J. Agric. Sci. Mansoura Univ., 25 (9): 5931 - 5939, 2000.

EFFECT OF WATER APPLICATION LEVELS AND DIFFERENT WETTING DEPTHS ON SUGARBEET YIELD AND ITS WATER RELATIONS AT NORTH DELTA

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ABSTRACT

Two field experiments were conducted at Sakha Agriculture Research Station Farm, during 1997/98 and 1998/99 seasons to study the effect of water applied levels (watering at field capacity, field capacity + 5% and field capacity – 5%) and different wetting depths (30, 45 and 60 cm) on sugarbeet yield and its water relations.

The results showed that treatment W1, (field capacity) achieved the highest values of sugarbeet yield (20.17 ton/fed.) followed by treatment W3 (field capacity – 5%) , while treatment W2 (field capacity +5%) recorded the lowest values (18.52 ton/fed. The data indicated that treatment D1 (soil moisture depth of (30 cm) produced the highest values of sugarbeet yield and weight of the root per plant. The highest sugar yield was scored from soil moisture depth of 30 cm (D1) in the 1st and 2nd seasons (3419.55 and 3791.49 kg/fed.), respectively followed by treatment (D2). The lowest value of sugar yield was obtained from treatment (D3). Treatment W3 (field capacity plus 5%) recorded the highest values of water consumptive use (2479.4 and 2563.34 m3/fed.) followed by treatment W1 (2400.86 and 2484.87 m3/fed.) for the 1st and 2nd seasons, respectively. The highest values of water applied was recorded with the irrigation levels at field capacity + 5% and soil moisture depth of 60 cm. The lowest values were recorded by irrigation at field capacity – 5% and to soil moisture depth of 30 cm. Irrigation at field capacity – 5% (W3) treatment produced the highest values of water use efficiency for sugarbeet and sugar yield in the 1st and 2nd seasons, followed by treatment (W1) that irrigated at field capacity. Irrigation at field capacity + 5% treatment (W2) recorded the lowest values of water use efficiency.

Irrigation at 30 cm of soil moisture depth (D1) achieved the highest values of water use efficiency for both sugarbeet and sugar yield followed by treatment D2 irrigated at depth of 45 cm. While the lowest values were obtained from treatment D3 (irrigated at depth of 60 cm).

Data of soil moisture extraction reveal that most of the moisture was removed from the upper soil surface layer depth. There was a substantial reduction in moisture extraction downward throughout the soil profile.

Generally about 70% of the available soil moisture was extracted by roots from the first foot (0-30 cm), and the rest (30 %) from the second down foot of soil profile.

INTRODUCTION

Sugarbeet has become one of the major winter field crops in Egypt due to its high income to the farmers. Sugarbeet can be irrigated with about one-fourth the water utilized by sugarcane.

Sugarbeet production could be increased through cultivation of high yielding varieties and appropriate agronomic practices. Among the most important practices is water management. The increased emphasis on crop water relations can be attributed to its role as a controlling factor in crop production. It would be obviously valuable to know these relations for crops, because much can be concluded in regard to water policy and optimization of water use. The present study focus on the different levels of irrigation water applied and different depths of water extractions as a source of irrigation control in water management.

Production and water relations of sugarbeet has been widely investigated by many researchers; Doorenbos et al. (1979), Howell et al. (1987), Bailey (1990), and Emara, (1990).

No significant differences was found in root yield between water treatments; (Yonts 1984).

Within the limits of this study, the level of water applied was not found to be the first limiting constraint of sugar yield. Factors such as deeper penetration of roots, a perched water table, soil type or a combination of these may affect yield. The efficiency of water use was higher in deeply irrigated treatments than in shallow irrigated ones; Farman et al. (1981).

The water that plants actually extract is difficult than defined by available water. Plants extract water preferentially from the upper portion of the soil profile (Gardener, 1983). Ratliff et al. (1983) developed relationship of the upper and lower limits of plant extractable water based on various soil properties.

Increasing irrigation intervals decreased clearly soil moisture content especially when accompanied with the least water applied of 4 cm and longest period of 21 days. Soil moisture content in the other sub-surface 30 cm dos'nt reach the wilting point under any treatment of this study (Eid, 1994).

