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MAXIMIZING WATER USE OF SUGAR BEET UNDER IRRIGATION SYSTEMS

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ABSTRACT

Field experiments were conducted in an area of 1.50 fed during 2009-2010 the season at Experimental Farm of the Faculty of Agriculture, Zagazig University, Sharkia Governorate, at Khattara region under sandy soil conditions to study the effect of irrigation systems (surface trickle and subsurface leaky pipes) ; irrigation water applied (100%, 75% and 50% of IRa) ; materials reducing water losses (polymers, anti-transpiration and no materials) and soil mulching (black plastic, transparent plastic and bare soil) on weed control, sugar beet production and quality, saving water, water use efficiency, production cost per yield and net profit under Egyptian conditions.

The results obtained can be summarized as follows:

The highest values of total actual irrigation water requirements (2355 m^3/fed) and weed control (350 kg/m^2) were found under trickle irrigation, no materials, bare soil and 100% of IRa. The highest sucrose percentage value was found by using subsurface irrigation. The highest root and sugar yield values of 23.36 and 4.4 Mg/fed were found by using subsurface irrigation, 100% of IRa, polymers and black plastic mulch. The highest water use efficiency values was 13.58 kg/m^3 for root yield and 2.64 kg/m^3 for sugar yield respectively, were remarked under 75% of IRa, subsurface irrigation, polymers and black plastic mulch. The highest net profit and the lowest production cost per yield values were 6977 LE/fed and 48.5 LE/Mg by using subsurface irrigation, 100% of IRa, polymers and black plastic mulch.

Keywords: irrigation systems, sugar beet, irrigation water applied, materials reducing water losses, saving water and net profit.

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INTRODUCTION

One of the major problems in new land is the shortage of water supply. Water management is very important to improve production and save water resources. Irrigation is considered one of the most important factors that play the greatest role in increasing sugar beet production. Mulching may be a suitable method for decreasing soil moisture losses and weed control prevents leaching of nutrients and decreases the fluctuation between day and night temperatures. Sugar beet has been considered one of the major winter field crops in Egypt, especially that it can be grown under a wide variety of soil and climatic conditions **(Abou-Shieshaa 2001). Albinet (1986)** mentioned that mean annual water uptake of sugar beet was 6764 m^3/ha; 60% of that water was consumed during root growth and swelling phases. **Rafeet (1995)** found that the total tomato yield and water use efficiency were 9.9, 11.4 and 9.6 ton/fed and 6.0, 6.95 and 5.85 kg/m^3 in non-plastic mulch, black plastic mulch and transparent plastic mulch respectively. **Abd El-Wahab *et al.* (1996)** found that the highest value of consumptive use (58.03 cm) was recorded when plants were irrigated by I_1 (3503.63 m^3/fed), while the lowest one (46.29 cm) was recorded with using I_3 (2453.63 m^3/fed). WUE values were 16.44, 13.92 and 13.81 kg/m^3 for root yield and 3.25, 2.81 and 2.9 kg/m^3 for sugar yield using treatments of I_1, I_2 (2978.63 m^3/fed) and I_3 respectively. **Emara (1996)** stated that the maximum irrigation water treatment of 2500 m^3/fed not including sowing irrigation resulted in the highest root (36.95 ton/fed) and sugar yield (6.44 ton/fed), while the highest values of root length and purity percentage were obtained as a result of applying the lowest amount (1500 m^3/fed). **Selim *et al.* (1996)** found that the black plastic mulch gave the best weed control (97.5 and 98.9%) following by transparent plastic (92 and 97.6%) then yellow color (84 and 93.2%) in both seasons. **El-Mansi *et al.* (2000)** found that the black plastic mulch increased total yield by 32% and the transparent plastic mulch by 19.7% over the bare soil. **Shams El-Din (2000)** found that amounts of water applied at 60 cm depth were 3414, 3632 and 3322 m^3/fed and water consumptive use were 2592, 2669 and 2486 m^3/fed for W_1, W_2 and W_3 respectively. He added that W_1 achieved the highest values of sugar beet yield (20.17 ton/fed) followed by treatment W_3, while treatment W_2 recorded the lowest value (18.52 ton/fed). **Sakellariou-Makrantonaki** ***et al.*** **(2002)** found that the subsurface trickle irrigation lead to greater yield and higher sugar content making significant saving water compared to surface trickle irrigation. **El-Gendy** ***et al.*** **(2007)** found that at 75% ETc treatment saved about 25% from applied water in the first treatment. Water use efficiency was the highest in 50% ETc, but economically, 75% ETc was the best one. **Hassanli** ***et al.*** **(2009)** indicated that the average water applied in the irrigation with subsurface trickle was much less than that using surface trickle. The maximum saving water, highest yield and maximum irrigation water use efficiency were obtained using subsurface trickle with 5907 m^3/ha water applied, 12.11 ton/ha and 2.12 kg/m^3 respectively. **Hassanli and Beecham (2010)** checked on subsurface and surface trickle irrigation and showed that the highest root yield (79.7 Mg/ha), the highest IWUE in root and sugar yield production (9 and 1.26 kg/m^3) were obtained using surface trickle irrigation. **Topak** ***et al.*** **(2011)** found that with trickle irrigation method at 75% level had significant benefits in terms of saved irrigation water and large WUE. WUE was the highest in 75% irrigation conditions and the lowest in full irrigation conditions (50 and 25%). In an economic viewpoint, 25% saving of irrigation water (75%) caused 6.1% reduction in the net income.

The objectives of this research were to determine the effect of irrigation systems, irrigation water applied, materials reducing water looses and soil mulching on weed control, sugar beet production and quality, saving water, water use efficiency, production cost per yield and net profit.

MATERIASLS AND METHODS

Field experiments were conducted in an area of 1.50 feddan during the 2009-2010 season at the Experimental Farm of the Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt, at Khattara region under sandy soil conditions. Conventional analyses of the soil sample and irrigation water used were preformed and the results are tabulated in Tables (1, 2 and 3).

Table (1): Physical characteristics of the experimental soil.

