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SUGAR BEET CROP PRODUCTION UNDER IRRIGATION PERFORATED TUBES SYSTEM

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ABSTRACT

Two field experiments on clay soil were conducted at the experimental farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, during two successive seasons in 2006/2007 and 2007/2008 seasons for the monogerm variety sugar beet planting. The research devoted to carried out to design and locally manufactured perforated tubes system its calibration. Then Field experimental work to study the effective irrigation perforated tubes system with LASER land leveling technique at 0.1% slope (T1) and irrigation conventional method with traditional land leveling at 0.0 % slope (T2) under different cases of ridges (double furrows) lengths on the sugar beet production (yield and yield component) and its irrigation water relations [water application efficiency (WAE), water distribution efficiency (WDE) and water use efficiency (WUE)] under prevailing condition in Egyptian old valley due to: the first, saving of irrigation water is considered a strategically target of Egypt; the second, soil moisture is a major factor limiting sugar beet production and also, sugar beet plants consumes less water than sugar cane. The effects of applying such methods on advance and recession time and total water applied for sugar beet were considered. The obtained results showed that there were slightly deviation between outlets flow measured along the perforated tubes system designed and its recommended per each furrow. The uniformity distribution of flow through outlets along the perforated tubes system was about 92.8 %. The research recommended that using irrigation perforated tubes system with LASER land leveling technique at 0.1% slope and the ridge (double furrows) length of 75 m gives a highest values of sugar beet production, root volume, sugar and root yield. Also, a highest values of WAE, WDE and WUE and saving about 46.3% of water application than conventional irrigation methods with traditional land leveling at 0.0% slope under three treatments of ridges (double furrows) lengths.

Keywords: Perforated tubes, land leveling, surface irrigation, water advance time, recession time, infiltration opportunity time, sugar beet, yield, efficiency.

INTRODUCTION

As the world becomes increasingly dependent on the production of irrigated lands, irrigated agriculture is facing serious challenges that threaten its sustainability. If irrigated agriculture is to survive as an economically viable and environmentally acceptable venture, it will require innovative mergers of managerial and technological skill. Agricultural and irrigation Egyptian policies have been working to improve the surface irrigation system especially in the Egyptian old valley by using irrigation-gated pipe. Economic use of irrigation water is vital problem, which confronts agriculture scientists in irrigated areas.

Sugar beet is a biennial crop that is the second sugar crop of the two main crops responsible for sugar production. Accordingly, sugar beet supplying area has increased from 17 thousand feddans in 1982 to around 249.159 thousand feddans in 2007. It is characterized by short growing season, consumes less water than sugar cane (about two third) and may also grow under a wide soil texture and climatic conditions (Abou Shieshaa, 2001). Therefore, government is planning to increase the growing area of sugar beet and improving the technique of agricultural processes. On the other hand sugar beet is adversely affected by water logging which aggravates some problems including various diseases, leaching of available nitrogen and harvesting difficulties (Dunham, 1993). The soil moisture is a major factor limiting sugar beet production Abd El-Tawwab *et al.* (2007). Also the surface irrigation often has a highly irregular distribution. Therefore, the water is excessive in some places or not adequate for successful seed beet mergence. Thus it may necessary to control and manage the available water supply to face overuse problem and minimize water losses to improve irrigation efficiency (Badawy *et al.* 2001). Hassan (2004) mentioned that the overall irrigation efficiency is a function of a number of efficiencies as application, conveyance and distribution efficiency. An increase of one efficiency may increase the overall irrigation efficiency. El-Gindy *et al.* (1996) stated that the precision land leveling using laser grade control has been proven to be feasible both technically and economically. Precision land leveling has a positive effect on increasing agricultural production either vertically or horizontally. Vertically by increasing yield per unit area and horizontally by increasing water application efficiency of surface irrigation. El-Mowelhi *et al.* (1995) reported that the best treatment of land leveling in the Northern Delta region is 0.1 % ground surface slope to obtain the highest yield for most crops and increases surface irrigation efficiencies. Metwally *et al.* (2003) found that using the ridge irrigation methods (double furrows) gives the maximum sugar beet root yield, minimum water consumption use and maximum field water use efficiency. Tawfik *et al.* (2005) recommended that using modified furrow surface irrigation system saved applied irrigation water compared with traditional furrow surface irrigation system. Doorenbos and Kassam (1986) indicated that water requirements of sugar beet ranged from 550 to 750 mm. Moreover, they added that irrigation increased root yield but decreased sugar content. Awad *et al.* (2003) mentioned that the average water consumptive use during two successive growing seasons for sugar beet yields at El-Bostan (Nubaria Sector) was 3958 m^3/fed furrow irrigation. El-Yazal *et al.* (2002) found that using irrigation perforated pipe system increased the water use efficiency by 38.8% in average compared with traditional irrigation method. Abd El-Motaleb *et al.* (2006) mentioned that controlled surface irrigation systems by using enclosed pipe lines have been successfully demonstrated in recent years. The common type of pipes system is perforated pipes technique, which is a simplified type of gated pipes. El-Berry *et al.* (2006) reported that using developed surface irrigation system saved applied irrigation water by about 30.54% to 37.37% compared with traditional irrigation system. Abd El-Rahman (1985) concluded that water efficiencies increased as flow rate and soil slope increased. Omara (1997) found that the irrigation application efficiency and irrigation distribution efficiency increased of 72.5 % and 92.0 % respectively by using gated pipe system through furrow irrigation. Krinner and Estrada (1994) reported that irrigation method (gravity or pressure) is influencing the conveyance and global efficiency. They found that an automatic surface irrigation system with gated pipe and with a re-use system could be a very efficient method of applying irrigation 91.9 % water application efficiency. Hassan (1998) referred to the best flow rate per furrow in clay soil as 1.2 l/s at furrow length 100 m, and furrow spacing of 0.60 m or 2 l/s per one meter of width. Kincaid and Kemper (1982), reported that the discharge coefficient (Cd) is usually assumed constant. A value of Cd = 0.68 was used. Jensen (1983) mentioned that for increasing the uniformity of application of water to their furrow irrigated crops; gated pipe was suggested especially to be helpful. Gated pipe can be regulation of the size of stream flowing into the furrow. El-Sayed (1998) found that the pressure head needed to operate the system is fairly low. The required head to operate the gated pipe system in the field is 50 cm or less, therefore pumping unit is not a must. Smith *et al.* (1986) found that the range of values of the Hazen- Williams coefficient for rigid aluminum or PVC gated pipe would therefore appear to lie between 130 and 150. Morcos *et al.* (1994) proposed mathematical relationship relates the affecting factors with water distribution rates and uniformity for perforated tube. He also reported that the total friction head losses inside the perforated pipe and the superimposed pressure head estimated as following equations:

$$Q_n = \sum_{n=1}^{N} q_n \quad (1)$$

$$Vn = 0.001.\ Q_n / A \quad (2)$$

$$h_{fn} = k\left(\frac{Qn}{CHw}\right)^{1.852} . \times D^{-4.87} \times s \quad (3)$$

$$hft = \sum_{n=1}^{N} h_{fn}\ ,\ m \quad (4)$$

$$Hsn = (V^2_{max} - V^2_n)/\ 2 \quad (5)$$

$$Hcom = hp + Hsn - hft \quad (6)$$

$$q = a.V \quad (7)$$

Where:

Qn = the flow rate inside the perforated pipe just before any orifice, l/s;
qn =the actual measured orifice discharge rate, l/s;
D = inside perforated pipe diameter, mm;
k= constant.
s = the spacing between orifice along the perforated pipe, m;
CHw = Hazen William' s coefficient, dimension less;
h_{fn} = the friction head losses inside the perforated pipe just before any orifice, m;
hft = total friction head losses inside the perforated pipe just before any orifice, m;
Vn = the flow velocity inside the perforated pipe just before any orifice, m/s;
A = the perforated pipe cross section area, m^2;
Hsn= The superimposed pressure head, m;
V_{max} = The maximum inside flow velocity at perforated pipe inlet, m/s;
V_n = The velocity of flow inside the perforated pipe just before any orifice, m/s;
Hcom =The resultant pressure head, cm;

hp= The measured pump pressure head, cm

v = measured outlet flow velocity, m/s;

a = area of outlet, m^2;

Khurmi (1982) reported that in long pipes, the major losses of head is due to friction in the pipe. The minor losses are so small, as compared with friction losses, and may be neglected. The Reynold's number determined according to Albertson *et al.* (1960) by equation:

$$Re = \frac{V.D}{\upsilon} \quad \text{...(8)}$$

Where:

V = Average velocity in the pipe, m/sec;

D = Inside pipe diameter, m;

υ = Kinematics viscosity, m^2/sec

Jensen (1983) reported that the expression of evaluating uniformity distribution through the variation of flow through orifices along the lateral line named flow variation along the lateral line " q_{var} ". The uniformity distribution increased as flow variation decreased.

$$q_{var} = \frac{q_{max} - q_{min}}{q_{max}} \quad \text{...(9)}$$

Where:

q_{var} = The orifice flow variation %,

q_{max} = The maximum orifice flow along the lateral line, l/s and,

q_{min} = The minimum orifice flow along the lateral line, l/s.

Chu (1984), Wu and Gitlin (1983), Kincaid and Kemper (1982) stated that the pressure head variation can be determined by form of:

$$H_{var} = \frac{H_{max} - H_{min}}{H_{max}} \quad \text{...................................... (10)}$$

Where:

H_{var} = pressure variation along sub-main,

H_{max} = maximum pressure in sub-main, m, and

H_{min} = minimum pressure in sub-main, m

For a practical design the pressure variation is usually kept less than 20%, which is about equivalent to 10% Variation of lateral line flow along sub-main. **Douglas *et al.* (1992)** reported that the coefficient of discharge might be defined as the ratio between actual discharge and the theoretical discharge passing through an orifice. It is denoted by "Cd", Mathematically;

$$Cd = \frac{\text{Actual discharge}}{\text{Theoretical discharge}} \quad \text{...........................(11)}$$

The research devoted to find out the effective irrigation perforated tubes system and irrigation conventional method under different cases of ridges (double furrows) lengths on the sugar beet production (yield and yield component) and its irrigation water relations (water application efficiency (WAE), water distribution efficiency (WDE) and water use efficiency (WUE)) under prevailing condition in Egyptian old valley.

