IRRIGATION WATER MANAGEMENT FOR SUGAR BEET CROP

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ABSTRACT

Field experiments were conducted at Tameia Res. Station, Fayoum Governorate during 2007/2008 and 2008/2009 seasons to study the effect of the combination between two ridge width treatments, i.e. (R_1): ridges of 60 cm width and (R_2) : ridges of 120 cm width (beds planted from both sides), with four irrigation regimes, i.e. (I_1) : 30%, (I_2) : 45%, (I_3) : 60% and (I_4): 75% available soil moisture depletion (ASMD) on sugar beet yield and its components, quality and some water relations. A split - plot design with four replication was used. The main obtained results were as follows:

1. Root length, root diameter, root weight, fresh root yield / fed, sucrose, T.S.S., juice purity percentages and sugar yield/fed were significantly affected by ridge width, irrigation regime treatments and their interaction in both seasons, to different magnitudes.
2. Planting on ridges of 60 cm width and irrigation at 30% ASMD gave the highest root diameter (16.8, 17.3cm), root weight (2.64, 2.73gm) and root yield (19.78 and 20.56 t/fed in 2007/2008 and 2008/2009, respectively). However, the lowest averages were obtained from bed (R_2) planting and irrigation at 75% ASMD in both seasons. Root length under both ridge width treatments significantly increased as ASMD increased from 30% to 75% in both seasons.
3. The highest sucrose %, i.e. 18.26 and 18.55% in the two successive seasons were detected from wide ridges planting and irrigation at 30% ASMD, whereas planting on ridges of 60 cm width and irrigation at 30% ASMD gave the highest sugar yield (3.58 and 3.80 t/ fed in 2007/2008 and 2008/2009 seasons), respectively.
4. Seasonal consumptive use (ET_C) averaged 52.80 and 54.38 cm in the two successive seasons. The highest ET_C values, i.e. 58.86 and 60.26 cm in 2007/2008 and 2008/2009 seasons, respectively were detected from planting on ridges of 60 cm width and irrigation at 30% ASMD. Planting on beds and irrigation at 75% ASMD gave the lowest ET_C values, i.e. 46.82 and 47.73 cm in the two successive seasons. Planting on wide ridges (beds) decreased ET_C by 7.00 and 8.71% in the two seasons.
5. Daily ET_C rates started with low values, then increased during Jan. and Feb. months and reached its maximum values during March, then redecreased during April and May. The crop coefficient (K_C) during the growing season months from November until May were 0.55, 0.7, 0.83, 1.05, 1.11, 0.79 and 0.59, respectively, (average of two seasons).
6. Planting on wide ridges (beds) and irrigation at 45% ASMD was found to be the optimum efficiency of water use, i.e. 8.018 and 8.021 kg roots/m^3 water consumed in 2007/2008 and 2008/2009 seasons, respectively, as a treatment for water rationalization.

Key words: Sugar beet yield, Quality, Ridging, Water relations.

INTRODUCTION

Irrigation managements play the important role in the agriculture strategy, due to the limited water resources and the expansion of the newly reclaimed areas. Thus, water use rationalization in irrigation can be achieved throughout many agricultural practices, i.e. tillage, ridging, drought tolerant varieties, fertilization,….etc. **Musick and Dusek (1982)** indicated that a common practice to limit the quantity of water intake in graded furrows has been to irrigate widely spaced furrows or alternate furrows. **Musick *et al.* (1985)** reported that seasonal consumptive use of corn (ET_C) planted on furrows of 0.75 m width was greater than wide furrows of 1.5 m width .**Tawadros and Abd El-Aziz (1992)** pointed out that increasing ridge width caused a reduction in cotton and corn water consumption. **Salib *et al.* (1998)** concluded that increasing ridge width from 0.7 m to 1.4 m caused significant decreases in yield and yield components, whereas seasonal ETc of sunflower reduced by 12.7% .**Ashry *et al.* (2008)** found that planting grain sorghum on beds of 120 cm width significantly decreased all yield components, grain yield by 5.9%, and seasonal consumptive use by 5.37% than those planted on ridges of 60 cm width.