Soil layer (cm)	Particle size distribution %			Texture class	Bulk density (g/cm^3)	Field capacity (%)	Wilting point (%)	Available water (%)
	Sand	Silt	Clay					
0 –20	89.1	8.8	2.1	Sandy	1.65	13.25	5.5	7.75
20-40	87.8	10.0	2.2		1.56	14.25	4.9	9.35
40-60	87.3	10.1	2.6		1.44	14.50	4.3	10.20

Table (2): Chemical characteristics of the experimental soil.

Soil layer (cm)	SAR	PH	EC ds/m	Soluble anions (meq /l)				Soluble cations (meq /l)			
				CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
0 –20	1.66	8.7	1.4	0.1	0.93	1.98	9.61	6.23	2.24	3.44	0.51
20-40	1.74	8.5	1.3	0.1	1.15	2.05	9.85	6.45	2.26	3.76	0.58
40-60	1.84	8.3	1.2	0.1	1.33	2.11	10.16	6.65	2.29	3.91	0.65

Table (3): Chemical characteristics of irrigation water.

SAR Meq/L	RSC	ESP	Ca/Na %	PH	EC (ds/m)	Soluble anions (meq / l)				Soluble cations (meq / l)			
						CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
12.1	0.2	78.1	9.8	7.14	1.18	0.1	4.7	10.6	8.15	1.8	2.8	18.4	0.55

Irrigation systems

The irrigation systems (surface trickle and subsurface leaky pipes) contains the following general components: control head : centrifugal pump (electrical centrifugal pump is used with 60 hp and a discharge 100 m^3/h at 4 bar pressure head with 6/6 inch inlet outlet diameter), nonreturn valve, valve, air release valve, pressure gauges, sand filters with 200 mesh and fertilizer venturi, main and submain lines (110 and 90 mm diameter PVC), manifold pipes made of PVC with 75 and 63 mm diameters and lateral line:

- Trickle-lines GR that are connected with the manifold pipes. They are made of polyethylene pipes with 16 mm diameters, 25 m long, 25 cm emitter distance and 4 lit/h emitter discharge for trickle irrigation.
- Lateral leaky pipes with pipe porous flexible rubber hose 16 mm diameter with flow rate of 4 lph/m. Lateral leaky pipes were installed 15 cm deep under the soil surface, 0.6 m spaced from each other and 25 m long.

The experiment included 54 treatments with the following treatments:

1. Two irrigation systems (surface trickle and subsurface leaky pipes).

2. Irrigation water applied (100%, 75% and 50% of IRa) "actual irrigation water requirements".
3. Materials reducing water losses (polymers, anti-transpiration and no materials).
4. Soil mulching types (black plastic (B P), transparent plastic (T P) and bare soil (B S) control).

The experimental design

The experimental design used was split-split plot, where the irrigation system was considered as the main treatment plot. The irrigation water applied was assigned as subplots. The materials reducing water losses (polymers, anti-transpiration and soil mulching) were taken as the sub-subplots. The total area of each subplot was 90 m^2 divided into six rows (3.6 m width) with 25 m long and three replicates. Materials reducing water losses: Super absorbent polymers (AQUA KEEP), anti-transpiration and soil mulching.

During soil preparation the land was plowed using chisel plow. All experimental units received equal amounts of organic manure (20 m^3/fed) and calcium super phosphate (15.5% P_2O_5) at a rate of 200 kg/fed as mixed with the soil before plowing. Nitrate (33.5 %N) was added at a rate of 400 kg/fed divided on 5 times. Potassium fertilizer of potassium sulphate (48.5% K_2O) at rate of 50 kg/fed was added on 2 times. Sugar beet *Beta vilgarus* (Carola) as planted manually on 20 Oct. 2009 at 0.25 m planting space and 0.6 m between rows with two seeds per hill. It is worthy to mention that irrigation treatments took place after the thinning stage. The harvesting was carried at 15th of April 2010.

Measurements and calculations:

1. **Water distribution and application**

   a- Soil moisture distribution

Soil moisture was determined vertically and horizontally before and after irrigation. Samples were collected vertically at different depths 0-10, 10-20, 20-30 and 30-40 cm from the soil surface under all treatments and were taken from lateral pipes in horizontal directions, in both sides (right and left) from the lateral center (water source) at different distances of 0-10, 10-20, 20-30, and 30-40 cm. Golden software (Surfer 8.0) was used to create the moisture distribution curves.

b- Actual irrigation water requirements.

The actual irrigation water requirements under each irrigation system was calculated according to **James (1988)** as following equation:

$$IRa = \frac{[(\theta_{FC} - \theta_v) \times d] + Lf}{Es} \quad \text{-------}\rightarrow 1$$

Where:

IRa : Actual irrigation water requirements (mm/intervals)

?v : Soil moisture content (%) under soil condition.

D : Depth of soil layer (20 cm for the initial stage and 40 cm for the last stage).

Es : System efficiency (%).

θ_{FC} : Volumetric soil moisture content (%)

Lf : Leaching factor calculated according to **Droonbos and Pruitt (1984)** using the following equation:

$$\text{Lf} = \frac{\text{ECw}}{\text{5ECe - ECw}} \quad \text{-------}\rightarrow 2$$

Where:

ECw : Salinity of the applied irrigation water (dS/m)

ECe : Average soil salinity tolerated by the crop as measured on a soil saturation extract (dS/m).

2. Weed control:

Weeds were collected from one square meter at random from each replicate every 30 days after sowing. The weed control rate was calculated using the following equation:

$$\text{Weed control rate} = \frac{\text{A - B}}{\text{A}} \times 100 \quad \text{-------}\rightarrow 3$$

Where:

A: Fresh mass of weeds in the control plot (kg/m^2).

B: Control mass of weeds in the different plot (kg/m^2).

3. Sugar beet yield and characteristics.

Root length (cm), root diameter (cm), sucrose percentage in the root (%), apparent purity (%), root and sugar yields (Mg/fed).

