INFLUENCE OF DRIP IRRIGATION MANAGEMENT ON SUGAR BEET YIELD AND SOME WATER RELATIONS AT NORTH NILE DELTA

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ABSTRACT

Two field experiments have been conducted at the experimental farm of Agriculture Faculty, Kafr El-Sheikh University, Kafr El-Sheikh Governorate (31° 05' N latitude and 30° 56' E longitude) during the two successive growing seasons of 2009/2010 and 2010/2011 to study the overall effect of drip irrigation management on sugar beet productivity, its components and some water relations in clay soil in North Nile Delta. The treatments were arranged in a split plot design with four replicates. The main plots were assigned to three types emitters of drip irrigation system namely: built-in, simple orifice and long-path. Three irrigation regimes i.e. 10 minutes daily, 20 minutes every two days and 30 minutes every three days were allocated in the sub plots.

The main results in this study can be summarized in the following points:

1-The drip irrigation with long-path emitters (Turbo) had been achieved the highest average values of root length (34.54 and 34.20 cm), root diameter (14.43 and 14.29 cm), sucrose percentage (20.77 and 20.71%), root yield (25.93 and 26.26 ton fed.$^{-1}$), sugar yield (5.39 and 5.44 ton fed.$^{-1}$), water productivity (18.74 and 18.84 kg root m^{-3} water consumptive use) and irrigation of water productivity (15.33 and 15.32 kg root m^{-3} applied water) during 2009/2010 and 2010/2011 growing seasons, respectively.

2-The highest average values of root yield (26.16 and 26.51 ton fed.$^{-1}$), sugar yield (5.0 and 5.05 ton fed.$^{-1}$), water productivity (17.56 and 17.64 kg root m^{-3} water consumptive use) and irrigation of water productivity (14.82 and 14.87 kg root m^{-3} applied water) had been obtained at irrigation sugar beet 20 minutes every two days in the 1st and 2nd seasons, respectively.

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3-The highest average values of root yield (27.76 and 28.0 ton fed^{-1}) and sugar yield (5.81 and 5.85 ton fed^{-1}) were obtained with interaction between irrigation 20 minutes every two days and the Turbo emitter (long–path) in the 1^{st} and 2^{nd} seasons, respectively, while, the lowest average values of root yield (20.79 and 21.08 ton $fed.^{-1}$) and sugar yield (3.70 and 3.73 ton fed^{-1}) had been obtained with irrigation 30 minutes every three days using the Metalic emitter (simple-orifice) in the same growing seasons, respectively.

Keywords: *Sugar beet, Simple orifice, Built-in, long-path, drip irrigation, water productivity.*

INTRODUCTION

Irrigation water is gradually becoming scarce not only in arid and semi-arid regions but also in the regions where rainfall is abundant. Egypt is a country of water scarcity due to general low precipitation, high evaporation and the temporal and spatial distribution of rainfall. Therefore, water saving and conservation is a vital and essential demand to face the water gap problem and support agricultural activities, which account for 85% of the total water consumed in semi-arid regions. Irrigation is one of the most important inputs in agricultural practices and particularly in all crops cultivation to increase crop productivity. Crop water management and its yield in different environments are very important concern in irrigation planning and maximizing yield.

Drip irrigation has been considered one of the most important obligatory irrigation systems, which keeps and management water in arid land and dry areas in addition to, it allows a large degree of water saving enabling accurate application of irrigation amounts according to crop water requirements. Under optimum management, drip irrigation system will reduce the water losses caused by evaporation and by deep percolation. Sepaskhah and Kamgar-Haghighi (1997) reported that frequent every-other-furrow irrigation at 10-days irrigation intervals used a smaller amount of irrigation water, but some yield reduction occurred. However, frequent every-other-furrow irrigation at 6-day intervals produced a similar root yield to that of every-furrow irrigation at 10-day intervals and saved about 23% of irrigation water. Crop yield may be increase if proper irrigation practices are used. Drip irrigation has been shown to reduce irrigation water needs compared to sprinkler or furrow systems for a variety of crops under certain circumstances, including sugar beet (Tognetti *et al.,* 2003). Improving drought tolerance of commercial varieties of sugar beet may be a promising approach in maximizing water use efficiency (Rytter, 2005), but sugar beet breeding is long-term and expensive. An efficient way of assessing the extent and complexity of the water stress problem in sugar beet production throughout Europe may be to use crop growth modeling approach to evaluate the effects of future climatic scenarios (Richter *et al.,* 2001). Increasing the amount of water applied gives benefits in terms of sugar beet root yield and sucrose accumulation. Drip irrigation (even applied every-other-furrow) appears to be consistently advantageous with respect to low-pressure sprinkler irrigation for sugar beet performances in semi-arid environments (Tognetti *et al.*, 2003).