Regarding, the effect of irrigation on sugar beet crop, **Doorenbos *et al.* (1979)** reported that water requirements ranged between 55 and 75 cm. The crop coefficient (K_C) is 0.4-0.5, 0.7- 0.85, 1.05-1.2, 0.9-1.0 and 0.6-0.7 during the initial, crop development, mid-season, late season and harvesting periods, respectively. The water use efficiency (WUE) is 6-9 kg roots/m^3 water consumed. **Prasad *et al.* (1985)** indicated that the maximum sugar yield (6.3 t/ha) and water consumptive use (65 cm) were observed from irrigation at 80% available soil moisture (ASM**). Semaika *et al.* (1988)** revealed that irrigation at 40% ASMD gave the highest root length and diameter. Consumptive use decreased as ASMD increased and highest $K_{C.}$ Values were detected from irrigation at 20% ASMD. **Ibrahim (1990)** found that irrigation at 30,60 and 90% ASMD resulted in water consumptive use (ET_C) of 2699.5, 2271.8 and 2127.7 m^3/fed, respectively. The highest (WUE) was resulted from irrigation at 30% ASMD. **Khafagi and El-Lawendy (1997)** showed that decreasing irrigation frequency decreased root weight, root length and carbohydrate content of roots. **Massoud and Shalaby (1998)** indicated that irrigation every 15, 30 or 45 days had no significant effect on sugar yield and water consumptive use values were 6028, 5107 and 3449 m^3/ha, respectively. **El-Askari *et al*.(2003)** pointed out that irrigation with water amount equal to 90% field capacity gave the highest crop yield, acceptable yield quality and good WUE values. **El-Shouny *et al.* (2003)** reported that consumptive use values were 75.08, 73.29 and 70.58 for irrigation at 40,60 and 80%ASMD, respectively. The highest WUE was attained from irrigation at 60% ASMD**. Ashry *et al.* (2007)** concluded that irrigation at 35% ASMD gave the highest values of root diameter, root weight, root yield (19.96 t/fed) sugar percentage, juice purity%, sugar yield (3.94 t/fed), seasonal ET_C (62.19 cm), daily ET_C and WUE (7.73 kg roots/m^3 water consumed), compared with irrigation at 55% or 75% ASMD. However, the highest root length and T.S.S. values were observed from irrigation at 75% ASMD. The K_C values from Oct. until May were; 0.52, 0.71, 0.88, 1.14, 1.28, 1.08, 0.69 and 0.55, respectively.

MATERIALS AND METHODS

Two field experiments were conducted at the farm of Tameia Agric.Res. Station, Fayoum Governorate during 2007/2008 and 2008/2009 seasons to study the effect of ridge width and irrigation regime treatments on sugar beet crop and its quality and crop water relations. To achieve these targets two ridge width treatments, i.e. R_1: planting on ridges of 60 cm width from one side and R_2: planting on ridges (beds) of 120 cm width from both sides, were combined with four irrigation treatments, i.e. I_1 irrigation at 30%, I_2:45%, I_3: 60% and I_4: 75% available soil moisture depletion (ASMD) in a split-plot design with four replications. The effect of different experimental treatments on yield components, yield, and yield quality and crop water relations was studied. Sugar beet seeds (*Beta vulgars* L**.**) at the rate of 5-6 kg seeds/fed were planted on Nov. 5^{th} and 15^{th} in 2007/2008 and2008/2009 seasons, respectively, in hills of 15.0 cm apart and thinned for one plant/hill immediately before the first irrigation. Nitrogen fertilization (ammonium nitrate 33.5% N) at the rate of 80 kg N/fed was added in two equal doses (at the 1^{st} and 2^{nd} irrigation). Calcium super phosphate (15.5% P_2O_5) at the rate of 200 kg/fed and potassium sulphate (48%K_2O) at the rate of 50 kg/fed were added during the field preparation. Harvesting was carried out on May 7^{th} and 12^{th} in the two successive seasons. The soil physical and chemical properties of the experimental plots were determined according to **Klute (1986)** and **Page *et al.* (1982)** and presented in Table **(1)**. The monthly averages of climatic factors for Fayoum Governorate during the two growing seasons are shown in Table **(2)**. Application of irrigation regime treatments started from the second irrigation. The soil moisture constants of the experimental field (mean of the two seasons) are listed in Table **(3).** Whereas dates of irrigation and irrigation intervals for different treatments in 2007/2008 and 2008/2009 seasons are recorded in Table (4). The soil moisture values were determined gravimetrically on oven dry basis, as the technique of Water Requirements and Field Irrigation Dept., A.R.C., Egypt for different layers, each of 15.0 cm from soil surface and down to 60 cm depth. At harvesting time the following data were recorded for each sub-plot.

I. Yield and yield component:

Ten guarded plants were randomly chosen from the middle ridge of each sub-plot to determine the following data:

1- Root length (cm) **2-** Root diameter (cm) **3-** Root weight (kg).

4- Fresh root yield/fed.: determined from root yield of the whole sub- plot.

II . Crop quality.

1. Sucrose percentage: was determined by Sucrometer and using lead acetate according to the methods of **A.O.A.C. (1965).**

2. Total soluble salts (T.S.S): was determined by the Refractometer.

3. Juice purity percentage: was calculated as follows:

Juice purity%= {(Sucrose %) ÷ (T.S.S) × 100}.