4. Water use efficiency (WUE).

WUE were calculated according to **Jensen (1983)** as follows:

$$WUE_{rootyield} = \frac{\text{Root yield(kg/fed)}}{\text{Actual applied irrigation water } (m^3/fed)}, kg/m^3 \text{ ------} \rightarrow 4$$

$$WUE_{sugaryield} = \frac{\text{Sugar yield(kg/fed)}}{\text{Actual applied irrigation water } (m^3/fed)}, kg/m^3 \text{ ------} \rightarrow 5$$

5. Saving water

Saving water technologies; know how to use less water for the plantation. The main idea is to use the minimum amount of water needed to plant.

6. Cost analysis

Cost analysis was carried out by using the current dealer price for equipment and installation according to 2011 price level and sugar beet production cost.

- Cost calculation:

The total production costs of sugar beet included irrigation system cost, fertilization cost, weed control cost, pest control cost and materials reducing water losses.

- Net profit:

The economical profit of sugar beet was calculated according to **(Younis *et al.*, 1991)** as follows:

$$P = (Yt \times d) - Ct \text{ ------} \rightarrow 6$$

Where:

P : net profit, (LE/fed), **Yt** : total yield (ton/fed),

d : yield price (LE/ton) and **Ct** : total production costs (LE/fed).

- **Production cost per yield:** was calculated by using the following formula:

$$\text{Cost of production unit} = \frac{\text{Total costs(LE/fed)}}{\text{Total yield (kg/fed)}} \text{ ------} \rightarrow 7$$

RESULTS AND DISCUSSION

1. Water distribution and application

a- Soil moisture distribution

Soil moisture distribution is shown in (Fig 1). The results showed that the redistribution process was nearly completed 24 hours after irrigation in all studied treatments. Subsurface irrigation treatments exhibited a moisture content ranging from 10.53 to 20, 10 to 27.3 and 21 to 30.1% by weight near the leaky pipe in the top 0-10, 10-20 and 20-30 cm soil layers at the 0 to 20 cm distances from the leaky pipe with 100% of IRa, respectively. Out of these layers it decreased gradually. The decrease was more pronounced in the deepest layer (30-40 cm) from the leaky pipe which revealed (6.5, 11.7 and 13.8%) by weight in the same order. The trickle irrigation treatments exhibited a moisture content ranging from about (12 to 21, 19 to 29 and 25 to 32%) by weight under the emitters in the top 0-10 and 10-20 and 20-30 cm layers at the 0 to 20 cm distances from them with 100% of IRa, respectively. Out of these layers it decreased gradually. The decrease was more pronounced in the deepest layer (30-40 cm) and first distance 25 cm from the emitters which revealed (8, 13 and 15%) by weight in the same order. From the previous discussion it could be concluded that the subsurface irrigation with 100% of IRa may give sufficient available water in the top layers (0-40 cm) where the plants consume most of their water demand, followed by surface trickling with the same conditions.

b- Actual irrigation water requirements

The data recorded in Fig (2) reveal that the highest value of IRa was found by using trickle irrigation, no materials, bare soil and 100% of IRa, while the lowest value was found with using subsurface irrigation, anti-transpiration and black plastic mulch under 50% of IRa. Concerning irrigation systems, the subsurface irrigation reduced the irrigation water applied by 5.1% compared with the trickle irrigation under 100% of IRa, bare soil and no materials. As for effect of materials, the data at anti-transpiration revealed that, the irrigation water applied decreased by 10.42 and 2,18% compared to no materials and polymers under trickle irrigation, 100% of IRa and black plastic mulch.

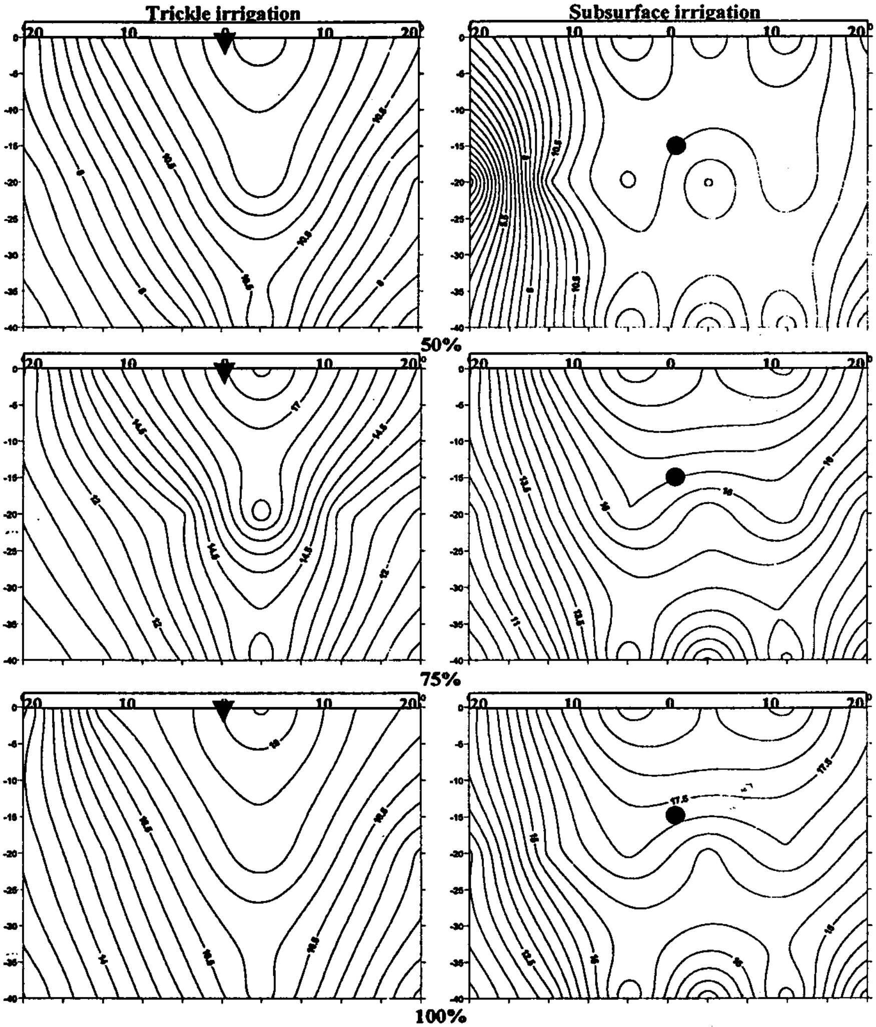

Fig. (1) The moisture distribution under different irrigation systems and irrigation water applied. (▼ emitters - ● leaky pipes)

Considering the irrigation water applied, the irrigation water applied at 50% of IRa with decreased by 49.78 and 34.09% compared with 100 and 75% of IRa under trickle irrigation, no materials and transparent plastic mulch. As for the effect of mulching, using black plastic reduced the IRa under all treatments. The bare soil increased the irrigation water applied by 2.05 and 5.67% compared with transparent and black plastic mulch under subsurface irrigation, 100% of IRa and no materials.

