length (cm):

Data in Table (3) revealed that decreasing irrigation water amounts significantly promoted increasing the root length to reach maximum value 43.47 cm at 2267.6 m^3 water fed^{-1} level.

The results showed also that the roots grow longer under water tress than that excessive water status. The water stress enhanced deep rooting. These results are in line with those obtained by Winter (1980); Emara (1990-1996) and Abd El-Wahab *et al.* (1996).

With relation to the effect of zinc on root length, data clarify that application of zinc fertilizer to the soil gave significant pronounced positive effect on root length recording maximum value 40.03 cm when the zinc fertilizer applied at the rate of 6 kg Zn fed^{-1}.

Also, the interaction between irrigation and zinc achieved significant synergistic effect and continued to increase the root length to reach the maximum value 43.54 cm by using 2267.6 m^3 water fed^{-1} level and 4 kg Zn fed^{-1} (Table 4).

7. Consumptive water use (Cu):

Data in Table (5) shows that both monthly and seasonal Cu values were increased with increasing the amounts of irrigation water applied to the soil. For monthly values the rate of Cu were gradually increased with crop development and reached its beaks in April and then reduced during ripening stage (May).

Table (5): Effect of irrigation regimes on monthly or seasonal consumptive use and water uptake pattern for sugar beet plants

Irrigation treatment	Layer depth, cm	Monthly and seasonal consumptive use cm							Total	W.U.P
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May		pattern
I_1	0-15	0.736	2.073	2.062	1.847	2.700	5.451	4.038	18.907	32.84
	0-30	0.482	1.359	1.653	1.860	2.284	5.049	3.303	15.990	27.77
	0-45	0.213	0.601	1.026	1.459	1.591	4.371	3.124	12.385	21.51
	0-60	0.092	0.259	0.700	1.185	1.319	3.607	3.136	10.298	17.88
Total		1.523	4.292	5.441	6.351	7.894	18.478	13.601	57.58	
I_2	0-15	0.566	1.596	1.858	2.006	2.298	4.506	4.00	16.830	31.83
	0-30	0.403	1.136	1.623	2.074	2.116	4.595	3.185	15.132	28.62
	0-45	0.208	0.586	0.833	1.063	2.090	4.051	3.269	12.100	22.88
	0-60	0.082	0.230	0.323	0.407	1.673	2.881	3.218	8.814	16.67
Total		1.259	3.548	4.637	5.550	8.177	16.033	13.672	52.88	
I_3	0-15	0.549	1.548	1.802	1.945	2.229	4.00	4.00	16.07	33.61
	0-30	0.371	1.045	1.259	1.409	2.053	3.803	3.088	13.028	27.25
	0-45	0.132	0.372	0.617	0.862	2.027	3.683	3.024	10.717	22.42
	0-60	0.035	0.101	0.242	0.394	1.623	2.785	2.808	7.988	16.71
Total		1.087	3.066	3.92	4.61	7.932	14.271	12.92	47.81	

Sowing irrigation = 520.4 m^3 fed^{-1}
Rain off = 172.2 m^3 fed^{-1}

In relation to seasonal Cu of sugar beet plants the maximum value 57.58 cm which corresponding to 0.29 cm/day was obtained when 3317.6 m^3 water fed^{-1} (or water regime I_1) was applied, whereas the minimum one (47.81 cm) that corresponding to 0.24 cm/day was recorded at 2267.6 m^3 water fed^{-1} level (or at water regime I_3). These results are in harmony with those obtained by Doorenbos *et al.* (1979); Sobh (1985); Abd El-Wahab *et al.* (1996) who stated that the seasonal values may be differ due to climate, availability of soil water and length of the total growing period.

8. Water uptake patterns of sugar beet:

The prediction of the degree of root distribution among different depths of the effective root zone can be realized by using the parameter of water uptake patterns. Thus, data in Table (5) revealed that the uptake of soil water was decreased with the soil depth and the greater uptake values were 32.8, 31.8 and 33.62% for the surface layer of the water treatments I_1, I_2 and

I_3, respectively. While less water was extracted from the subsurface layers. The relatively higher water uptake from the upper layers compared to the deepest ones was attributed to the concentrated roots in the upper layer (Ibrahim *et al.,* 1988).