The irrigation number, amount and uniformity of water applications are used mainly to determine the efficiency of irrigation scheduling. Excessive doses of infrequently applied water will lead to high percolation losses. There is stiff competition for water by the agricultural, domestic and industrial users during the dry season, hence there is the need for farmers to conserve and make judicious use of the available water, (Adekalu and Okunade, 2006 and Ancuta *et al.,* 2007). Kayombo *et al*., (2002) indicated that the crop water use efficiency has been shown to depend on irrigation amount and frequency, also, the type of irrigation system and tillage practices can influence the water use efficiency for a given irrigation frequency. Byan *et al.*, (2002) indicated that water consumptive use (WCU) of cowpea amounted to 0.426, 0.532 and 0.639 $m^3 m^{-2}$ when irrigated by 80, 100 and 120% of water calculated by class a pan method, respectively.

The main aim of the present investigation was to study the effect of drip irrigation system and irrigation intervals on sugar beet productivity, its components and some water relations in clay soil in North Nile Delta.

MATERIALS AND METHODS

Two field experiments were conducted at the experimental farm, faculty of agriculture, Kafr El-Sheikh University, Kafr El-Sheikh Governorate (31° 05’ N latitude and 30° 56’ E longitude), Egypt in two successive growing seasons of 2009/2010 and 2010/2011 to study the effect of drip irrigation system and irrigation intervals on sugar beet productivity, its components and some water relationships.

Soil samples were randomly taken from the experimental sites and prepared for analysis of both physical and chemical properties and presented in Table (1).

Table (1): Some physical and chemical properties of the experimental soil

Soil depth (cm)	**Sand %**	**Silt %**	**Clay %**	**Texture**	**EC dSm^{-1} (1:5 Soil : Water extract)**	**pH 1: 2.5 Soil: Water suspension**	**Available nutrients Mg kg^{-1} soil**		
							N	**P**	**K**
0-15	33.0	28.6	38.4	Clay loam	3.32	7.80			
15-30	33.4	28.4	38.2	Clay loam	3.58	7.60			
30-45	33.2	28.5	38.3	Clay loam	3.45	7.70	22	1.6	18
45-60	33.0	28.6	38.4	Clay loam	3.49	7.75			

Field capacity, permanent wilting point and bulk density were measured according to Klute (1986). Available soil moisture was calculated as the difference between the field capacity and permanent wilting point and presented in Table (2).

Table (2): Average values of field capacity and bulk density for the two growing seasons.

Soil depth	**Bulk density (kg m^{-3})**	**Field capacity %**	Per-wilting point %	Available water %	EC of irrigation water	Readily available water %
0-15	1120	40.50	20.64	19.86		12.91
15-30	1260	38.02	19.04	18.98	0.64	12.34
30-45	1340	36.25	18.22	18.03	dSm^{-1}	11.72
45-60	1380	35.75	17.91	17.84		11.60

Experimental layout:

The experimental design was laid out in split plot design with four replicates in both growing seasons.

The main treatments were drip irrigation system with three types of emitters as follows:

A- Simple orifice (Metalic) (M).

B- Built-in (GR).

C- long-path (Turbo).

The sub treatments were irrigation regimes as follows:

1- 10 minutes daily.

2- 20 minutes every two days.

3- 30 minutes every three days.

Each experimental block was 2 m in width (across the crop rows) and 30 m in length (along the crop rows). The irrigation network consisted of a main delivery pipe (PE, 32 mm) and the secondary ones (PE, 25 mm). The drip laterals were of 16 mm inside diameter, polyethylene pipe with in line drippers of 4 L h^{-1}, at 30 cm apart the laterals were located 60 cm apart, one or two laterals for each plants row. Irrigation water was filtered through gravel filters and refiltered through screen filters.