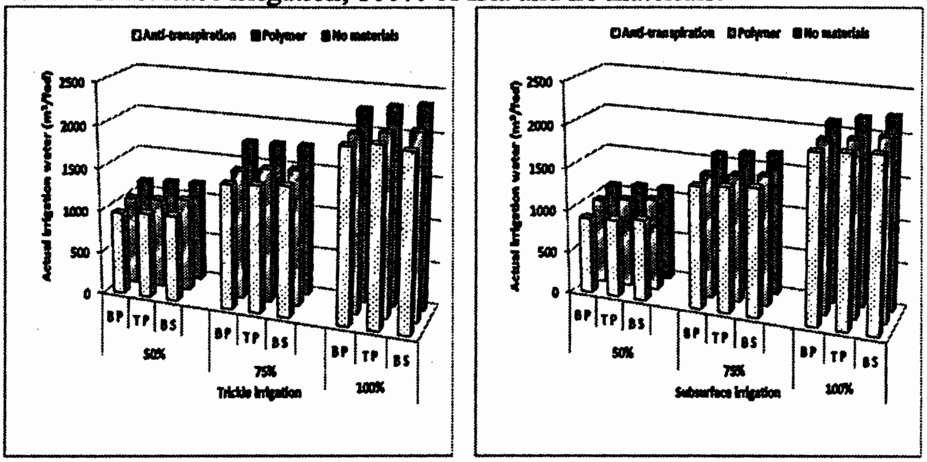

Fig. (2) The actual irrigation water requirements under different treatments.

2- Weed control.

Data in Fig. (3) show the effect of different treatments on weed control. Using the trickle irrigation caused increasing for weed control compared with subsurface irrigation. The highest weed control value was 350 kg/m^2 found by using trickle irrigation, 100% of IRa, no materials and bare soil. Applying irrigation water equal to 50% of IRa caused a reduction for weed control. The weed control increased by about 105.88 and 40 % when applying 100% of IRa compared with applying 75 and 100% of IRa under trickle irrigation, no materials and bare soil. Concerning the materials effect, no materials, the weed control increased by 25 and 50% compared with polymers and anti-transpiration under trickle irrigation, 100% of IRa and transparent plastic mulch. As for the mulching effect, black plastic decreased the weed control compared with bare soil and transparent plastic.

3- Sugar beet yield and characteristics.

a. Root length.

Data in Table (4) show that the tallest root was 29.9 cm by using trickle irrigation, 50% of IRa, no materials and bare soil, while the lowest value was 17.2 cm by using subsurface irrigation, 100% of IRa, anti-transpiration and black plastic mulch. The roots grow longer under water stress than with excessive water status (**Abd El-Wahab *et al.* 1996**).

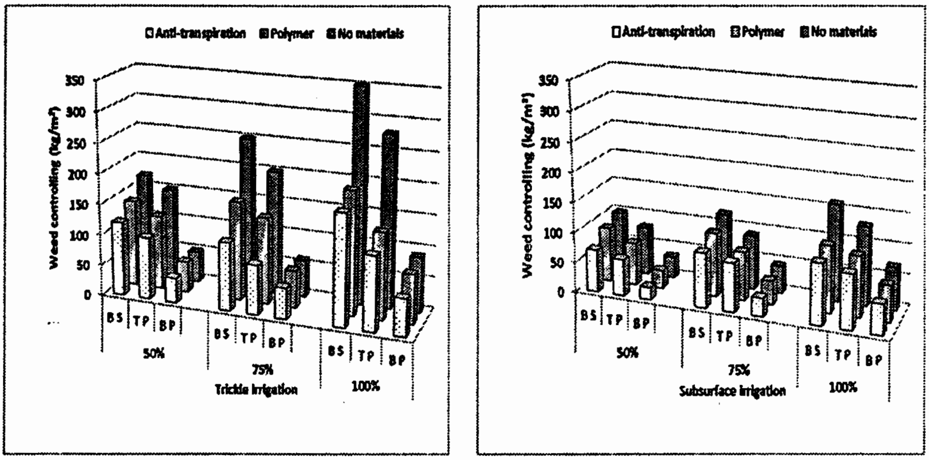

Fig. (3)The weed control under different treatments

At 50% of IRa, the root length decreased by 9.37 and 18.73% compared with 75 and 100% of IRa under trickle irrigation, no materials and bare soil. As for the effect of materials, the root length at polymers increased by 7.87% compared with anti-transpiration, while decreased by 9.8% compared with no materials under trickle irrigation, 50% of IRa and transparent plastic mulch. Concerning mulching, the black plastic mulch decreased the root length by 1.69 and 2.68 % compared with transparent plastic mulch and bare soil under trickle irrigation, 50% of IRa and no materials.

b.Root diameter.

Data in Table (4) shows that the highest root diameter value was found by using trickle irrigation; however subsurface irrigation had the lowest value. From data, highly decreasing in root diameter happened with the decreased the irrigation water applied. In this connection **Sorour (1995)** attributed the reduction in root diameter at low soil moisture level to decrease leaf area dry matter accumulation and root dimensions. Similar results were obtained by **Emara (1996)** and **Abd El-Wahab *et al.* (1996).** The obtained results indicated that the root diameter was practically increased by polymers compared with anti-transpiration and no materials. The obtained results indicated that the root diameter was practically increased by using black plastic mulch compared with bare soil and transparent plastic mulch.

c. Sucrose percentage.