9. Crop coefficient KC of sugar beet:

Data in Table (6) shows that the seasonal crop coefficient values (KC) increased with increasing Cu value. The theoretical values of evapotranspiration (ETo) was calculated to be 705.23 mm from Modified Penman equation (with KC values of 0.82, 0.75 and 0.68), 664.64 mm from Radiation equation (with KC values 0.87, 0.79, and 0.72) and 442.93 mm from Modified Blaney-Criddle equation (with KC values of 1.30, 1.19 and 1.08) for water regimes I_1, I_2, I_3, respectively.

Table (6): Effect of different water regimes on consumptive use indices of sugar beet

Water treat.	Cu m^3 fed^{-1}	Added water m^3 $fed.^{-1}$	KC* ET0 = 705.23 mm	KC** ET0 = 664.64 mm	KC** ET0 = 442.93 mm	Root yield kg fed^{-1}	Sugar yield kg fed^{-1}	W.Ut.E kg/m^3		W.U.E. kg/m^3		W.A.E. %
								Root	Sugar	Root	Sugar	
I_1	2418.4	3317.6	0.82	0.87	1.30	42390	8347	12.78	2.52	17.53	3.45	72.89
I_2	2218.0	2792.6	0.75	0.79	1.19	38500	7600	13.79	2.72	17.36	3.43	79.42
I_3	2008.0	2267.6	0.68	0.72	1.08	22900	4704	10.10	2.07	11.40	2.34	88.55

*** Calculated evapotranspiration values from Modified Penman Equation.**
**** Calcuatled evapotranspiration values from Radiation Equation.**
***** calculated evapotranspiration values from Modified Blaney-Criddle-equation.**

The data also indicate that ETo values calculated using Blaney-Criddle equation is lower than the actual consumptive use of water (Cu). However, Modified Penman or Radiation equations agree well with the value of Cu determined under the present study.

10. Water efficiencies:

The optimum water management is achieved by obtaining the greatest consumptive use of water with increasing the grain yield per unit area. Thus with respect to the effect of different irrigation treatments on water use efficiency (W.U.E.), water utilization efficiency (W.Ut.E) and water application efficiency (W.A.E.) are shown in (Table 6). The data showed that the irrigation regime (I_2) seemed to be superior in increasing the value of W.Ut.E for both root and sugar yields (13.79 and 2.72 kg/m3, respectively followed by I_1 and I_3. The highest values of W.U.E. for root and sugar (17.53 and 3.45 kg/m^3, respectively, were achieved with I_1 (3317.6 m^3 fed^{-1}) followed by I_2 (2792.6 m^3/fed^{-1}) treatment

This trend may be due to the severe reduction in yield (root and sugar) as a result of soil moisture stress. In relation to water application efficiency (W.A.E.) data indicated that its values were increased as the amount of irrigation water decreased and reached to the maximum value (88.55%) with treatment (I_3). It can be said that as the total irrigation water delivered increased, the application efficiency decreased and vice versa. These results are supported those obtained by Abd El-Wahab (1996).

However, I_2 treatment gave the suitable values of W.Ut.E and W.U.E. indicating that the water regime which utilize reasonable amount of water with suitable Zn application resulted in a great yield, W.Ut.E. and W.U.E.

It could be concluded that for sugar beet production the suitable water regime (3317.6 and 2792.6 m^3 fed^{-1}) and zinc application (4 kg Zn fed^{-1}) which should be adopted in clayey soils in Northern Delta.