4. Sugar yield (t/fed): was calculated from the sucrose percentage and the fresh root yield of the same treatment.

All the measurements and data collected were subjected to the statistical analysis according to the methods described by **Snedecor and Cochran (1980).**

III. Crop water relations:

1. Seasonal consumptive use (ET_C)

For obtaining the crop water consumptive use (ET_C), soil samples were taken just before and 48 hours after each irrigation, as well as at harvesting time. The crop water consumptive use between each two successive irrigations was calculated according to the following equation **(Israelsen and Hansen, 1962).**

$Cu\ (ET_C) = \{(Q_2 - Q_1) / 100\} \times Bd \times D$

Where: Cu = crop water consumptive use (cm)

Q2= soil moisture percentage 48 hours after irrigation.

Q1= soil moisture just before irrigation.

Bd = soil bulk density (gm/cm^3).

D = soil layer depth (cm).

2. Daily ET_C rate (mm/day).

Calculated from the ET_C between each two successive irrigations divided by the number of days.

3. Reference evapotranspiration (ET_0)

Estimated as a monthly rate (mm/day), using the monthly averages of climatic factors of Fayoum Governorate and the procedures of the **FAO-Penman Monteith** equation **(Allen *et al.* 1998)**

4. Crop Coefficient (K_C).

The crop coefficient was calculated as follows:

$K_C = ET_C / ET_0$

Where: ET_C = Actual crop evapotranspiration and ET_0 = Reference evapotranspiration.

5. Water use efficiency (WUE).

The water use efficiency as kg roots/ m^3 water consumed was calculated for different treatments as the method described by **Vites(1965):**

WUE = {root yield (kg/fed.) / Seasonal crop consumptive use "Cu"(m^3/fed.)}

Table (1). Some physical and chemical properties of the experimental field during 2007/2008 and 2008/2009 seasons (average of two seasons).

Physical properties					
Sand %	Silt%	Clay %	Texture classes	Organic matter%	$CaCo_3$%
38.0	21.2	40.7	Clay loam	1.7	5.2

Chemical analysis														
Soluble cations meq/1L				Soluble anions meq/1L				EC dS/m	pH 1:2.5 Extract	CEC Meq/ 100 gm soil	Exchangeable Cations Meq/100 gm soil			
Ca^{++}	Mg^{+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	CO_3^{--}	SO_4^{--}				Ca^{++}	Mg^{++}	K^{+}	Na+
8.18	7.69	24.67	0.33	20.73	3.06	_	17.08	4.00	8.12	31.83	16.29	10.29	1.2	4.05

Table (2). The monthly averages of climatic factors for Fayoum Governorate during 2007/2008 and 2008/2009 seasons.

Month		Temperature C°			Relative humidity (%)	Wind speed (m/sec)	Pan evaporation (mm/day)
		Max.	Min.	Mean			
November	**2007**	26.7	12.8	19.8	54	1.49	2.7
	2008	26.6	13.1	19.9	52	1.50	2.6
December	**2007**	21.3	8.2	14.8	58	1.03	1.6
	2008	22.2	9.1	15.6	54	1.03	1.6
January	**2008**	17.7	5.7	11.7	59	1.18	1.5
	2009	20.7	6.7	13.7	53	1.17	1.7
February	**2008**	20.0	6.5	13.2	57	1.66	2.3
	2009	22.3	6.4	14.4	48	1.65	2.9
March	**2008**	28.6	11.6	20.1	52	2.11	3.8
	2009	23.2	7.9	15.5	49	2.11	3.3
April	**2008**	31.6	13.7	22.6	49	2.42	5.6
	2009	30.8	12.5	21.6	46	2.43	5.5
May	**2008**	35.4	18.2	26.8	47	2.78	7.0
	2009	32.8	16.7	24.8	46	2.77	6.9

Table (3). The average values of soil moisture constants for the experimental field during 2007/2008 and 2008/2009 seasons (average of the two seasons).

Soil depth(cm)	Field capacity (%)	Wilting point (%)	Bulk density (g/cm^3)	Available moisture (%)
0-15	42.46	21.06	1.41	21.4
15-30	40.73	19.81	1.43	20.92
30-45	38.12	18.55	1.31	19.57
45-60	33.55	17.32	1.39	16.23

RESULTS AND DISCUTION

I. Yield and yield components

The results presented in Table (5) reveal that the average values of sugar beet yield and yield components (root length, root diameter and root weight) were significantly affected by ridge width treatments in both seasons. Planting sugar beet on bed of 120 cm width caused significant reductions in root length, root diameter, root weight and fresh root yield/fed by9.4, 6.9, 12.6 and 7.13%, respectively, in 2007/2008 season and by 14.9, 2.8, 15.1 and 6.3%, respectively, in 2008/2009 season. These results may be referred to the inadequate wetting of the lower parts under wide ridges (beds) for some days after irrigation; which in turn reduced growth of roots. These results are in the same trend of those reported by **Salib *et al. (*1998)** and **Ashry *et al***. **(2008)**.