The present investigation was initiated to study the effect of different water application levels and different depths of water extraction on sugarbeet yield and its water relations.

MATERIALS AND METHODS

This investigation was conducted at Sakha Agriculture Research Station Farm, during 1997/98 and 1998/99 seasons. The soil of the experimental sites was clayey in texture and non-saline non-alkaline soils. The experimental design was split plot with four replicates to study the effect of the following treatments on sugarbeet yield and its water relations:

1-The main plots were occupied by water treatments (W);

W1: Amount of irrigation water applied to refill the root zone to field capacity at each irrigation.

W2: Amount of irrigation water applied to refill the root zone to field capacity plus 5% at each irrigation.

W3: Amount of irrigation water applied to refill the root zone to field capacity minus 5% at each irrigation.

2- Sub-plot treatments were the depths of soil moisture extraction(D):

D1: Depth of witting is 30 cm

D2: Depth of witting is 45 cm
D3: Depth of witting is 60 cm

Sugarbeet seeds (variety Top) were hand sown in hills 20 cm apart at the rate of 3-5 seed balls per hill at the third and second week of October 1997and 1998, respectively. Plants were thinned twice and the later one was done to obtain a single plant /hill. Calcium super phosphate (15.5%, P2O5) was applied during tillage operation at the rate of 100 kg/fed. While potassium sulfate (48%, K2O) was applied at the rate of 50 kg/fed. before the second watering. Nitrogen fertilization in the form of urea (46%, N) at the rate of 70 kg/fed. was applied in two equal doses before the first and the second watering.

Studied characters:

At maturity, five plants were taken at random from each plot and the following characteristics were recorded:
1-Root fresh weight (gm)
2-Root yield of each plot was estimated in kg and converted to record root yield in ton/fed.
3-Sucrose percentage was determined polarimetrically on lead acetate extract of fresh roots according to method described by Le-Decote (1927).
All the data were statistically analyzed according to Snedecor and Cochran (1967).

Water relations:

1-Water consumptive use:

It Was calculated according to the following equation described by Israelsen and Hansen, (1962).

$$Cu = \sum_{i=1}^{i=n} \frac{\Theta 2 - \Theta 1}{100} \; x \; Bd \; x \; \frac{60}{100} \; x \; 4200$$

Where:
Cu water consumptive use (m^3/fed.)
N =number of irritations
Θ2= Soil moisture content (%) after irrigation.
Θ1= Soil moisture content (%) before the next irrigation.
Bd = Bulk density (g/cm^3).

2- Amount of irrigation water applied:

Values of water was measured by cut-throat flume (20x90 cm) and calculated as m3 /fed.(Early, 1975).

3-Water use efficiency (WUE):

Water use efficiency was calculated in kg/m3 by using the following formula:
WUE = yield (kg/fed.)

Water consumptive use (m3/fed.)

(Abd El-Rasool et al., 1971)

3- Soil moisture extraction patterns:

The percentage of soil moisture extraction pattern was calculated according to the formula:

$$\frac{(\Theta 2 - \Theta 1)\ for\ each\ depth}{(\Theta 2 - \Theta 1)\ for\ all\ depths} \times 100$$

RESULTS AND DISCUSSION

1- Sugarbeet yield and weight of the root per plant:

Values of sugarbeet yield and weight of the root per plant in the two season of investigation as affected by different levels of water applied and soil moisture depths are presented in Table (1).

Results show that both sugarbeet yield and weight of the root per plant are significantly affected by the different treatments except for the sugarbeet yield in the first season which is not significantly affected under water applied levels. Treatment (W1) achieved the highest values of sugarbeet yield (20.17 ton/fed.) especially in the second season followed by treatment (W3), while treatment (W2) recorded the lowest values (18.52 ton/fed).

In the case of the first season, the different water applied levels had no significant effect on sugarbeet yield. Concerning the weight of the root per plant, the data revealed that the treatment (W1) produced the highest values of root weight per plant (1.681 and 2.1 kg) in the 1st and 2nd season, respectively followed by treatment (W2). The treatment (W3) recorded the lowest values of root weight per plant (0.764 and 0.9 kg) for both seasons.