MATERIALS AND METHODS

Two field experiments on clay soil were conducted at the experimental farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, during two successive seasons in 2006/2007 and 2007/2008. The monogerm variety sugar beet planting. Perusing the above-mentioned objective; the following work was carried out:

1- Design and locally manufactured of perforated tubes system and calibration experimentally on the operating field condition.
2- Field experimental work to study the effect of irrigation system and land leveling technique under different ridge lengths (double furrows) on the Monogerm sugar beet production and yield component, water application efficiency, water distribution efficiency and water use efficiency under prevailing condition in Egyptian old valley. Also, its effects on advance and recession time, total water applied, yield and water use efficiency for sugar beet.

1- Design and locally manufactured of perforated tubes system and its calibration:

To compute the suitable outlets diameters along the irrigation perforated tubes system gives the flow rate required per each ridge (double furrows) designed a locally perforated tubes. A perforated tubes system serving an area about 0.3 feddan as a maximum field length of about 100-meter, the width of this area was about 12 meter. One meter spacing between the outlets of the perforated tubes, the number of the discharging outlets of perforated tubes was about 12 outlets. The flow rate recommended per meter width having 100 meter long in clay soil was about 2 l/s as (Hassan 1998). Therefore the designed flow rate per each outlet was about 2.0 l/s. Thus the total flow rates required was about 24 l/s (86.4 m3/h). Since the average flow velocity inside the tubes is about 1.5 m/s. Therefore the suitable inside diameter of perforated tubes computed by equation (3) is about 150 mm. Thus six inches diameter, 6-meter length aluminum alloy tubes were used for the perforated tubes system. The specifications of these tubes are shown in Table (1).

The calibration of the pumping unit was tested through water re-circulation system, in which the pumping unit received water from long lining canal, was constructed in the field. The pumping unit flow rate was adjusted to be as close as possible to pumping flow rate 90 m3/h measured by six inches flow meter. The specifications of the pump and engines are shown in Table (2). The actual pressure head measured by the manometer at the perforated tubes inlet was about 0.75 meter.

The perforated tubes system designed for testing on the field were locally manufactured in the workshop of the Sakha Agricultural Research Station, Kafr El-Sheikh Governorate. They were manufactured using two aluminum tubes (12 meter long) of 150 mm inside diameter with closed end having 12 circular outlets were drilled. Valves (to control irrigation) and water flow meters of 0.1 m^3 accuracy (to measure the amount of water applied), pressure gauge and peizometers (to measure pump and outlets pressure head) were attached to the pump by flexible quick hitch hose.

Table (1): The Specifications of the used pipes for the perforated tubes system.

No.	Item	Specification
1	Pipe source	Helwan Co. for nonferrous industries.
2	Manufacturing	Longitudinal welding
3	Length	6.0 m
4	Outside diameter	154 mm
5	Inside diameter	150 mm
6	Metal thickness	1.17 mm
7	Pipe weight	9.38 Kg
8	Operating head	11 ATM
9	Explosion pressure	36 ATM
10	Operating pressure	263 N/mm
11	Maximum stress	273 N/mm
12	Equipped fittings	Quick coupler at one end

Table (2): The specification of the pumping unit.

Type of pump	Type of Engine	Motor Power, Hp	Rpm	Max. Discharge, m^3/h	Max. operating pressure, bar	Suction pipe Diameter, inch	Delivery pipe Diameter, inch
Centrifugal	Diesel	5.5	1450	90	1	6	5

Measuring the outlets flow rate along the perforated tubes system under actual field operating condition tested the actual performance of the perforated tubes system. From the experimentally measured of pressure head, the discharge velocity of each outlet, and flow rate passing before any outlet, the friction losses, the superimposed pressure head were estimated from equation (2) through equation (7). Also the water uniformity distribution from outlets along the perforated tubes system was experimentally tested under the field condition using equation (8).

2- Field experimental work:

The experimental area plot was divided into two sub-plots. The first sub-plot was leveled and irrigated by conventional method (T1). The second sub-plot was leveled at 0.1 % slope by laser technique and irrigated by irrigation perforated tubes system (T2). The layout of the experiments is shown in Fig (1).