Regarding the effect of irrigation regime treatments, the data recorded in Table (5) show that irrigation regime treatments significantly affected the studied sugar beet yield/fed and yield components in both seasons. Increasing the available soil moisture depletion (ASMD) from 30 to 45% significantly decreased root diameter, root weight and fresh root yield/fed in the 1st season

Table 4

by 7.5, 15.0 and 5.6%, respectively, and in the2nd season by 9.0, 13.7 and 6.6%, respectively. However, the root length was significantly increased by 5.4 and 5.7% in 2007/2008 and 2008/2009 seasons, respectively. More increase in the ASMD, i.e. from 30 to 75% caused remarkable reductions in root diameter, root weight and fresh root yield/fed in 2007/2008 season by 28.1, 44.2 and 33.9%, respectively, and in 2008/2009 season by 30.1, 54.0% and 37.04%, respectively. On the other hand, the root length was significantly increased by 18.6% and 20.0% in the two successive seasons when the ASMD increased from 30% to 75%.

It could be concluded that increasing ASMD in the root zone of sugar beet plants caused significant reductions in fresh yield/fed and yield components except root length. These results may be due to the effect of soil moisture stress on reducing water and nutrients absorption and this in turn reduced photosynthesis, cell division and dry matter accumulation in storage organs. However, whereas drought may encourage the primary root to go down elongation searching about moisture in far depths. Such findings are in agreement with those reported by **Prasad *et al.* (1985), Khafagi and El-Lawendy (1997)** and **Ashry *et al*. (2007)**.

Table (5): Effect of ridge width, irrigation regimes and their interaction on sugar beet root yield and components in 2007/2008 and 2008/2009 seasons.

Treatments		2007/2008				2008/2009			
Ridge width	**Irrigation Regimes (ASMD)**	**Root Length (cm)**	**Root Diameter (cm)**	**Root weight (kg)**	**Fresh root Yield (t/fed)**	**Root Length (cm)**	**Root Diameter (cm)**	**Root Weight (kg)**	**Fresh root Yield (t/fed)**
(R_1) 60cm	**I_1 : 30%**	21.3	16.8	2.46	19.78	22.7	17.3	2.73	20.56
	I_2 : 45%	22.8	15.2	2.00	18.14	23.9	15.2	2.35	19.01
	I_3 : 60%	24.6	13.9	1.53	14.89	25.4	14.1	1.68	15.63
	I_4 : 75%	25.2	11.8	1.34	13.38	27.6	11.1	1.21	12.85
Mean		**23.5**	**14.4**	**1.83**	**16.55**	**24.9**	**14.4**	**1.99**	**17.01**
(R_2) 120 cm	**I_1 : 30%**	19.4	15.2	2.07	18.13	19.2	15.8	2.23	19.02
	I_2 : 45%	20.2	14.4	1.84	17.66	20.6	15.0	1.94	17.94
	I_3 : 60%	22.5	12.8	1.32	14.01	22.0	13.1	1.52	14.73
	I_4 : 75%	23.1	11.1	1.17	11.68	22.9	12.0	1.06	12.06
Mean		**21.3**	**13.4**	**1.60**	**15.37**	**21.2**	**14.0**	**1.69**	**15.94**
Means of irrigation									
Mean I_1		20.4	16.0	2.26	18.96	21.0	16.6	2.48	19.79
Mean I_2		21.5	14.8	1.92	17.90	22.2	15.1	2.14	18.48
Mean I_3		23.6	13.4	1.42	14.45	23.7	13.6	1.60	15.18
Mean I_4		24.2	11.5	1.26	12.53	25.2	11.6	1.14	12.46
L. S. D. : 0.05 Ridge width (R)		0.99	0.84	0.07	0.11	0.47	0.65	0.06	0.07
Irrigation regimes(I)		0.27	0.22	0.03	0.04	0.33	0.17	0.03	0.04
(R) × (I)		0.28	0.23	0.03	0.04	0.34	0.17	0.04	0.05

The data listed in Table (5) indicate that the interaction between ridge width and irrigation regime treatments had significant effects on fresh root yield/fed and yield components in both seasons of this study. The highest averages of root diameter, root weight and fresh root yield/fed (19.78 and

20.56 t/fed) were detected from planting on normal ridges of (60 cm width) and irrigation at 30% ASMD in the two seasons. However, planting on beds (wide ridges of 120 cm width) and irrigation at 75% ASMD gave the lowest averages of root diameter, root weight and fresh root yield/fed (11.68 and 12.06 t/fed) in both seasons. The highest averages of root length were resulted from planting on normal ridges (60 cm) and irrigation at 75% ASMD, whereas the lowest ones were obtained from irrigation at 30% ASMD and (120 cm) beds planting. These results were found to be true in the two seasons.