Multigerm seeds of sugar beet (Rao poly cv.) were sown by hand in hills on 15th August 2009 and 19th August 2010, at row spacing of 60 cm and in- row spacing of 25 cm. Plants were thinned to one plant per hill after 40 days from sowing (at 4-6 leaves stage). Fertilizers were added according to the technical recommendation of the Egyptian Ministry of Agriculture at rates of 90 kg N, 15 kg P_2O_5 and 100 kg k_2sO_4 fed.$^{-1}$, (1 feddan = 0.42 hectar). Phosphorus fertilizer was broadcast at seedbed preparation in the form of calcium super phosphate (15.5% P_2O_5). Nitrogen fertilizer in the form of ammonium nitrate (33.5% N) was added in two equal doses before the first irrigation (after thinning) and before the second irrigation. Potassium fertilizer was applied by topdressing in one application of potassium sulphate (48% k_2O) before the first irrigation. All agricultural practices for sugar beet were done as recommended by the Egyptian Ministry of Agricultural and Land Reclamation, except the factors under study. The harvesting date was February 25th and 28th (after 190 days from sowing) for two growing seasons.

-Crop and water parameters:

-Irrigation water applied (IWA):

The amount of irrigation water applied for drip irrigation system at each irrigation was measured by flowmeter and calculated according to Keller and Karmeli (1974) as follows:

$$IWA = \frac{ETo \,.\, Kc \,.\, Kr . II}{Ea} + LR$$

Where:

IWA = Irrigation water applied, mm.

ETo = Reference evapotranspiration, $mm.day^{-1}$.

Kc = Crop coefficient, dimensiondess.

Kr = Reduction factor (Keller and Karmeli, 1974).

II = Irrigation intervals, days.

Ea = Irrigation efficiency, % = K_1 x K_2 = 0.80.

K_1 = Emitter uniformity coefficient = 0.90.

K_2 = Drip irrigation efficiency coefficient = 0.90.

LR = Leaching requirements (10% of Etc).

Reference evapotranspiration (ETo) were estimated using penman-Monteith, as calculated by Allen *et al.* (1998).

-Water Consumptive Use (CU):

Soil moisture content was determined before and after each irrigation to calculate water consumptive use according to the following equation (Hansen *et al.*, 1979).

$$SMD = Cu = \sum_{i=1}^{1=4} D_1 \text{ x } D_{b1} \text{ x } \frac{PW_2 - PW_1}{100}$$

Where:

SMD = Soil moisture depletion in the effective root zone, cm.

CU = Water consumptive use, cm.

D_1 = Soil layer depth, cm (root depth).

D_{b1} = Soil bulk density for this depth.

PW_1 = Soil moisture percentage before irrigation (%, d.b.).

PW_1 = Soil moisture percentage, 48 hours after irrigation ((%, d.b.).

I = Number of soil layers each (15 cm) depth.

-Water productivity (WP):

Water productivity was calculated according to Ali *et al.*, (2007) as follows:

$$WP = GY/ET$$

Where:

Gy = Root yield, kg fed.$^{-1}$.

ET = Total water consumptive use of the growing season, m^3 fed.$^{-1}$.

-Productivity of irrigation water (PIW)

Productivity of irrigation water was calculated according to (Ali *et al.*, 2007).

$$PIW = GY/IW$$

Where:

Gy = Root yield, kg fed.$^{-1}$.

IW =Irrigation water applied, m^3 fed.$^{-1}$.

-Crop parameters:

-Root length and diameter.

At harvest time, (190 days after sowing) random sample of ten plants, were chosen from each plot to determine some plant parameters of sugar beet growth (i.e. root diameter and root length (cm), as well as, root weight (Kg). Also, some characters of sugar beet roots quality have been measured and calculated such as sucrose (%) and the purity (%) were measured at Delta sugar Company Limited Laboratories at El-Hammol, Kafr El-Sheikh Governorate.

-Yield and its components of sugar beet:

The root yield (ton.fed.$^{-1}$), sucrose percentage and juice purity (%) were determined for sugar beet from the three central furrows of the plots by the Delta sugar Company Limited Laboratories at Kafr El-Sheikh Governorate.

The gross sugar content was calculated as follows:

Gross sugar = sucrose percentage × root yield (ton fed.$^{-1}$).

-Plant analysis:

Samples of sugar beet roots were taken to determine their composition before harvesting. The root samples were dried at 70^{o} C for 24 hours, ground and then wet digested by sulfuric and perchloric acids according to the method described by Chapman and Pratt (1961). Sucrose percentage and root juice purity were determined in fresh root at harvesting by an automatic sugar polarimeter as described by Mc Ginnus (1971).