Figure (1) shows that each subplot was divided into three treatments 50 meters ridge (double furrows) length (L50), 75 meters length (L75) and 100 m length (L100). Each treatment was repeated at three replicates. The first sub-plot area was leveled at 0.0 slopes by manual hydraulic scraper and irrigated with conventional method (water is delivered to each basin through a system of small ditches inside the field by pumping irrigation water through six-inch flow meter into a concrete canal to flow from the canal to small ditches into ridges (double furrows)). Six-inch aluminum perforated tubes irrigated the second experimental area sub-plot. The spacing between two consecutive outlets was to be one meter apart facing each ridge (double furrows). At each station along the ridge (double furrows) length, the water advance and recession times were recorded at equal spacing (25 m) along each treatment. Also, the opportunity times (time while water was above the ground), was found. The amount of irrigation water for each treatment was measured by six inches flow meter attached to the pumping unit.

Sugar beet is sown in Egypt during the period extends from august to November. Thus common land preparation practices included chiseling, disking using disc harrow, grading with a land plane, and furrowing using opener (spaced 1.0 m apart) before planting. Therefore, Monogerm sugar beet was sown at 15 August. All other agronomic practices were identically applied according to the recommended practices. The crop harvest done at 10 March then the root yield of each plot was estimated in Mg/fed. Sucrose percentage was determined polarimetrically according to **Mc Ginnus (1971)**. The soil moisture was determined before and after irrigation.

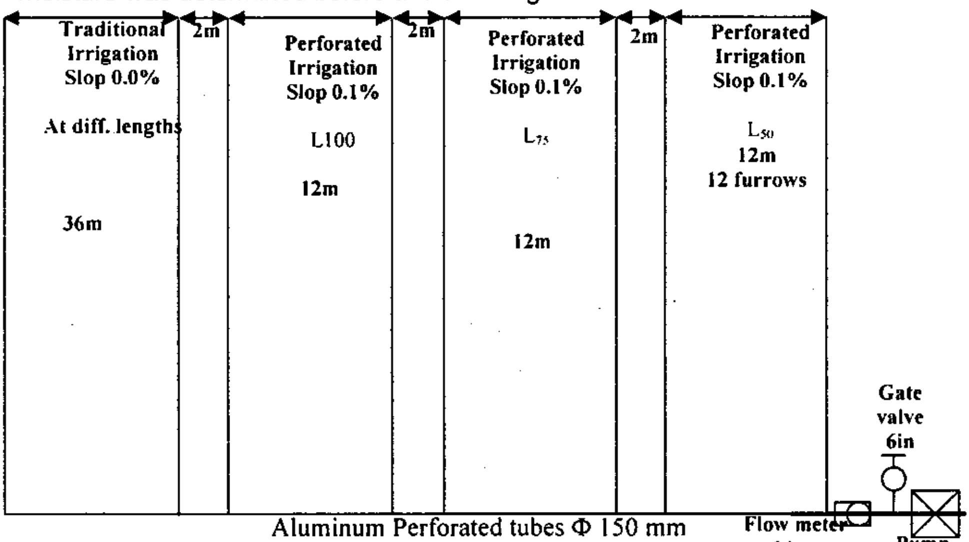

Fig. 1: Lay out of the experiment.

The stream of irrigation was cut off at 100 % of the irrigation run (as traditional practice). After that, for all treatments, all the agricultural processes were the same.

a- Soil analysis: Soil samples were taken until 60 cm in depth to determine some physical and chemical properties (Table 3) of the experimental site. Physical and mechanical analysis of the soil samples was determined by Soil and Water Research Institute, Agricultural Research Center, Giza, according to **Black *et al.* (1965) and Jackson (1958)**.

Table 3: Some physical and chemical properties of soil before planting.

Soil depth, cm	Clay, %	Silt, %	Sand, %	Soil texture	$CaCO_3$, %	Soil moisture characteristic F.C., %	W.P, %	Bd, g/cm^3	pH	Ec., ds/m	Basic Inf., cm/h
0-15						50.3	17.5	1.3	8.2	3.85	1.2
15-30	54.2	29.3	14.2	Clay	2.3	51.7	18.2	1.46	8.3	4.20	1.0
30-45						52.3	18.5	1.57	8.3	4.50	0.9

b- **Advance and recession times:** The advance of water in surface irrigation plays an important role in the application of the soil land and the distribution of water in the soil root zone. The water advance and recession times were recorded at equal distances along each plot. The difference between recession and advance times at each station gives the infiltration opportunity time for each station. The ridge (double furrow) length divided into stations. The spacing between two consequent stations was 25 m. At each station along the ridge (double furrow) length, the water advance and recession times were recorded at equal spacing (25 m) along each treatment. Also, the opportunity times (time while water was above the ground), was found by measuring the time interval between the advance and recession. Soil moisture was determined 24 hours before irrigation and 48 hours after irrigation to calculate the water consumptive use for every irrigation (it was measured in for depths i.e., 0-15, 15-30, 30-45 and 45-60 cm from soil surface) according to **Israelson and Hansen (1962)** as follows:-

$$Cu = \frac{Q2 - Q1}{100} \times D \times B \quad \text{.......... (12)}$$

c- **The water application efficiency(WAE): Jensen (1983)** stated that the water application efficiency is the ratio of the average depth of the irrigation water infiltrated and stored in the root zone to the average depth of water applied according to (**Downy, 1970**) as follows:

$$WAE = \frac{\text{Average depth of water infiltrated and stroed into root zone} \times 100}{\text{Average depth of water applied}} \quad \text{...... (13)}$$

d- **Water distribution efficiency(WDE):** indicates the extent to which water is uniformly distribution along the run. **Israelsen and Hansen (1962)** as defined it:

$$WDE = \left[1.0 - \left(\sum \left|Y_i - d\right|\right) / \left(N \times d\right)\right] \quad \text{.......... (14)}$$