Results in table (4) showed that the highest value of sucrose percentage was found with subsurface irrigation, while the lowest value was found by using trickle irrigation. Data show that applying 50% of IRa to reach the increased the sucrose percentage compared with applying 100 and 75% of IRa. These results are in agreement with **Abd El-Wahab *et al.* (1996).** Data reveal that using materials affect sucrose percentage by using anti-transpiration, the sucrose percentage increased compared with polymers and no materials. Results revealed that black plastic mulch decreased the sucrose percentage compared with bare soil and transparent plastic mulch.

d. Purity percentage.

Data in table (4) showed that by using trickle irrigation, the purity percentage increased compared with subsurface irrigation. As for the materials effect, using polymers increased the purity percentage compared with anti-transpiration and no materials. Considering mulching, using bare soil increased the purity compared with transparent and black plastic.

Table (4) some crop characteristics under irrigation systems

Items			Trickle irrigation				Subsurface irrigation			
			Root length (cm)	Root diameter (cm)	Impurity (%)	Sucrose (%)	Root length (cm)	Root diameter (cm)	Impurity (%)	Sucrose (%)
50 %	No materials	B S	29.9	11.3	86.5	18.8	27.7	10.5	84.7	20.7
		T P	29.6	11.6	86.2	18.8	27.2	10.8	84.2	20.6
		B P	29.1	11.9	85.8	18.6	26.8	11.1	84.0	20.4
	Anti-transpiration	B S	25.0	8.3	88.0	20.5	23.1	7.7	86.2	21.0
		T P	24.6	8.5	87.7	20.4	22.6	8.0	86.0	20.8
		B P	24.1	9.0	87.3	20.2	22.1	8.3	85.7	20.4
	Polymer	B S	27.0	11.5	89.7	19.8	27.5	10.7	87.9	20.6
		T P	26.7	11.8	89.6	19.7	27.1	11.0	87.6	20.3
		B P	26.4	12.0	89.2	19.6	26.7	11.4	87.1	20.1
75 %	No materials	B S	27.1	12.2	85.5	18.5	25.1	11.4	83.3	18.8
		T P	26.9	12.4	85.1	18.4	24.8	11.8	83.0	18.7
		B P	26.5	12.7	84.9	18.3	24.2	12.1	82.9	18.4
	Anti-transpiration	B S	22.9	9.4	87.8	20.3	21.2	8.7	85.6	20.9
		T P	22.8	6.6	87.2	20.0	21.0	8.9	85.2	20.8
		B P	22.5	10.0	86.8	19.9	20.6	9.3	85.0	20.5
	Polymer	B S	28.5	12.8	89.0	19.1	26.4	11.9	86.7	19.8
		T P	28.2	12.9	88.6	19.0	26.0	12.1	86.2	19.7
		B P	27.9	13.1	88.1	19.0	25.7	12.6	86.0	19.5
100 %	No materials	B S	24.3	11.7	84.9	17.5	22.5	11.5	82.3	18.0
		T P	24.1	11.7	84.0	17.4	22.2	11.7	82.2	17.9
		B P	23.9	12.0	83.1	17.4	21.9	12.0	81.8	17.8
	Anti-transpiration	B S	19.5	11.3	87.4	19.9	18.0	10.5	84.8	20.0
		T P	19.2	11.4	87.0	19.8	17.7	10.8	84.3	19.9
		B P	18.8	11.9	86.7	19.7	17.2	11.3	84.1	19.8
	Polymer	B S	25.6	14.0	88.6	19.0	23.6	13.1	86.0	19.2
		T P	25.3	14.2	88.3	18.9	23.3	13.5	85.8	19.0
		B P	24.7	14.6	88.0	18.8	22.9	13.9	85.3	18.9

Black plastic mulch (B P), Transparent plastic mulch (T P) and Bare soil control (B S).

e. Root yield.

Data in Fig. (4) showed that the highest root yield value was 23.36 Mg/fed found by using subsurface irrigation, 100% of IRa, polymers and black plastic mulch. The root yield increased by 25.07 and 64.62 % when applying 100% of IRa compared with 75 and 50% of IRa under trickle irrigation, no materials and bare soil. These results go parallel with those obtained by **Abd El-Wahab** ***et al.*** **(1996)** and **Shams El-Din (2000).** Concerning the materials effect, it was found that the root yield at polymers increased by 44.74 and 25.2% compared with anti-transpiration and no materials under trickle irrigation, 100% of IRa and black plastic mulch. As for the mulching effect, black plastic increased the root yield compared with bare soil and transparent plastic.

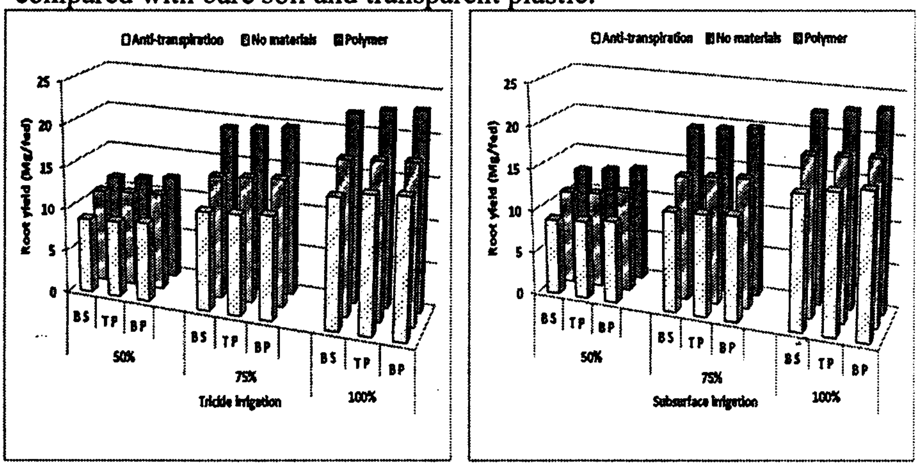

Fig. (4) The root yield under different treatments

f. Sugar yield.