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استجابة بنجر السكر للتسميد بالزنك تحت كميات رى مختلفة فى أراضى شمال الدلتا

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أجريت تجربة حقلية بمحطة البحوث الزراعية بسخا عام ١٩٩٩/١٩٩٨م لدراسة تأثير كميات مختلفة من ماء الرى: ٣٣١٧,٦ ، ٢٧٩٢,٦ ، ٢٢٦٧,٦ ^{٣} م٣ للفدان ، والتسميد بالزنك بمعدلات ٢ ، ٤ ، ٦ كيلو جرام زنك/للفدان.
ويمكن تلخيص النتائج المتحصل عليها كالآتى:

١- زيادة محصول الجذور ومحصول السكر بالطن/فدان معنويا بزيادة كميات الماء المضافة ومعدل التسميد بالزنك.
٢- زيادة نسبة السكر والمواد غير النقية فى الجذور ونقص النقاوة بنقص كمية ماء الرى المضافة بينما لم يتضح تأثير التسميد بالزنك على هذه المكونات حتى ٤كجم زنك/للفدان.
٣- زيادة قطر الجذور بالسم معنويا مع زيادة كميات ماء الرى بينما لا يوجد تأثيرا معنويا للتسميد بالزنك.
٤- زيادة طول جذر البنجر (بالسم) معنويا بنقص كمية ماء الرى وزيادة معدلات التسميد بالزنك.
٥- تأثر محصول الجذور ومحصول السكر وقطر الجذر ونسبة السكروز% وطول الجذر والنقاوة تأثيرا معنويا بالتفاعل بين كمية الماء ومعدل التسميد بالزنك فأعلى قيم (٤٤,٧٢ طن/فدان ، ٨,٨ طن/فدان ، ١٢,٣١سم) لمحصول الجذر. ومحصول السكر وقطر الجذر أمكن الحصول عليها باستخدام المعاملة (I_1 X Zn_3) بينما أعلى القيم (٢٠,٨٦% ، ٤٣,٧٣سم ، ٨٥,١٣%) للسكروز وطول الجذر والنقاوة% أمكن الحصول عليها بالمعاملات (I_3 X Zn_2) و (I_3 X Zn_1) و (I_1 X Zn_3) على الترتيب.
٦- أتضح أن أعلى قيمة للأستهلاك المائى السنوى ٥٧,٥٨سم حصل عليها عندما روى النبات بـ ٢٦٢٥م^{٣}/للفدان بينما أقل قيمة للأستهلاك المائى وجدت ٤٧,٨١سم عند الرى بـ ١٥٧٥م^{٣}/للفدان.
٧- وجدت القيم العالية لأمتصاص الرطوبة من الطبقة السطحية كانت ٣٢,٨٤% ، ٣١,٨٣% ، ٣٣,٦١% للمعاملات I_3, I_2, I_1 على الترتيب.
٨- كانت قيم معامل المحصول السنوى ٠,٨٢ ، ٠,٧٥ ، ٠,٦٨ للمعاملات I_3, I_2, I_1 باستخدام معادلة Modified Penman بينما كانت قيم معامل المحصول السنوى هى ٠,٨٧ ، ٠,٧٩ ، ٠,٧٢ للمعاملات I_3, I_2, I_1 باستخدام معادلة الإشعاع Radiation وباستخدام معادلة Modified Planey-Cridd أمكن الحصول على قيم معامل المحصول ١,٣ ، ١,١٩ ، ١,٠٨ للمعاملات I_3, I_2, I_1 على الترتيب.
٩- وجد أن قيمة الكفاءة الإستعمالية للمياه كانت ١٢,٧٨ ، ١٣,٧٩ ، ١٠,١٠كجم/م^{٣} لمحصول الجذور وكانت ٢,٥٢ ، ٢,٧٢ ، ٢,٠٧كجم/م^{٣} لمحصول السكر مقابل معاملات الماء I_3, I_2, I_1 على التوالى.
١٠- وجد أن قيم كفاءة استخدام المياه (W.U.E.) كانت ١٧,٥٣ ، ١٧,٣٦ ، ١١,٤كجم/م^{٣} لمحصول الجذور وكانت ٣,٤٥ ، ٣,٤٣ ، ٢,٣كجم/م^{٣} لمحصول السكر مقابل معاملات الماء I_3, I_2, I_1 على الترتيب.
١١- وفيما يتعلق بكفاءة الرى التطبيقية (W.A.E.) وجد أن أعلى القيم (٨٨,٥٥%) أمكن الحصول عليها بإضافة٢٢٦٧,٦ م^{٣}/فدان.