II. Yield quality

The results recorded in Table (6) indicate that planting sugar beet on ridges of 60 cm width (R_1) significantly reduced the sucrose percentage, total soluble solids % (T.S.S) and juice purity%, compared to planting on wide ridges of 120 cm width (R_2) in both seasons. On the other hand, sugar yield of R_1 treatment overyielded those of R_2 treatment by 5.12% and 5.63% in 2007/2008 and 2008/2009 seasons, respectively. These results may be due to that the fresh root yield/fed, detected from R_1 treatment were higher than those of R_2 treatment by 7.68% and 6.71% in the two successive seasons, whereas the sucrose percentage reduced by 0.22% and 0.23% only in the two seasons.

The data listed in Table (6) show that the average values of yield quality parameters, i.e. sucrose%, T.S.S%, juice purity% and sugar yield/fed were significantly varied due to irrigation regime treatments in both seasons. Increasing the ASMD from 30% to45% or 60% or 75% led to significant decreases in sucrose, juice purity percentages and sugar yield/fed, whereas the T.S.S% increased in both seasons. The sugar yield, obtained from irrigation at 30% ASMD overyielded those detected from irrigation at 45, 60 and 75% ASMD in 2007/2008 season by 7.16%, 38.71% and 66.18%, respectively, and in 2008/2009 season by 10.24%, 39.69% and 74.28%, respectively. These obtained results may be attributed to the effect of soil moisture stress on decreasing growth attributes, fresh root yield/fed, and carbohydrate concentration in roots. These results are in harmony with those reported by **Khafagi and El-Lawendy (1997), El-Askari *et al.*(2003) and Ashry *et al.* (2007).**

The obtained results in Table (6) reveal that the averages of yield quality parameters were significantly affected by the interaction between ridge width and irrigation regime treatments in both seasons. Planting on wide ridges of 120 cm (beds) and irrigation at 30% ASMD gave the highest sucrose % and T.S.S. % in the two seasons. However, the highest sugar yield, i.e. 3.58 and 3.80 t/fed in 2007/2008 and 2008/2009 seasons, respectively, were detected from planting on ridges of 60 cm width and irrigation at 30% ASMD. The lowest sucrose percentages, i.e. 16.31% and 16.74% in the two successive seasons, respectively, were obtained from 60 cm ridge width and irrigation at 75% ASMD. Planting on wide ridges (beds) and irrigation at 75% ASMD gave the lowest sugar yield/fed, i.e. 1.96 and 2.04 t/fed in 2007/2008 and 2008/2009 seasons, respectively.

Table (6). Effect of ridge width, irrigation regimes and their interaction on the averages of sugar beet yield quality in 2007/2008 and 2008/2009 seasons.

Treatments		2007/2008				2008/2009			
Ridge width	Irrigation Regimes (ASMD)	Sucrose (%)	T.S.S. (%)	Juice Purity (%)	Sugar Yield (t/fed)	Sucrose (%)	T.S.S. (%)	Juice Purity (%)	Sugar Yield (t/fed)
(R1) 60cm	I_1 : 30%	18.12	20.53	88.26	3.58	18.47	20.45	90.32	3.80
	I_2 : 45%	17.84	20.87	85.48	3.24	17.91	20.97	85.41	3.40
	I_3 : 60%	16.70	21.03	79.41	2.49	17.00	21.00	80.95	2.66
	I_4 : 75%	16.31	21.57	75.61	2.18	16.74	21.32	78.52	2.15
Mean		**17.24**	**21.00**	**82.19**	**2.87**	**17.53**	**20.94**	**83.80**	**3.00**
(R2) 120 cm	I_1 : 30%	18.26	0.81	87.75	3.31	18.55	20.93	88.63	3.53
	I_2 : 45%	18.00	21.15	85.10	3.18	18.09	21.07	85.86	3.24
	I_3 : 60%	17.63	21.47	82.11	2.47	17.47	21.55	81.07	2.57
	I_4 : 75%	16.75	21.93	76.38	1.96	16.91	21.86	77.36	2.04
Mean		**17.66**	**21.34**	**82.84**	**2.73**	**17.76**	**21.35**	**83.22**	**2.84**
Means of irrigation									
Mean I_1		18.19	20.67	88.00	3.44	18.51	20.69	89.48	3.66
Mean I_2		17.92	21.01	85.29	3.21	18.00	21.02	85.64	3.32
Mean I_3		17.16	21.25	80.67	2.48	17.24	21.27	81.01	2.62
Mean I_4		16.53	21.75	76.00	2.07	16.82	21.59	77.94	2.10
L. S. D. : 0.05									
Ridge width (R)		0.09	0.09	3.93	0.07	0.06	0.1	3.46	0.09
Irrigation regimes (I)		0.03	0.06	1.38	0.02	0.04	0.06	2.31	0.02
(R) × (I)		0.03	0.06	1.45	0.03	0.04	0.06	2.42	0.02