The data presented in Fig. (5) show clearly that subsurface irrigation increased the sugar yield by 14.62% compared with trickle irrigation under 50% of IRa, no materials and bare soil. The highest sugar yield was 4.4 Mg/fed found under subsurface irrigation, 100% of IRa, polymers and black plastic mulch. Increasing irrigation water applied from 50 to 100% of IRa, the sugar yield increased by 85.4% under trickle irrigation, polymers and bare soil. Similar results were found by **Abd El-Wahab** ***et al.*** **(1996).** Concerning materials effect, the polymers had high sugar yield value, while no materials had the lowest value. As for the mulching effect, black plastic increased the sugar yield of 2.32% compared with bare soil under subsurface irrigation, 100% of IRa and polymers.

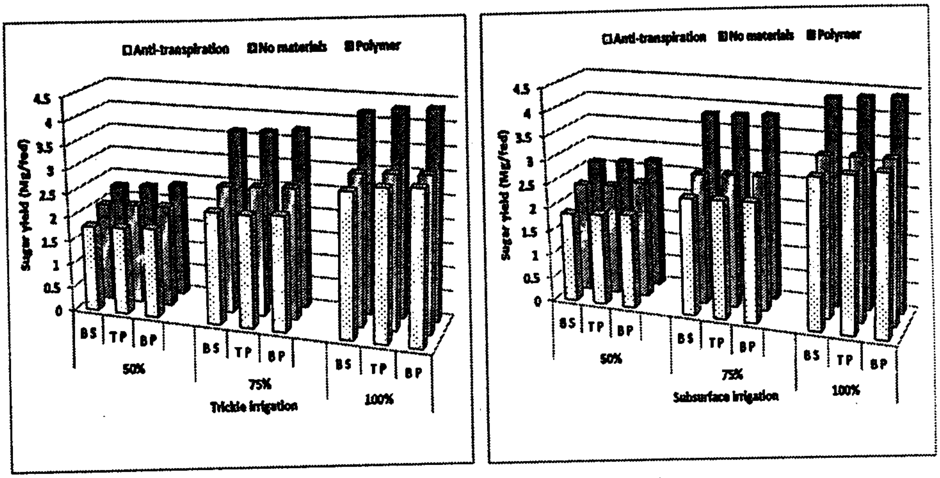

Fig. (5) The sugar yield under different treatments

4. Water Use Efficiency (WUE).

Results in Figs. (6 and 7) indicated that the highest WUE values were 12.66, 13.07 and 13.58 kg/m^3 for root yield and 2.51, 2.57 and 2.64 kg/m^3 for sugar yield by using bare soil, transparent plastic and black plastic, respectively under subsurface irrigation, 75% of IRa and polymer. The relative increases in WUE due to application of 50 and 75% of IRa were 21.23 and 6.29% for root yield and 30.83 and 12.78% for sugar yield respectively compared with 100% of IRa when using trickle irrigation, no materials and bare soil.

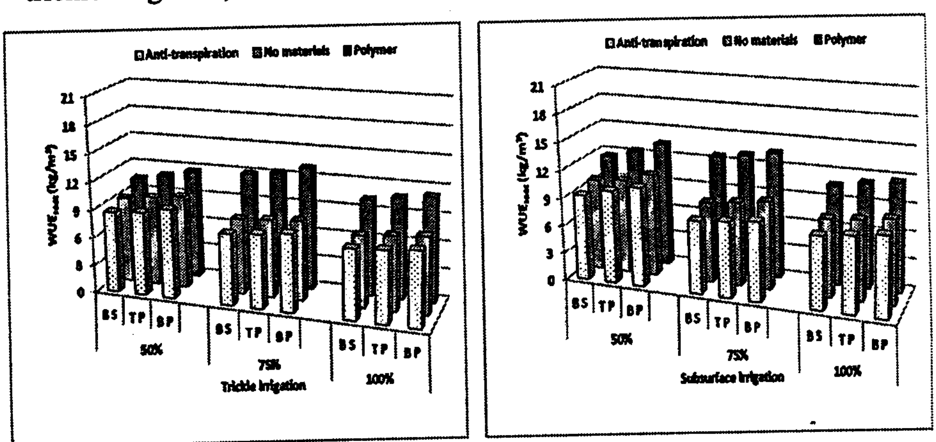

Fig. (6) The WUE$_{root}$ under different treatments

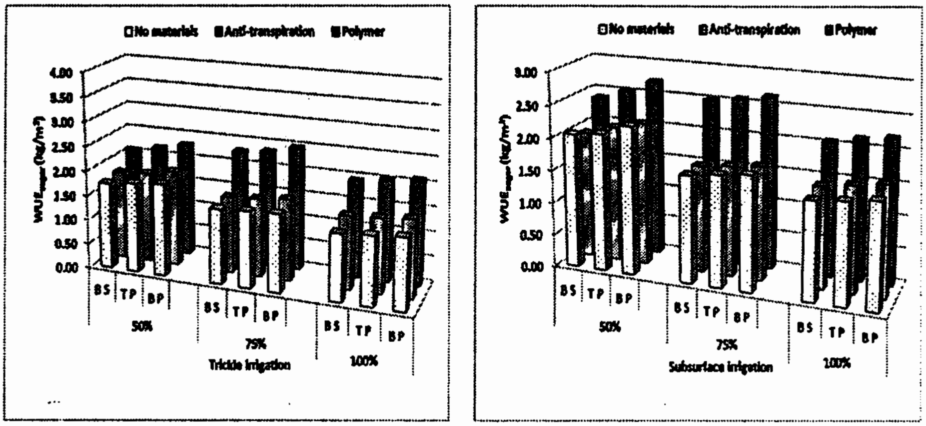

Fig. (7) The WUE_{sugar} under different treatments.