With respect to the effect of soil moisture depths on sugarbeet yield and weight of the root per plant, data indicate that the treatment D1 (soil moisture depth of 0-30 cm) was superior to the other two depths (D2 and D3) and it produced the highest values of sugarbeet yield and weight of the root per plant. The interaction between irrigation water applied levels and soil moisture depths recorded a significant effect on sugarbeet yield and root weight per plant.

It could be noticed that the highest sugarbeet yield is gained from (W1D1) treatment, which watered at field capacity to a depth of 30 cm. These results are in agreement with those obtained by Yonts (1984) and Bially (1990).

2- Sucrose percentage and sugar yield :

The sucrose percentage ranged between 17.22 and 17.31 % in the 1st season, while in the 2nd season varied between 17.33 and 17.6 %.

Sucrose percentage and sugar yield isn't significantly affected by water applied levels on this trait except for the sugar yield in the 2nd season of the study which was affected by different water applied depth.

With respect to the effect of soil moisture depth, the results showed that the sucrose percentage not affected significantly, but sugar yield was significantly affected.

The highest sugar yield was scored from soil moisture depth of 30-cm (D1) in the 1st and 2nd seasons 3419.55 and 3791.49 kg/fed. respectively followed by treatment (D2), while the lowest values of sugar yield was obtained from treatment (D3).

Statistical analysis of the data in Table (2) revealed that there is no response of sucrose percentage to the interaction among different water applied levels and soil moisture depths. However, there is a response of sugar yield to the interaction between water-applied levels and soil moisture depths.

Table (1): Sugarbeet yield in ton/fed. And weight of single root in kg for the two seasons.

Treatments	Sugarbeet yield		Weight of the root	
	1st season	2nd season	1st season	2nd season
Field capacity	17.93	20.17	1.681	2.10
Field capacity + 5%	17.94	18.52	1.122	1.67
Field capacity – 5%	18.01	18.90	0.764	0.90
F test	Ns	*	*	**
LSD 0.05	--	0.95	0.327	0.42
LSD 0.01	--	--	--	0.71
Root depth 30 cm	20.01	21.82	1.38	1.94
Root depth 45 cm	17.59	19.22	1.21	1.52
Root depth 60 cm	16.29	16.58	0.979	1.17
F test	**	*	*	**
LSD 0.05	1.2	1.5	0.318	0.28
LSD 0.01	2.1	2.4	--	0.51
Interaction	*		*	

Table (2): Sucrose % and sugar yield in kg/fed. for the two seasons.

Treatments	Sucrose %		Sugar yield	
	1st season	2nd season	1st season	2nd season
Field capacity	17.31	17.47	3103.68	3523.70
Field capacity + 5%	17.31	17.60	3105.41	3259.52
Field capacity – 5%	17.22	17.33	3101.32	3275.37
F test	Ns	Ns	Ns	*
LSD 0.05	--	--	--	212.0
LSD 0.01	--	--	--	
Root depth 30 cm	17.09	17.40	3419.55	3791.49
Root depth 45 cm	17.60	17.91	3095.68	3437.11
Root depth 60 cm	17.16	17.10	2795.2	2829.99
F test	Ns	Ns	*	*
LSD 0.05	--	--	315.0	361.0
LSD 0.01	--	--	--	--
Interaction	Ns	Ns	*	*

3-Actual water consumptive use:

Actual water consumptive use of sugarbeet was determined for the different treatments and the data are presented in Table (3). It is noticed that as the

amount of water applied increased the values of water consumptive use increased and vice versa. Treatment (W3) of field capacity plus 5% recorded the highest values of water consumptive use (2479.4 and 2563.34 m3/fed.) in the 1st and 2nd seasons, respectively. followed by treatment W1 (2400.86 and 2484.87 m3/fed.) for the 1st and 2nd seasons, respectively, and the treatment W3 (2309.86 and 2361.37 m3/fed.).

Regarding the effect of soil moisture depth treatments on water consumptive use, it can be said that increasing the soil moisture depth from 0-30 cm (D1) to O-60 cm (D3) increased the average actual water consumptive use of sugarbeet crop.

Table (3): Water consumptives use (m3/fed.) as affected by amount of water applied and root depth in the two seasons.