III. Crop water relations

1. Seasonal consumptive use (ET_C)

The results presented in Table (7) show that seasonal consumptive use values of sugar beet, as a function of ridge width and irrigation regime treatments were 52.80 and 54.38 cm in 2007/2008 and 2008/2009 seasons, respectively. Planting sugar beet on ridges of 120 cm width (beds) decreased seasonal ET_C by 7.0 and 8.71% in the two successive seasons, when compared with planting on ridges of 60 cm width. These obtained results may be referred to that the bottoms between wide ridges (beds) will be half those between normal ridges (60 cm width) and this in turn reduced water runoff, evaporation and inadequate wetting of the lower parts of the field, which may also reduced plant transpiration. These results are in the same trend with those reported by **Musick and Dusek(1982), Musick *et al.*(1985), Salib *et al.*(1998) and Ashry *et al*.(2008).**

Data listed in Table (7) indicated that the highest seasonal ET_C values, i.e. 56.61 and 58.08 cm in 2007/2008 and 2008/2009 seasons, respectively, were detected from irrigation at 30% ASMD. However, irrigation at 75%ASMD gave the lowest ET_C values, i.e. 48.72 and 50.49 cm in the two successive seasons. It is evident that increasing the ASMD in the root zone of sugar beet from 30 to 45, 60 and 75% caused reductions in ET_C by 3.78, 9.22 and 13.94% in 2007/2008 season, respectively, and by 4.20, 8.25 and 13.07% in 2008/2009 season, respectively. It could be concluded that increasing

Table 7

ASMD in sugar beet root zone decreased seasonal ET_C. These results are in accordance with those reported by **Doorenbos *et al.* (1979), Semaika *et al.*(1988), Ibrahim(1990), Massoud and Shalaby(1998), El-Shouny *et al.*(2003) and Ashry *et al.*(2007)**

Results of Table (7) reveal that the highest ET_C values, i.e. 58.86 and 60.26 cm in 2007/2008 and 2008/2009 seasons, respectively, were resulted from planting on ridges of 60 cm width and irrigation at 30% ASMD. However, planting on wide ridges (beds) of 120 cm width and irrigation at 75% ASMD gave the lowest seasonal ET_C values, i.e. 46.82 and 47.73 cm in 2007/2008 and 2008/2009 seasons, respectively.

2. Daily ET_C rate (mm/day)

The data recorded in Table (7) generally indicate that the daily ET_C rates as a mean of different treatments, tested (over all mean) were started with low values during November (1.55 and 1.88 mm/day) and December (1.54 and 1.76 mm/day) in the two successive seasons, then increased during January (2.10 and 2.19 mm/day) and February (3.50 and 3.37 mm/day). The daily ET_C rates reached its maximum values during March (4.28 and 4.12 mm/day in 2007/2008 and 2008/2009 seasons, respectively), then declined again during April to reach its low values (3.62 and 3.80 mm/day) during May (harvesting) in the two successive seasons. Such findings may be due to that at the initial growth period and seedling stages, most of water losses are caused by evaporation from bare soil during Nov. and Dec.. Thereafter, as the crop cover increased, transpiration will took place beside evaporation (Jan. and Feb.) and the peak of ET_C occurred during the rapid increase in root size and storage stage (March and Apr.). During May most of plant leaves dried and ET_C rate decreased until harvesting.

The results of Table (7) show that planting on wide ridges of 120 cm width (beds) led to decreases in daily ET_C rates throughout the growing season months from Dec. to May in both seasons, than the values of ET_C rates resulted from planting on ridges of 60 cm width.

The presented data in Table (7) reveal that irrigating sugar beet at 30% ASMD (frequent irrigations) gave the highest daily ET_C rates during all the growing season months in the two seasons. However, irrigation at 75% ASMD gave the lowest values of daily ET_C rates from Dec. until May in both seasons. It is obvious that increasing ASMD in the root zone of sugar beet during the growing season decreased the daily ET_C rate, especially during vegetative and storage periods.