Where:

WDE = Water distribution efficiency, percent.

d = Average depth of water stored along the run during the irrigation.

$\left|Y_i - d\right|$ = Average absolute numerical deviation from d.

N = Number of readings

e- **Water use efficiency (WUE):** values were calculated according to **Jensen (1983)** as follows:

$$WUE = \frac{\text{Sugar beet root yield or Sugar yield (Mg/fed.)}}{\text{Applied irrigation water (m}^2\text{/fed.)}} \quad (\text{Mg/m}^3) \text{....... (15)}$$

f- **Root volume:** was measured by immersing it in a container filled with water and received the excess water in calibrated cylinder.

g- **Sugar yield:** per feddan equals to root yield per feddan (ton) multiplied by sucrose percentage.

h- **Root yield:** average values of root yield were calculated after harvesting. The yield of harvested roots was determined by massing the roots lifted by a manual shovel. The following equation was used:

$$R = \frac{4200 \times M}{1000 \times A} \quad \text{Mg/fed.} \quad \ldots\ldots\ldots\ldots\ldots\ldots (16)$$

Where:

R = the root yield; M = mass of lifted root, kg; and A = harvested area, m^2.

i- **Sugar yield:** per feddan equals to root yield per feddan in Mg multiplied by sucrose percentage. The sucrose percentage was measured in Sugar Crops Research Institute by using sucrometer instrument. It was estimated polarimertrically on a lead acetate extract of fresh macerated (**Le-Docte, 1927**).

RESULTS AND DISCUSSION

The practical of performance of the designed and locally manufactured perforated tubes system:

The field experimental work covered on experimental computation of the flow head inside the design and locally manufactured of perforated tubes system and its calibration experimentally on the operating field condition. The theoretical calculation of the flow head inside the design and locally manufactured perforated tubes along its whole length based on the actual flow rate and actual pressure head experimentally measured from the pumping unit. The theoretical determination and calculation in predicting the flow pressure head at each outlet along the perforated tubes system was carried out to estimate the expected suitable outlets diameters along the perforated tubes giving the flow rate recommended per each furrows (2.0 l/s) by using step- step method proposed by Morcos *et al.* (1994). The results of the theoretical computation of the outlets diameters along the perforated tubes and the outlets flow rates experimentally measured are shown in Table (4).

Table 4: Expected and measured performance of the design and locally manufactured of perforated tubes system based on the experimental pumping unit flow rate 87 m^3/h and pumping unit discharge head of 75 cm of water.

No.	q_{rec}	V_n	h_{ft}	H_{sn}	h_{com}	d_{cop}	h_m	q_{cop}	q_m	cd
1	2.0	1.36	1.34	0.0	73.66	25.9	74.7	2.71	1.96	0.723
2	2.0	1.25	2.48	1.5	74.05	25.9	74.5	2.70	1.94	0.719
3	2.0	1.13	3.43	2.88	74.45	25.8	74.2	2.70	1.93	0.715
4	2.0	1.02	4.22	4.11	74.90	25.8	74.3	2.70	1.94	0.716
5	2.0	0.91	4.85	5.23	75.38	25.7	74.5	2.70	1.96	0.726
6	2.0	0.79	5.34	6.21	75.87	25.7	74.6	2.70	2.0	0.741
7	2.0	0.68	5.71	7.06	76.35	25.6	74.8	2.71	2.01	0.742
8	2.0	0.57	5.98	7.78	76.81	25.6	74.8	2.71	2.04	0.753
9	2.0	0.45	6.15	8.37	77.22	25.6	74.9	2.71	2.04	0.753
10	2.0	0.34	6.25	8.82	77.57	25.6	74.9	2.71	2.05	0.756
11	2.0	0.23	6.30	9.15	77.85	25.5	75.2	2.72	2.05	0.754
12	2.0	0.11	6.31	9.35	78.03	25.5	75.6	2.72	2.08	0.765

Table (4) shows that outlets number along the perforated tubes system (No), flow rate recommended (q_{rec}) per each outlet (2 l/s), the average flow velocity inside the perforated tubes system just before any outlet (V_n), m/s (equation 2), the head losses due to friction just before any outlet (h_{ft}), cm, (equations 3 and 4), the pressure head generated due to the decreasing in the flow velocity inside the perforated tubes system (H_{sn}), cm along the perforated tubes system (equation 5), the outlets pressure heads expected (h_{exp}), cm (equation 6), the outlet diameter computed (q_m), mm (equation 7). Also the original pressure head (h_{on}) was measured using a pressure gauge and the actual measured outlet flow rate experimentally measured along the perforated tubes (q_m), l/ by using direct method.