Treatments		Water consumptive use m3/fed		Mean
Water applied depth	**Root depth cm**	**1st season**	**2nd season**	
Field capacity	30	2183.58	2267.7	2225.64
	45	2489.76	2531.4	2510.58
	60	2529.24	2655.5	2592.37
Mean		2400.86	2484.87	2442.86
Field capacity + 5%	30	2251.2	2335.2	2293.2
	45	2580.9	2622.29	2601.6
	60	2606.1	2732.52	2669.31
Mean		2479.4	2563.34	2521.37
Field capacity - 5%	30	2102.1	2170.1	2136.1
	45	2362.08	1406.6	2384.34
	60	2465.4	2507.4	2486.4
Mean		2309.66	2361.37	2335.61

3- Amount of water applied:

The amount of irrigation water applied to sugarbeet for different treatments in the two seasons are presented in Table (4). It can be noted that amount of water applied was lower with treatment (W3) than those applied with treatment (W1) and (W2).

Table (4) : Amount of water applied (m3/fed.) as affected by depth of water applied and root depth in the two seasons under cultivation of sugarbeet.

Treatments		Amount of water applied m3/fed		Mean
Water applied depth	**Root depth cm**	**1st season**	**2nd season**	
Field capacity	30	2364.7	2455.67	2410.19
	45	2977.35	3027.58	3002.47
	60	2331.28	3479.24	3414.26
Mean		2891.11	2993.5	2942.31
Field capacity + 5%	30	2475.18	2567.54	2521.36
	45	3079.78	3129.17	3104.48
	60	3595.58	3669.99	3632.79
Mean		3050.18	3122.23	3086.21
Field capacity - 5%	30	2243.16	2312.42	2277.79
	45	2902.71	2957.42	2930.07
	60	3294.67	3350.8	3322.74

Mean		2813.51	2873.55	2843.53

It is clear from the data that amount of water applied increased by increasing soil moisture depth.

As a general, it can be concluded that much more water was applied when irrigation was practiced at field capacity + 5% and to soil moisture depth of 60 cm and the lowest values were recorded by irrigation at field capacity – 5% and to soil moisture depth of 30 cm.

5-Water use efficiency:

The term water use efficiency has been widely used in irrigation crop production to describe the efficiency of irrigation with respect to crop yield. It is particularly important in comparing crop production from the standpoint of water conservation and production cost. Water use efficiency, as used in this discussion is defined as kilograms of sugarbeet roots or sugar yield produced per m3 of water consumed. Values of water use efficiency as affected by irrigation treatments in the two seasons are presented in Table (5). The data clearly show that the irrigation at field capacity – 5% (W3) treatment recorded the highest values of water use efficiency for sugarbeet and sugar yield in the 1st and 2nd seasons, followed by treatment (W1) that irrigated at field capacity. It is interesting to note that the irrigation at field capacity + 5% treatment (W2) recorded the lowest values in both seasons.

With regard to the effect of soil moisture depth on water use efficiency, results show2 that the irrigation at 30 cm of soil moisture depth (D1) achieved the highest values of water use efficiency for both sugarbeet and sugar yield followed by irrigate at depth of 45 cm (D2). While the lowest values were obtained from treatment (D3) irrigated at depth of 60-cm (D3). These results are in agreement with those obtained by Gardener, (1983) and Ratliff et al, 1983.

Table (5): Water use efficiency as affected by water applied levels and soil moisture depths in the two seasons under cultivation of sugarbeet.

Treatments		**Beet yield**		**Mean**	**Sugar yield**		**Mean**
Water applied depth	Root depth cm	1st season	2nd season		1st season	2nd season	
Field capacity	30	8.67	10.01	9.34	1.48	1.74	1.61
	45	7.2	8.02	7.61	1.27	1.44	1.36
	60	6.69	6.49	6.59	1.15	1.11	1.13
Mean		7.52	8.17	7.85	1.30	1.43	1.37
Field capacity + 5%	30	7.97	9.51	8.74	1.36	1.65	1.51
	45	7.34	6.88	7.11	1.29	1.23	1.26
	60	6.50	5.91	6.21	1.12	1.01	1.07
Mean		7.27	7.43	7.35	1.26	1.30	1.28
Field capacity - 5%	30	8.57	9.63	9.10	1.46	1.67	1.57
	45	8.05	8.04	8.05	1.42	1.44	1.43
	60	6.90	6.52	6.71	1.18	1.11	1.15
Mean		7.84	8.06	7.95	1.35	1.41	1.38

6-Soil moisture extraction pattern:

Soil moisture extraction by sugarbeet roots was calculated for each treatment as shown in Table (6).