3. Reference evapotranspiration rate (ET_0)

The reference ET or ET_0 daily rates (mm/day) during sugar beet growing season duration from Nov. to May in both seasons were estimated using the FAO Penman-Monteith equation and the meteorological data of Fayoum area and recorded in Table (8). The obtained results show that the daily ET_0 rate values were high during Nov., then decreased during Dec. and January months. Thereafter, the daily ET_0 values started to increas from Feb. and up to May. These results are mainly attributed to the changes in climatic factors from month to the other.

4. Crop coefficient (K_C)

The K_C values, as a function of ridge width and irrigation regime treatments for the growing season duration months from November to May in 2007/2008 and 2008/2009 seasons are listed in Table (8). Results of Table (8) reveal that the K_C values for sugar beet, as affected by different treatments

Table 8

(over all mean) were low in the initial growth period (Nov. and Dec.), then increased during Jan., and Feb., as the crop cover increased (vegetative growth period). The K_C values reached its maximum values during March, as the maximum growth and storage in roots. Thereafter, the K_C values redecreased again when plants started maturity (April) to reach its minimum values during harvesting (May). These results may refer to the large diffusive resistance of bare soil at the initial growth period, which decreased with increasing plant growth or crop cover percentage until reaching peak of growth and root storage. However, but at maturity stage the plant transpiration decreased, as the drying of most green leaves of the plants.

Data recorded in Table (8) indicate that increasing ridge width from 60 to 120 cm decreased the K_C values during the months of the growing season duration in both seasons. These results were found to be true, since the daily ET_C values of R_2 treatment were lower than those of R_1 treatment and the ET_0 rate is a constant number during each month of season. On the other hand, increasing the ASMD to 45, 60 or 75% caused reductions in the K_C values in all the months of the two growing seasons. Irrigation at 30% ASMD gave the highest K_C values during all months of the growing season duration, whereas the lowest ones were recorded from irrigation at 75% ASMD in both seasons. For high sugar beet fresh root yield and high sugar yield the K_C values were; 0.55, 0.79, 0.95, 1.15, 1.21, 0.84 and 0.65 for Nov., Dec., Jan., Feb., Mar., Apr. and May, respectively (mean of the two seasons). These obtained results are in the same order with those found by **Doorenbos *et al.* (1979), Semaika *et al*. (1988) and Ashry *et al.* (2007).**

5. Water use efficiency (WUE).

The results presented in Table (9) show that the mean values of WUE, as affected by ridge width and irrigation regime treatments were; 7.154 and 7.174 kg roots/m^3 water consumed in 2007/2008 and 2008/2009 seasons, respectively. Data of Table (9) clearly show that the effect of ridge width treatments on WUE values was different in 2007/2008 season than in 2008/2009 season. Planting on ridges of 60 cm width gave the highest WUE value in 2007/2008 season, i.e. 7.162 kg roots/m^3 water consumed, whereas in 2008/2009 season, planting on wide ridges of 120 cm width gave the highest WUE value (7.264 kg root/m^3 water) consumed. These results may be referred to that in 2007/2008 season, planting on wide ridges (120 cm) decreased yield by 7.13%, however ET_C decreased by 7.0 % only. In 2008/2009 season root yield decreased by 6.3% and ET_C decreased by 8.71%. These results are in the same trend of those reported by **Salib *et al.* (1998) and Ashry *et al.* (2008).**

Data listed in Table (9) indicate that irrigating sugar beet crop at 30% ASMD gave the highest WUE values, i.e. 7.972 and 8.112 kg roots/m^3 water consumed in 2007/2008 and 2008/2009 seasons, respectively. Irrigation at 45 or 60% ASMD decreased the WUE values in the 1st season by 1.77 and 16.02% and in the 2nd season by 2.48 and 16.32%, respectively, as compared with irrigation at 30% ASMD. The lowest WUE values, i.e. 6.116 and 5.881 kg root/m^3 water consumed were detected from irrigation at 75% ASMD in the two successive seasons. It could be noticed that WUE decreased as ASMD increased over 45%. Such findings are in harmony with the results found by **Doorenbos *et al.* (1979), Ibrahim(1990), El-Askari *et al.* (2003) and Ashry *et al.* (2007).**

Table (9). Effect of ridge width, irrigation regime treatments and their interaction on WUE of sugar beet (kg roots/m3 water consumed) in 2007/2008 and 2008/2009 seasons.