-Statistical analysis:

The obtained data were statistically analyzed by analysis of variance. The data of the two seasons showed nearly the same trend, Thus, combined analysis was done according to Gomez and Gomez (1984) .Means of the treatment were compared by the least significant difference (LSD) at 5% level of significance which developed by Waller and Duncan (1969).

RESULTS AND DISCUSSION

1-Sugar beet yield and quality:

a- Root and sugar yield:

Data in Table 3 show that root and sugar yields of sugar beet were significantly affected by type of emitter and irrigation regimes during two growing seasons of 2009/2010 and 2010/2011. The Turbo emitter (long–path) achieved the highest average values of root yield (25.93and 26.26 ton fed.$^{-1}$) and sugar yield (5.39 and 5.44 ton fed.$^{-1}$), while, the lowest average values of root yield (22.55 and 22.90 ton fed.$^{-1}$) and sugar yield (3.86 and 3.90 ton fed.$^{-1}$) had been obtained with the Metalic emitter (simple-orifice) in the 1st and 2nd growing seasons, respectively.

Data also indicate that there are significant differences between irrigation regimes treatments in root and sugar yield for two growing seasons. The treatments which were irrigated 20 minutes every two days recorded the maximum average values of root yield (26.16 and 26.51 ton fed.$^{-1}$) and sugar yield (5.0 and 5.05 ton fed^{-1}) of 2009/2010 and 2010/2011 growing seasons, respectively. Meanwhile, the treatments which were irrigated 30 minutes every three days gave the minimum average values of root yield (22.82 and 23.22 ton fed.$^{-1}$) and sugar yield (4.46 and 4.52 ton fed.$^{-1}$) in the two growing seasons, respectively. However, the root yield increased by (7.83 and 7.81 %) and sugar yield increased by (10.6 and 10.5%) as a result of irrigation 20 minutes every two days instead of irrigation 10 minutes daily in the 1st and the 2nd season, respectively. Interaction between type of drippers and irrigation intervals had a highly significant effect on the root and sugar yield.

Table 3: Mean values of sugar beet yield, gross sugar yield and sucrose percentage as affected by drip irrigation system and irrigation regimes during 2009/2010 and 2010/2011 seasons.

Type of drippers	Irrigation regimes, min.	Sugar beet yield , ton fed^{-1}		Gross sugar, ton fed^{-1}		Sucrose, %	
		2009/ 2010	2010/ 2011	2009/ 2010	2010/ 2011	2009/ 2010	2010/ 2011
Biult-in	10 daily	24.68	24.90	4.63	4.66	18.75	18.70
	20/ 2 days	26.35	26.80	5.05	5.12	19.15	19.10
	30/ 3 days	23.25	23.78	4.54	4.62	19.52	19.44
Simple-orifice	10 daily	22.49	22.90	3.73	3.78	16.60	16.50
	20/ 2 days	24.37	24.72	4.15	4.18	17.02	16.92
	30/ 3 days	20.79	21.08	3.70	3.73	17.80	17.70
Long-path	10 daily	25.60	25.98	5.20	5.26	20.31	20.24
	20/ 2 days	27.76	28.00	5.81	5.85	20.92	20.89
	30/ 3 days	24.43	24.80	5.15	5.21	21.08	21.00
L.S.D at 0.05		**0.079**	**0.203**	**0.019**	**0.058**	**0.030**	**0.088**
Mean of drippers types	Biult-in	24.76	25.16	4.74	4.80	19.14	19.08
	Simple- orifice	22.55	22.90	3.86	3.90	17.14	17.04
	Long-path	25.93	26.26	5.39	5.44	20.77	20.71
L.S.D at 0.05		**0.114**	**0.063**	**0.031**	**0.025**	**0.066**	**0.075**
Mean of irrigation regimes	10 daily	24.26	24.59	4.52	4.57	18.55	18.48
	20/ 2 days	26.16	26.51	5.00	5.05	19.03	18.97
	30/ 3 days	22.82	23.22	4.46	4.52	19.60	19.38
L.S.D at 0.05		**0.170**	**0.200**	**0.046**	**0.060**	**0.096**	**0.121**

The results also indicate that the highest average values of root yield (27.76 and 28.0 ton fed^{-1}) and sugar yield (5.81 and 5.85 ton fed^{-1}) were obtained with the Turbo emitter (long–path) and irrigation 20 minutes every two days in the 1st and 2nd seasons, respectively, while, the lowest average values of root yield (20.79 and 21.08 ton fed.$^{-1}$) and sugar yield

(3.70 and 3.73 ton fed^{-1}) had been obtained with the Metalic emitter (simple-orifice) and irrigation 30 minutes every three days in the 1st and 2nd growing seasons, respectively.