The results of Table (4) show that the most flow in perforated tubes system occurs at Reynolds number between 104 and 105 and the flow was about fully turbulent flow agreement with Kincaid and Kemper (1982). There were slightly deviation between outlets flow measured along the perforated tubes system and the outlets flow recommended per each furrow, but there were deviation between outlets flow measured (q_m) along the perforated tubes system and the theoretical computation of outlets flow rates (q_{com}) (equation 7) due to coefficient of discharge resulting from the outlets manufacturing. Concerning the total head losses due to friction was increased gradually until reached 8.4 % of the original pumping pressure head measured. But the pressure head generating due to decrease in flow velocity along the perforated tubes system increased towards the tube dead end until reached about 12.5 % of the original pumping pressure head measured. The flow variation through 12 m apart of the perforated tubes system (equation 9) was about 7.2 %. Therefore the uniformity distribution of flow through outlets along the perforated tubes system was about 92.8 %. On the other hand pressure head variation (equation 10) was about 1.85%. The pressure head increasing gradually until reached the maximum at the tube dead end due to the increasing in pressure head gained overcome the pressure head losses by friction.

Field experimental work:

Field experimental work to study the effect of irrigation system and land leveling technique under different ridge lengths (double furrows) on the monogerm sugar beet production and yield component, WAE, WDE and WUE under prevailing condition in Egyptian old valley also, its effects on advance and recession time, total water applied, yield and water use efficiency for sugar beet.

1- Advance and recession times:

The water advance and recession times were recorded at equal distances along each plot. The average values through three replicates of advance, recession and opportunity times for traditional irrigation methods (T1) under different treatment of ridge (double furrows) length L_{100}, L_{75} and L_{50} are shown in Figs. from (2 to 4) respectively. The average values of advance, recession and opportunity times for perforated tubes system (T_2) at L_{100}, L_{75} and L_{50} treatments are shown in Figs. from (5 to 7). The results revealed that the values of advance for traditional methods were 118, 88 and 55.5 minute at L_{100}, L_{75} and L_{50} respectively. Dealing with the average values of advance for irrigation with perforated tubes system were 65.0, 55.7 and 41.6 minute at L_{100}, L_{75} and L_{50} respectively. Also, the results gave the same trend as traditional method of decreasing the advance and recession times as ridges (double furrows) length decreased. The opportunity time for irrigation with perforated tubes system decreased by 25.4, 23.1 and 8.0% in average

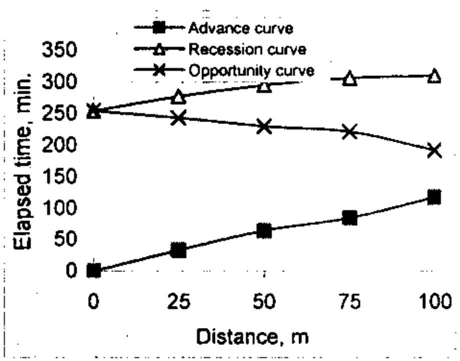

Fig. 2: Advance-Recession-Opportunity curves for traditional irrigation method under 100 m border length (L100).

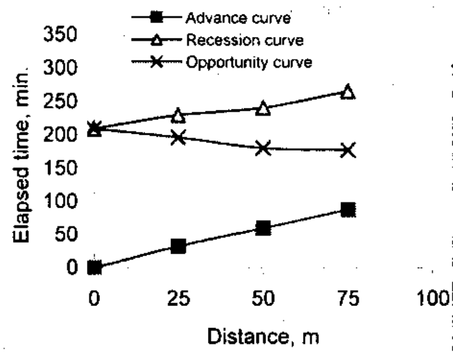

Fig. 3: Advance-Recession-Opportunity curves for traditional irrigation metshod under 75 m ridge(double furrow) length (L75).

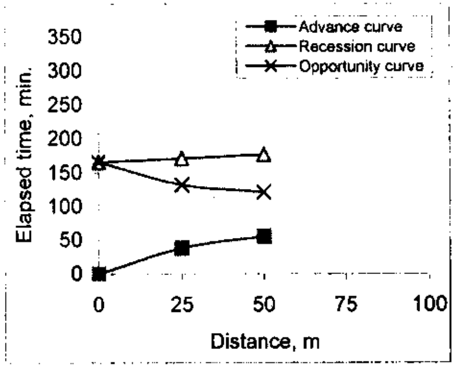

Fig.4: Advance-Recession-Opportunity curves for traditional irrigation method under 50m ridge (double furrow) length (L50).