Data of soil moisture extraction reveal that most soil moisture was removed from the upper soil surface layer depth. However, the data clearly show that there was a substantial reduction in moisture extraction downward throughout the soil profile and this trend was clear with all treatments under study.

Generally about 70% of the available soil moisture was extracted by roots from the first foot (0-30 cm), and the rest (30 %) as extracted from the second down foot of soil profile.

Table (5): Water use efficiency as affected by water applied levels and soil moisture depths in the two seasons under cultivation of Sugarbeet.

Treatments		1st season				2nd season			
Water applied depth	Root length cm	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60
Field capacity	30	44.25	28.5	17.83	9.41	41.67	29.73	18.32	10.28
	45	40.46	29.13	19.98	10.43	38.64	28.95	20.85	11.56
	60	41.82	29.11	19.69	9.38	40.27	29.67	19.96	10.09
Mean		42.18	28.11	19.16	9.74	40.19	29.45	19.71	10.64
Field capacity + 5%	30	42.12	30.07	20.22	7.59	41.49	27.63	20.79	10.09
	45	40.72	28.70	21.03	9.56	38.86	28.55	21.97	10.62
	60	39.76	29.12	20.30	10.82	41.24	29.34	20.49	8.93
Mean		40.87	29.30	20.52	9.32	40.53	28.51	21.08	9.88
Field capacity - 5%	30	38.12	30.15	22.14	9.57	39.02	27.92	22.35	10.71
	45	39.58	29.70	20.63	10.11	40.65	29.16	20.26	9.93
	60	41.84	29.03	20.63	8.77	42.81	28.54	20.02	8.63
Mean		39.85	29.63	21.04	9.48	40.83	28.54	20.88	9.76

It is concluded that the irrigation at field capacity with 30-cm root depth produced the highest yield of sugarbeet root.

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تـأثير الـري بمسـتويات وأعمـاق مختلفـة علـى المحصـول والعلاقـات المائيـة لبنجـر السكر بمنطقة شمال الدلتا

حسن على شمس الدين

معهد بحوث الأراضي والمياه والبيئة- محطة البحوث الزراعية بسخا

أجريـت تجربتـان حقليتـان بمزرعـة محطـة البحـوث الزراعيـة بسـخا فـي موسـمي 98/1997 و 99/1998 وذلـك لدراسـة أثـر الـري بمسـتويات (السـعة الحقليـة ، السـعة + 5 % ، السـعة الحقليـة – 5 %)وأعماق مختلفة (30 ، 45 ، 60 سم) على المحصول والعلاقات المائية لبنجر السكر ودلت النتائج : حققت معاملة الري عند السعة الحقلية أعلى محصول جذور (20.17 طن/ فدان) ثم معاملة الري عند السعة الحقلية – 5 %بينما كان اقل محصول من معاملة الري عند السعة الحقلية + 5 % (18.52 طن/فدان) كما أن معاملة الري لعمق 30 سم حققت أعلي محصول جذور ومحصول سكر حيث كان محصول السكر (3419.5 ، 3791.3 كجم/فدان) وكانت اقل القيم تحت معاملة الري لعمق 60 سم . كانت اقل قيم الاستهلاك المائي (2479.4 ، 2563.3 م^3 /فدان) لمعاملة الري عند السعة الحقلية - 5 % . كانت أعلى كميات مياه مضافة عند الري بالسعة الحقلية + 5 % وعمق 60 سم .

وقد حقق الري لعمق 30 سم أعلي كفاءة استخدام المياه لمحصول بنجر السكر ثم الري عند 45 سم وكانت اقل القيم عند الري لعمق 60 سم .

دلت النتائج ايضا أن معظم استخلاص الجذور للرطوبة كان من القدم العلوي للقطاع الأرضي ويقل ذلك مع العمق . وعموما فإن حوالي 70% من الماء الميسر يتم استخلاصها من القدم العلوي والـ 30 % الباقية يتم استخلاصها من القدم الذي يليه.