Increasing in sugar beet yield may be due to increasing the available soil moisture and supplying sugar beet plants with more nutrients which in turn produced high vegetative growth as well as carbohydrates translocation process from the vegetative growth to roots and this increase sugar beet yield. These results agreed with those obtained by Isoda *el al.* (2007) Abo-Shady *et al.* (2010), El-Nemr (2010), Hassanli *et al.* (2010) and Baigy *et al.* (2012).

b- Sucrose percentage:

Data presented in Table 3 indicate that sucrose percentage significantly influenced type of emitter and irrigation intervals during growing seasons of 2009/2010 and 2010/2011. The highest average values of sucrose percentage (20.77 and 20.71 %) were recorded with the Turbo emitter (long-path) during 2009/2010 and 2010/2011 growing seasons, respectively. While, the lowest average values of sucrose percentage (17.14 and 17.04%) were obtained with the Metalic emitter (simple-orifice) for the same seasons.

On the other hand, the treatments which were irrigated 30 minutes every three days attained the maximum average values (19.60 and 19.38 %) of sucrose percentage compared with the other treatments for two growing seasons. These obtained results were in good agreement with those of Ibrahim *et al.* (2002), Rytter (2005), Ghadami Firouz Abadi and Mirzaei (2006), Isoda *et al.* (2007) and Hassanli *et al.* (2010).

c- Root length and diameter:

Data of sugar beet length and diameter, which significantly affected by type of emitter and irrigation intervals for growing seasons 2009/2010 and 2010/2011, are presented in Table 4.

The maximum average values of root length (34.54 and 34.20 cm) and root diameter (14.43 and 14.29 cm) were realized with the Turbo emitter (long-path) for 2009/2010 and 2010/2011 growing seasons, respectively. Whereas, the minimum average values of root length (31.36 and 31.10 cm) and root diameter (12.64 and 12.48 cm) were fulfilled with the Metalic emitter (simple-orifice) for two growing seasons, respectively.

Data also manifest that irrigating sugar beet crop 30 minutes every three days gave the highest average values of root length (35.0 and 34.58 cm) and the minimum average values of root diameter (12.29 and 12.06 cm) compared with the other irrigation regimes. However, the irrigation regime 10 minutes daily accomplished the minimum average values of root length (31.41 and 31.12 cm) and maximum average values of root diameter (14.19 and 14.03 cm) for two growing seasons, respectively. In case of irrigation through short regimes, the water is still available in the upper layers of the soil consequently, the plant roots do not grow vertically but the root diameter becomes more. On the century, in case of increasing irrigation regimes the root length increases to get the water requirements for plants from deeper layers but the root diameter is less.

In the present study indicated that, proportionately; higher root length and lower root diameter might be possible by the application of relatively low amounts of irrigation water. Similar observations were reported by El-Maghraby *et al.* (2008), Abo-Shady *et al.* (2010) and Baigy *et al.* (2012).

Table (4): Mean values of root length and root diameter as affected by drip irrigation systems and irrigation regimes in 2009/2010 and 2010/2011 seasons.

Type of drippers	Irrigation regimes, minute.	Root length, cm		Root diameter, cm	
		2009/ 2010	2010/ 2011	2009/ 2010	2010/ 2011
Biult-in	10 daily	31.82	31.62	14.10	13.92
	20/ 2 days	33.92	33.57	13.92	13.86
	30/ 3 days	35.60	35.10	12.00	11.76
Simple-orifice	10 daily	29.80	29.50	13.16	13.02
	20/ 2 days	31.46	31.30	12.90	12.80
	30/ 3 days	32.82	32.50	11.86	11.62
Long-path	10 daily	32.62	32.25	15.30	15.16
	20/ 2 days	34.43	34.20	14.98	14.90
	30/ 3 days	36.57	36.15	13.01	12.81
L.S.D at 0.05		0.240	0.265	0.109	0.065
Mean of drippers types	Biult-in	33.78	33.43	13.34	13.18
	Simple- orifice	31.36	31.10	12.64	12.48
	Long-path	34.54	34.20	14.43	14.29
L.S.D at 0.05		0.126	0.116	0.065	0.070
Mean of irrigation regimes	10 daily	31.41	31.12	14.19	14.03
	20/ 2 days	33.27	33.02	13.93	13.85
	30/ 3 days	35.00	34.58	12.29	12.06
L.S.D at 0.05		0.263	0.275	0.126	0.110