5. Saving water.

The data in Fig. (8) show the saving water under the different treatments compared with 100% of IRa (2355 m^3/fed). Regarding the irrigation systems effect, results show that the highest saving water value was obtained under subsurface irrigation compared with trickle irrigation. As for the irrigation water applied effect, results show that at 100% of IRa, the saving water decreased by 34 and 31% compared with 75% of IRa under trickle and subsurface irrigations, respectively, no materials and bare soil. Regarding the materials used, the data show that using anti-transpiration increased saving water comparing with polymers and no materials under all treatments. The results also indicated higher saving

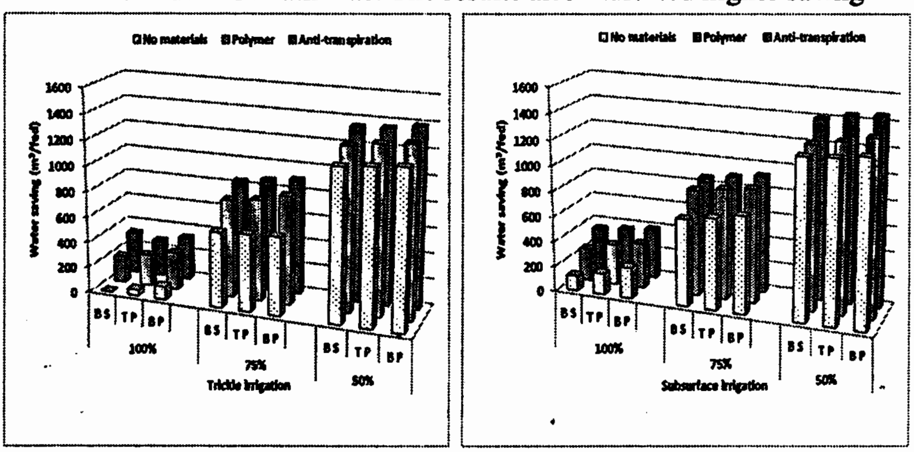

Fig. (8)The saving water under different treatments

water by using black plastic mulch and vice versa, the lowest value was recorded in the cases of bare soil under all treatments.

6. Cost analysis.

Data in Fig.(9) showed that the highest net profit value was 6977 LE/fed by using subsurface irrigation, 100% of IRa, polymers and black plastic mulch, while the lowest value was 2511 LE/fed by using trickle irrigation, 50% of IRa, anti-transpiration and bare soil. Increasing the irrigation water applied to 100% of IRa the net profit increased compared with 75 and 50% of IRa under all treatments. As for the materials effect, using polymers increased the net profit compared with anti-transpiration and no materials under all treatments. Concerning for mulching, the bare soil decreased the net profit compared with transparent and black plastic under all treatments. The highest production cost per yield value of 100 LE/Mg was found under trickle irrigation, 50% of IRa, anti-transpiration and transparent plastic mulch, while the lowest value was 48.5 LE/Mg when using subsurface irrigation, 100% of IRa, polymers and black plastic mulch.

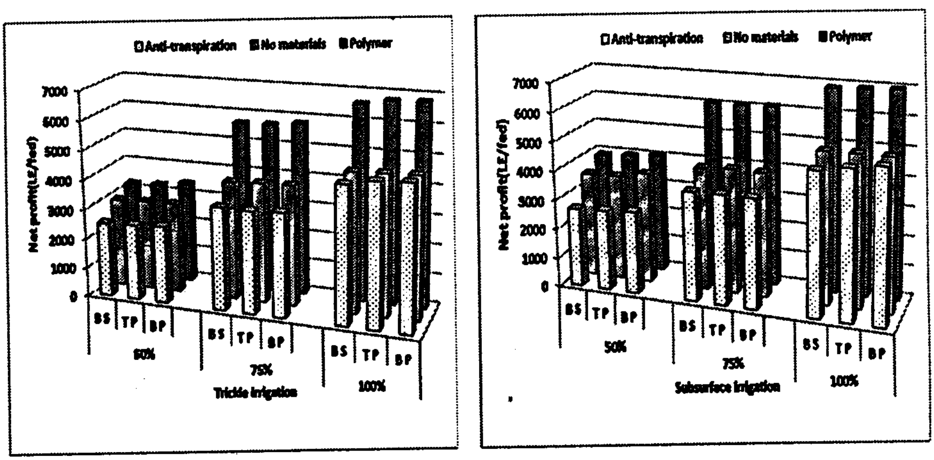

Fig. (9)The net profit under different treatments

CONCLUSIONS

The experimental results indicated the following conclusion:-

- The highest root and sugar yield values of 23.36 and 4.4 Mg/fed were found by using subsurface irrigation, 100% of IRa, polymers and black plastic mulch compared with different treatments.
- The highest actual irrigation water requirements value of 2355 m^3/fed and weed control of 350 kg/m^2 were found under trickle irrigation, no materials, bare soil and 100% of IRa.
- With using black plastic mulch, the root and sugar yield and saving water increased compared with bare soil and transparent plastic mulch.
- The highest net profit and the lowest production cost per yield values were 6977 LE/fed and 48.5 LE/Mg by using subsurface irrigation, 100% of IRa, polymers and black plastic mulch.

Generally, it could be concluded that under similar conditions, using subsurface irrigation, 100% of IRa (actual irrigation water requirements), polymers and black plastic mulch achieved the highest root yield, sugar yield, WUE, saving water and net profit.

REFERENCES

Abd El-Wahab, S. A., A. A. Amer, M. I. El-Shahawy and M.M. Sobh (1996). Effect of different irrigation amounts and potassium fertilizer rates on yield and quality of sugar beet and water efficiencies (1996). J. Agric. Sci. Mansoura Univ. 21 (12): 4687-4699.

Abou-Shieshaa, R.R. (2001). A study on mechanical topping of sugar beet under Egyptian conditions. Misr J. Agric. Eng., 18 (3): 596-584.

Albinet, E. (1986). Forecasting elements in watering sugar beet under the conditions of the Tijia high plain-Cercetari Aronomic in Moldova 19 (2): 34-38.