Ridge width	2007/2008					2008/2009				
	Irrigation regimes (ASMD)					Irrigation regimes (ASMD)				
	30%	45%	60%	75%	Mean	30%	45%	60%	75%	Mean
(R_1) 60 cm	8.001	7.644	6.708	6.293	**7.162**	8.124	7.801	6.661	5.746	**7.083**
(R_2) 120 cm	7.942	8.018	6.681	5,940	**7.145**	8.101	8.021	6.916	6.016	**7.264**
Mean	**7.972**	**7.831**	**6.695**	**6.116**	**7.154**	**8.112**	**7.911**	**6.788**	**5.881**	**7.174**

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ادارة مياه الري لمحصول بنجر السكر

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اقيمت تجربتان حقليتان بمحطة البحوث الزراعية بطاميه – محافظة الفيوم خلال موسمي الزراعة ٢٠٠٨/٢٠٠٧ ، ٢٠٠٩/٢٠٠٨ لدراسة تأثير التفاعل بين معاملتين لعرض الخط وهما R_1: الزراعة علي خطوط عرض ٦٠ سم علي ريشة واحدة، R_2 : الزراعة علي خطوط بعرض ١٢٠ سم (مصاطب تزرع من الريشتين) مع اربعة معاملات لنقص الرطوبة الارضية الميسرة وهي I_1 : الري عند فقد ٣٠ %، I_2 : عند فقد ٤٥%، I_3 : عند فقد ٦٠%، I_4 : عند فقد ٧٥%، من الماء الميسر علي محصول بنجر السكر ومكوناته وجودته وبعض العلاقات المائيه له واستخدم تصميم القطع المنشقة مرة واحدة في اربعة مكررات.

وفيما يلي ملخص لأهم النتائج المتحصل عليها :

١- تأثر طول وقطر ووزن الجذر ومحصول الجذور للفدان ونسبة السكر، نسبة المواد الصلبة، نقاوة العصير ومحصول السكر للفدان بعرض الخط ومعاملات الري وكذا التفاعل بينهما في كلا الموسمين:

٢- أدت الزراعة علي خطوط بعرض ٦٠ سم والري عند فقد ٣٠% من الماء الميسر للحصول علي اعلي متوسطات لقطر ووزن الجذر، محصول الجذور (١٩.٧٨ ، ٢٠.٥٦ طن/فدان خلال موسمي ٢٠٠٨/٢٠٠٧، ٢٠٠٩/٢٠٠٨ علي الترتيب).بينما نتجت اقل المتوسطات من الزراعة

علي مصاطب والري عند فقد ٧٥% من الماء الميسر في كلا الموسمين بينما زاد طول الجذر معنويا تحت معاملتي عرض الخطوط بزيادة نقص الرطوبة الميسرة من ٣٠- ٧٥% في كلا الموسمين

٣- تم الحصول علي اعلي نسبة سكر وهي ١٨.٢٦ ، ١٨.٥٥% في الموسمين المتعاقبين من الزراعة علي خطوط عريضة (مصاطب) والري عند فقد ٣٠ % من الماء الميسر. اعطي اعلي محصول سكر (٣.٥٨، ٣.٨٠ ط/فدان في ٢٠٠٧/٢٠٠٨، ٢٠٠٨/٢٠٠٩ علي الترتيب).

٤- كان متوسط الاستهلاك المائي للتفاعل بين جميع المعاملات هو ٥٢.٨، ٥٤.٣٨ سم في الموسمين المتعاقبين بينما نتج اعلي استهلاك مائي موسمي وهو ٥٨.٨٦، ٦٠.٢٦ سم في موسمي ٢٠٠٧/٢٠٠٨، ٢٠٠٨/٢٠٠٩ علي الترتيب من الزراعة علي خطوط بعرض ٦٠ سم والري عند فقد ٣٠% من الماء الميسر. الزراعة علي مصاطب عريضة والري عند فقد ٧٥% من الماء الميسر اعطي اقل قيم للأ ستهلاك المائي الموسمي وهي ٤٦.٨٢، ٤٧.٧٣ سم في الموسمين المتعاقبين وتبين أن الزراعة علي مصاطب عريضة تؤدي الي توفير حوالي ٧.٠٠ ، ٨.٧١ % من الماء المستهلك في كلا الموسمين.

٥- بدأ معدل الأستهلاك المائي اليومي بقيم منخفضة ثم تزايد خلال يناير، فبراير ووصل الي اقصي قيمة خلال مارس ثم عاود الإنخفاض مرة أخري خلال ابريل ،مايو. وتقدر قيم ثابت المحصول خلال أشهر النمو من نوفمبر وحتي مايو كما يلي: ٠.٥٥، ٠.٧، ٠.٨٣، ١.٠٥، ١.١١، ٠.٧٩، ٠.٥٩ علي الترتيب (متوسط الموسمين).

٦- تعتبر الزراعة علي خطوط عريضة (مصاطب) والري عند فقد ٤٥% من ماء التربة الميسر هي أنسب المعاملات للحصول علي كفاءة استهلاك مائي مرتفعة (٨.٠١٨، ٨.٠٢١ كجم جذور/ م^{٣} ماء مستهلك في ٢٠٠٧/٢٠٠٨ ، ٢٠٠٨/٢٠٠٩ علي الترتيب).