2- Water relations:

a- Irrigation Water Applied (IWA):

Amounts of irrigation water applied (m^3 fed.$^{-1}$) and water consumptive use (m^3 fed^{-1}) as affected by type of emitter and irrigation regimes during 2009/2010 and 2010/2011 seasons were presented in Table **5**. The average total amounts of irrigation water applied were 1820, 1795 and 1692 m^3 fed.$^{-1}$ with built-in, Metallic (simple- orifice) and Turbo (long-path) emitters, respectively in 2009/2010 growing season, whereas, it were 1836, 1810 and 1714 m^3 fed.$^{-1}$ in 2010/2011 season for the same irrigation system. It can be concluded that the lowest values of irrigation water were applied with the Turbo (long-path) emitter but, the highest average amounts of irrigation water were applied with the built-in emitter for two growing seasons.

b- Water consumptive use "CU" in m^3 fed.$^{-1}$:

Average values of water consumptive use of sugar beet in 2009/2010 and 2010/2011 growing seasons were significantly affected by type of emitter and irrigation intervals as show in Table **5**.

It is clear that the minimum average values of CU (1384 and 1394 m^3 fed.$^{-1}$) were obtained with the Turbo emitter while, the maximum average values of CU (1584 and 1596 m^3 fed.$^{-1}$) were recorded with the built-in emitter in the two growing seasons, respectively. On the other hand, the obtained average values of CU were 1518, 1498 and 1488 m^3 fed.$^{-1}$ in the 1st season but, it were 1529, 1510 and 1502 m^3 fed.$^{-1}$ in the 2nd season at using irrigation regimes 10 minutes daily, 20 and 30 minutes every two and three days, respectively.

Results reveal that water consumptive use increased with decreased intervals of irrigation, these obtained results were in good agreement with those of Rinaldi and Vonella (2006), Isoda (2007) and Hassanli et al. (2010).

Table (**5**): Water applied and water consumptive use as affected by drip irrigation systems and irrigation regimes during 2009/2010 and 2010/2011 seasons.

Type of drippers	**Irrigation regimes, minute.**	**Water applied, m^3 fed^{-1}**	**Precipitation m^3 fed^{-1}**	**Total Water applied, m^3 fed^{-1}**	**Water applied, m^3 fed^{-1}**	**Precipitation m^3 fed^{-1}**	**Total Water applied, m^3 fed^{-1}**	**Water consumptive use, m^3 fed^{-1}**	
		2009 / *2010*			**2010 / 2011**			**2009 / 2010**	**2010 / 2011**
Biult-in	**10 daily**	1690	130	1820	1726	110	1836	1605	1616
	20/ 2 days	1690	130	1820	1726	110	1836	1591	1605
	30/ 3 days	1690	130	1820	1726	110	1836	1556	1568
Simple-orifice	**10 daily**	1665	130	1795	1700	110	1810	1537	1550
	20/ 2 days	1665	130	1795	1700	110	1810	1521	1534
	30/ 3 days	1665	130	1795	1700	110	1810	1551	1568
Long-path	**10 daily**	1262	130	1692	1604	110	1714	1412	1420
	20/ 2 days	1262	130	1692	1604	110	1714	1382	1392
	30/ 3 days	1262	130	1692	1604	110	1714	1357	1370
L.S.D at 0.05			-	-	-	-	-	12.23	2.48
Mean of drippers types	**Biult-in**	1690	130	1820	1726	110	1836	1584	1596
	Simple-orifice	1665	130	1795	1700	110	1810	1536	1551
	Long-path	1262	130	1692	1604	110	1714	1384	1394
L.S.D at 0.05			-	-	-	-	-	8.06	4.41
Mean of irrigation regimes	**10 daily**	1639	130	1769	1677	110	1787	1518	1529
	20/ 2 days	1639	130	1769	1677	110	1787	1498	1510
	30/ 3 days	1639	130	1769	1677	110	1787	1488	1502
L.S.D at 0.05			-	-	-	-	-	14.80	6.47

c- Water productivity (WP):

Water productivity (WP) expressed in kg of roots m^{-3} of water consumed and productivity of irrigation water (PIW) in kg of roots m^{-3} of irrigation water applied in two growing seasons are presented in Table 6.