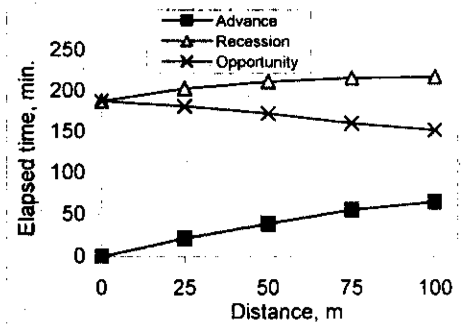

Fig. 5: Advance-Recession-Opportunity curves for perforated tubes system under 100m ridge(double furrow) length (L100) slope 0.1%.

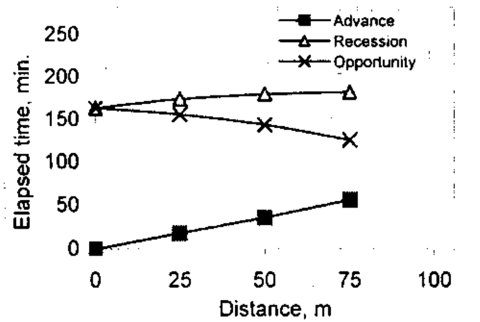

Fig. 6: Advance-Recession-Opportunity curves for perforated tubes system under75m ridge(double furrow) length (L750) slope 0.1%.

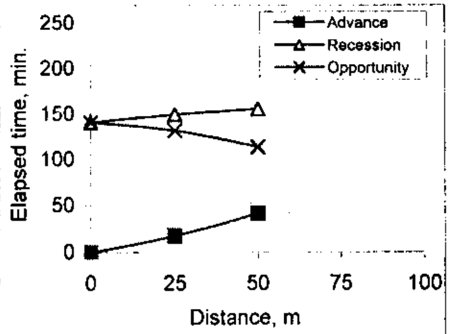

Fig. 7: Advance- Recession- Opportunity curves for perforated tubes system under 50m ridge(double furrow) length (L50) slope 0.1%.

than traditional irrigation method at L_{100}, L_{75} and L_{50} respectively due to 0.1% slope and fine water irrigation distribution by perforated tubes system.

2- Amounts of irrigation water:

The average total amounts of water received by sugar beet plants during two seasons through six irrigations for traditional (T1) and perforated tubes system (T2) under different ridges (double furrows) lengths at L_{100}, L_{75} and L_{50} are shown in Fig. (8). The figure shows that the average of total amounts of water for traditional methods through replicates at L_{100}, L_{75} and L_{50} were 3173, 3402 and 3685 m^3/fed respectively. The average total amounts of water for perforated tubes system during two seasons at L_{100}, L_{75} and L_{50} were 1788, 1818, and 1886 m^3 /fed respectively. Also, the figure showed that in the three cases of ridges (double furrows) lengths for traditional or perforated tubes systems, the sugar beet plant received more amounts of irrigation water as ridge (double furrow) length increased due to increased water opportunity time, as ridge (double furrow) length increased. Thus water losses with seepage, evaporation and run-off increased. Meanwhile, increasing ridge (double furrow) length from 50 m to 75 m, the values of water application amount per feddan increased of 7.2 and 1.7% for traditional and perforated tubes systems respectively. Increasing ridges (double furrows) length from 75 m to 100 m, the values of water application amount per feddan increased by 8.3 and 3.7 % for traditional and perforated tubes systems respectively. This means increasing percentage of the water losses of 5.5 and 4.6% in the second case for traditional and perforated tubes system respectively.

The results showed that using perforated tubes system in three cases of ridges (double furrows) lengths, saving irrigation water about 46.3 % per feddan in average. The result revealed that the traditional methods received more amounts of irrigation water than perforated tubes system in the three cases of ridges (furrows) lengths due to fine uniformity of water application gives good water distribution from outlets along the ridges (double furrows) width on the upper part of the field. Also, using LASER land leveling technique at 0.1% slope decreased the water losses by both deep percolation and runoff due to decrease the advance time and opportunity time.

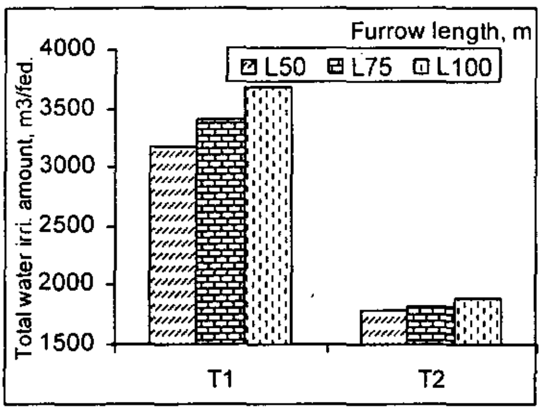

Fig. 8: Effect of irrigation systems and ridges (double furrows) lengths on the total irrigation amount of sugar beet crop.