El-Gendy, R. W., A. M. Gadalla, A. Hamdy, M. El moniem and A. Fahmy (2007). Irrigation saving water via scheduling irrigation of snap bean and direction of soil water movement under drip irrigation system. Saving water in Mediterranean agriculture and future research needs [Vol. 1]. Bari: 235-247.

Doorenbos, J. and W. D. Pruitt (1984). Crop Water Requirements. FAO Irr. & Dr. Paper No. 24, Rome, Italy, 144 pp.

El-Mansi, A. A., A. Bardisi and S. A. El-Atabany (2000). Effect of rhizobium inoculum and soil plastic mulch on nodulation, plant growth and yield of pea under sandy soil conditions. Zagazig J. Agric. Res.,27 (24): 899-912.

Emara, T. K. (1996). Studies on the effect of some cultural practices on water parameters of sugar beet in North Delta Region –Un published Ph.D. Thesis, Fac. of Agric. Mansoura Univ. Egypt.

Hassanli, A. M., S. A. and S. Beecham (2010). Evaluation of the influence of irrigation methods and water quality on sugar beet yield and water use efficiency. Agric. Water Manage., 97 (2): 357-362.

Hassanli, A.M., M. A.Ebrahimizadeh and S. Beecham (2009). The effect of irrigation methods with effluent and irrigation scheduling on water use efficiency and corn yields in an arid region. Agric. Water Manage., 96 (1): 93-99.

James, L. G. (1988). Principles of farm irrigation system design, Krieger publishing company, Krieger Drive, Malabar, Florida.

Jensen, M.E. (1983). Design and operation of farm irrigation systems. ASAE, Michigan, USA., Pp. 827.

Rafeet, M. A. A. (1995). Management of modern irrigation systems under arid climate conditions. Un published MSc., Thesis, Of Agric. Mech. Dept., Fac. of Agric. Ain Shams Univ.

Sakellariou-makrantonaki M., D. Kalfountzos and P. Vyrlas (2002). saving water and yield increase of sugar beet with subsurface drip irrigation. Global Nest: the Int. J., 4 (2-3): 85-91.

Selim, A. F. H., F. A. Ali, M. E. Sorial and M. Fothalla (1996). Herbicides, hoeing and mulching effects on onion growth, physiological behavior, yield attributes and weed control. Zagazig J. Agric. Res., 23 (4): 609-628.

Shams El-Din, H.A. (2000). Effect of water application levels and different wetting depths on sugar beet yield and its water relations at North Delta. J. Agric. Sci., Mansoura Univ., 25 (9): 5931-5939.

Sorour, S. Gh. R. (1995). Response of sugar beet to irrigation regime and plant population. Egypt, J. App. Sci., 10 (8): 648-668.

Topak Ramazan, Sinan Su¨heri and Bilal Acar (2011). Effect of different drip irrigation regimes on sugar beet (Beta vulgaris L.) yield, quality and water use efficiency in Middle Anatolian, Turkey. Irr. Sci. 29:79–89

Younis, S. M.; M. A. Shiboon and A. O. Aref (1991). Evaluation of some mechanical methods of rice production in Egypt. Misr J. Agric. Eng., 8 (1) : 39 - 49.

الملخص العربي

تعظيم الاستفادة من المياه لمحصول بنجر السكر تحت نظم الري

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من أهم المشكلات التى تتصف بها الأراضى الرملية قلة قدرتها علي الاحتفاظ بالماء، وتمثل الإدارة المزرعية المثلى لمياه الرى تحديا رئيسا لتحسين كفاءة استخدام المياه وزيادة محصول بنجر السكر , والذي يعتبر من المحاصيل الهامة في العالم وفي مصر. ونظرا لندرة المياه وزيادة التوسع الأفقى فى استصلاح الأراضى فانه يلزم دراسة كيفية ترشيد استهلاك المياه، لذا تم أجراء هذا البحث بهدف تقنين كمية المياه التى يحتاجها هذا المحصول مع نظم الري الحديثة.

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وفى هذا الإطار نفذت التجربة الحقلية فى تربة رملية بمزرعة كلية الزراعة بالخطارة - محافظة الشرقية خلال الموسم ٢٠٠٩/٢٠١٠ لدراسة تأثير نظم الري (بالتنقيط والري تحت السطحي) وكميات مياه الرى وهى (١٠٠ , ٧٥ , ٥٠% من الاحتياجات المائية الفعلية) وبعض المواد التى تساعد على تقليل فقد المياه (مضادات النتح) والبوليمرات (المواد الحافظة للماء) وتغطية سطح التربة بالبلاستك (البلاستك الأسود والشفاف عديم اللون وبدون تغطية) على توزيع الرطوبة في التربة وكمية الحشائش والمحصول وصفاته وترشيد المياه وكفاءة استخدام المياه والعائد الاقتصادي من الفدان في الأراضي الرملية. وكانت أهم النتائج كما يلى:

- أدي استخدام الري تحت السطحي وتغطية سطح التربة بالبلاستك الأسود مع إضافة البوليمرات للتربة إلى زيادة في كمية المحصول وتحسين صفاته، ونقص فى كمية الحشائش وأعلي ترشيد للمياه المستخدمة وكفاءة استخدام المياه والعائد الاقتصادي مقارنة بالمعاملات الأخرى.
- أدى رى نباتات بنجر السكر خلال موسم الدراسة بمعدل ١٠٠% من الاحتياجات المائية الفعلية إلي زيادة في معظم صفات النمو والمحصول الكلي بالنسبة للفدان والمحصول القابل للتسويق بالمقارنة بالمستوى الأقل من كمية الري.

توصى الدراسة باستخدم نظام الرى تحت السطحى ومعدل الري ١٠٠% من الاحتياجات المائية الفعلية وتغطية سطح التربة بالبلاستك الأسود مع استخدام البوليمرات في الأراضي الرملية المستصلحة حديثا، للحصول على أعلى انتاجية من محصول الجذور والسكر، وأعلى ترشيد للمياه واقل تكلفة لإنتاج الميجاجرام من المحصول واعلى عائد اقتصادى.