Water productivity determines the capacity of the plants to convert the consumed water to stop yield. The WP and PIW of sugar beet could be evaluated by both root and sugar yields. The obtained results show that the Turbo emitter (long –path) gave the highest average values of WP (18.74 and 18.84 kg root m^{-3} water consumed) while, the lowest average of WP (15.33 and 15.32 kg root m^{-3} water consumed) were recorded with the Metalic emitter (simple-orifice) during 2009/2010 and 2010/2011 growing seasons, respectively. The WP values increased by 19.9 and 27.7 % when the Turbo emitter (long–path) was used instead of the built-in emitters and Metalic (simple-orifice) emitters, respectively during the 1st season.

The results also indicated that the obtained average values of WP were 16.05, 17.56 and 15.69 kg root m^{-3} water consumed with irrigation intervals of 10, 20 and 30 minutes daily, every two and three days, respectively in the1st season. Similar observations were reported by Rytter (2005) and Baigy *et al.* (2012).

d- Productivity of irrigation water (PIW):

Results presented in Table 6 indicate that the highest average values of PIW 15.33 and 15.32 kg root m^{-3} of irrigation water applied were obtained with using the Turbo emitter (long –path) in the 1st and 2nd growing seasons, respectively. While, the lowest ones, 12.56 and 12.65 kg root m^{-3} of irrigation water applied were attained from irrigated by using the Metalic emitter (simple-orifice) during the 1st and the 2nd seasons, respectively. These results could be attributed to the significant differences among sugar beet yield, evapotranspiration and water applied values.

Concerning the effect of irrigation interval on the PIW, as shown in Table 6, results reveal that irrigating sugar beet crop 20 minutes every two days accomplished the maximum average values of PIW (14.82 and 14.87 kg root m^{-3} of irrigation water applied), whereas the minimum average values of PIW (12.93 and 13.02 kg root m^{-3} of irrigation water applied) in the two growing seasons were obtained with irrigation interval of 30 minutes every three days.

Table (6): Water productivity (WP) and productivity of irrigation water (PIW) as affected by drip irrigation systems and irrigation regimes during 2009/2010 and 2010/2011 seasons.

Type of drippers	Irrigation regimes, minute.	WP, Kg root. m^{-3}		PIW, Kg root. m^{-3}	
		2009/ 2010	2010/ 2011	2009/ 2010	2010/ 2011
Biult-in	**10 daily**	15.38	15.41	13.56	13.56
	20/ 2 days	16.56	16.70	14.48	14.60
	30/ 3 days	14.94	15.17	12.77	12.95
Simple-orifice	**10 daily**	14.63	14.77	12.53	12.65
	20/ 2 days	16.02	16.11	13.58	13.66
	30/ 3 days	13.40	13.44	11.58	11.65
Long-path	**10 daily**	18.13	18.30	15.13	15.16
	20/ 2 days	20.09	20.11	16.41	16.34
	30/ 3 days	18.00	18.10	14.44	14.47
L.S.D at 0.05		0.123	0.085	0.056	0.079
Mean of drippers types	**Biult-in**	15.63	15.76	13.60	13.70
	Simple- orifice	14.68	14.77	12.56	12.65
	Long-path	18.74	18.84	15.33	15.32
L.S.D at 0.05		0.079	0.059	0.056	0.033
Mean of irrigation regimes	**10 daily**	16.05	16.16	13.74	13.79
	20/ 2 days	17.56	17.64	14.82	14.87
	30/ 3 days	15.69	15.57	12.93	13.02
L.S.D at 0.05		0.147	0.105	0.089	0.081

CONCLUSION

It could be recommended to have highest and quality yield of sugar beet and sugar yield we must irrigate sugar beet crop 20 minutes every two days by using the drip irrigation with the Turbo emitter (long –path) in the soil at North Nile Delta.

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الملخص العربي

تأثير إدارة الري بالتنقيط على إنتاجية محصول بنجر السكر وبعض العلاقات المائية في شمال دلتا النيل

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أجريت تجربتان حقليتان بالمزرعة البحثية بكلية الزراعة بكفر الشيخ - جامعة كفر الشيخ خلال الموسمين الزراعيين ٢٠٠٩ / ٢٠١٠ و ٢٠١٠ / ٢٠١١ لدراسة تأثير إدارة نظام الري بالتنقيط على إنتاجية محصول بنجر السكر ومكوناته وبعض العلاقات المائية في الأراضي الطينية بشمال دلتا النيل، وقد صممت التجربة بنظام القطع المنشقة مرة واحدة في أربع مكررات حيث مثلت القطع الرئيسية ثلاثة أنواع من النقاطات وهي (Simple –orifice، long –path و Built-in) ، بينما شغلت القطع المنشقة فترات الري ممثلة في (الري لمدة ١٠ دقيقة يومياً - الري لمدة ٢٠ دقيقة كل يومين– والري لمدة ٣٠ دقيقة كل ثلاثة أيام) ، وكانت أهم نتائج الدراسة كما يلي:-

١- أوضحت النتائج أن معاملة الري بالتنقيط ذي النقاطات long –path حققت أعلي قيمة متوسطة لكل من طول الجذر(٣٤,٥٤ و٣٤,٢٠ سم) ، قطر الجذر(١٤,٤٣ ، ١٤,٢٩سم) ، نسبة السكر(٢٠,٧٧ و ٢٠,٧١ %)، وزن الجذور (٢٥,٩٣و ٢٦,٢٦ طن للفدان) ، إنتاج السكر (٥,٣٩ و٥,٤٤ طن للفدان)، كفاءة الاستهلاك المائي بواسطة نباتات بنجر السكر (١٨,٧٤ و ١٨,٨٤ كجم جذور لكل متر مكعب ماء مستهلك) وكذلك الكفاءة الإنتاجية لمياه الري المضافة (١٥,٣٣ و١٥,٣٢ كجم جذور لكل متر مكعب ماء مضاف) خلال موسمي الزراعة٢٠٠٩/٢٠١٠ و ٢٠١٠/٢٠١١ على التوالي .

٢- حققت معاملة الري لمدة ٢٠ دقيقة كل يومين أعلى قيمة لمتوسط إنتاج الجذور (٢٦,١٦ و ٢٦,٥١ طن للفدان) وإنتاج السكر (٥,٠ و ٥,٠٥ طن للفدان) وكفاءة الماء المستهلك (١٧,٥٦ و ١٧,٦٤كجم جذور لكل متر مكعب ماء مستهلك) والكفاءة الإنتاجية لمياه الري المضافة (١٤,٨٢ و١٤,٨٧كجم جذور لكل متر مكعب ماء مضاف) وذلك خلال موسم الزراعة ٢٠٠٩/٢٠١٠ و٢٠١٠/٢٠١١ على التوالي.

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٣- أشارت النتائج إلى أن أقل القيم من ماء الري المضاف (١٦٩٢ و ١٧١٤ م^{٣} للفدان) تم تسجيلها باستخدام الري بالتنقيط ذي النقاطات long–path خلال موسمي النمو ٢٠١٠/٢٠٠٩ و ٢٠١١/٢٠١٠، على التوالي ، بينما كانت أعلى القيم للماء المضاف (١٨٢٠ و ١٨٣٦ م^{٣} للفدان) تم تسجيلها باستخدام الري بالتنقيط ذي النقاطات biult-in خلال نفس موسمي النمو.

٤- أوضحت النتائج أن التفاعل بين أنواع النقاطات والفترة بين الريات أعطي أعلى القيم لمحصول بنجر السكر (٢٧,٧٦ و ٢٨,٠ طن/ فدان) ، وإنتاج السكر (٥,٨١ و٥,٨٥ طن للفدان) نتجت من الري لمدة ٢٠ دقيقة كل يومين بنقاطات من نوع long–path، بينما كان أقل محصول لبنجر السكر (٢٠,٧٩ و٢١,٠٨ طن للفدان) ، وإنتاج السكر (٣,٧٠ و٣,٧٣ طن للفدان) نتجت من الري لمدة ١٠ دقائق يومياً بنقاطات من نوع Simple–orifice.

- توصى الدراسة بري محصول بنجر السكر لمدة ٢٠ دقيقة مرة واحدة كل يومين باستخدام نقاطات من النوع long–path في الأراضي الطينية بشمال دلتا النيل للحصول على أعلى إنتاجية من محصول بنجر السكر والسكر.