3- Water application efficiency (WAE %):

The average depths of the irrigation water stored in the root zone for two seasons through three replicates for both irrigation traditional and perforated tubes systems under treatment L_{100}, L_{75} and L_{50} depending on soil moisture content before and after each irrigation was 36.5 cm. The average actual ridges (double furrows) depths of irrigation water applied through traditional irrigation method were 75.6, 81.0 and 87.7 cm at L_{100}, L_{75} and L_{50} respectively. On the other hand, the average actual (double furrows) depths of irrigation water applied through irrigation using perforated tubes system were 42.6, 43.3 and 44.9 cm at L_{100}, L_{75} and L_{50} respectively. The average values of water application efficiency (WAE) of sugar beet during two season for traditional irrigation (T1) and irrigation with perforated tubes system (T2) were affected by different ridges (double furrows) lengths as shown in Fig. (9).

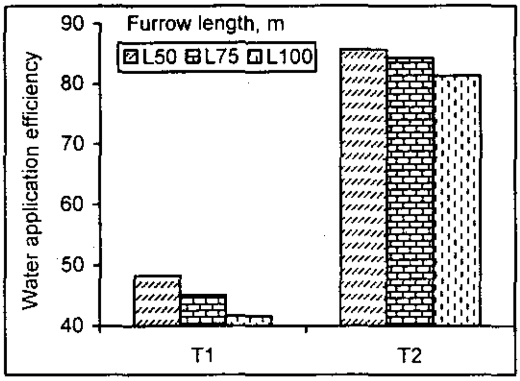

Fig. 9: Effect of irrigation systems and ridges (double furrows) lengths on the water application efficiency.

The figure show that the average values of water application efficiency for traditional irrigation were affected by ridges (double furrows) lengths were 48.3, 45.1 and 41.6 % at L_{100}, L_{75} and L_{50} respectively. Dealing with the irrigation with perforated tubes system (T2), the average values of water application efficiency were affected by ridges (double furrows) lengths were 85.7, 84.3 and 81.3 % at L_{100}, L_{75} and L_{50} respectively. The results revealed that the maximum value of water application efficiency for traditional irrigation method was achieved in case of L_{50} due to increase total water consumption use in the two other treatments L_{75} and L_{100} due to increase water irrigation losses by runoff, deep percolation and evaporation. On the other hand, increasing opportunity time increases water losses by evaporation and seepage. The maximum value of water application efficiency for the irrigation with perforated tubes was achieved in the case of L_{50} and L_{75} more than L_{100} due to increased water irrigation losses by deep percolation and seepage as ridges (double furrows) lengths increased. The results indicate that the water application efficiency for irrigation with perforated tubes system, increased of about 5.5 % at L_{50} and L_{75} over than L_{100}. On the other hand, the increasing in water application efficiency for irrigation with perforated tubes was larger than the values of water application efficiency achieved by traditional irrigation under the three cases of

L_{100}, L_{75} and L_{50} due to increased total irrigation water amounts consumed per feddan at the same condition of using perforated tubes system.

In conclusion, the result revealed that the traditional irrigation (T1) under different treatments of ridges (double furrows) lengths gave lower water application efficiency than irrigation using perforated tubes system (T2). Also, L_{50} and L_{75} by using perforated tubes system gave the highest water application efficiency due to the decrease in the water irrigation losses by deep-percolation, evaporation and run-off by high quality LASER technique land leveling at 0.1 % slop, closed conduit to carry water to the field and fine irrigation water distribution along the ridges (double furrows) over the upper part of the field through outlets.

4- Water distribution efficiency (WDE):

The average values of water distribution efficiency (WDE) for two seasons through three replicates of sugar beet crop calculated according to equation (14) for traditional irrigation method (T1) and irrigation using perforated tubes system (T2) were affected by different ridges (double furrows) lengths as shown in Fig. (10).

The average values of WDE in the case of traditional irrigation (T1) affected by ridges (double furrows) lengths were 89.2, 88.6 and 83.5% at L_{100}, L_{75} and L_{50} respectively. Dealing with the irrigation using perforated tubes system (T2), the average values of WDE, affected by ridges (double furrows) lengths, were 97.1, 96.0 and 93.2% at L_{100}, L_{75} and L_{50} respectively.

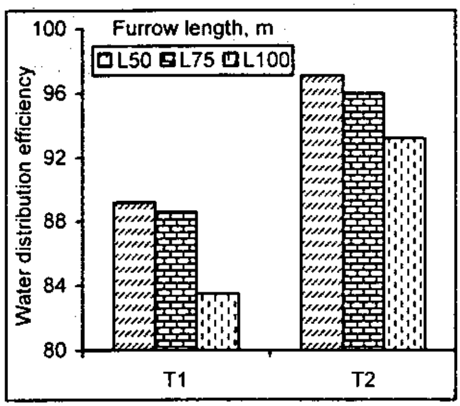

Fig. (10): Effect of irrigation systems and ridges (double furrows) lengths on the water application efficiency of sugar beet crop.

The data also indicated that the ridge (double furrows) L_{50} m realized the maximum values of water distribution efficiency (WDE) compared with the furrow L_{75} and L_{100} m for all different irrigation systems and land leveling methods. The values of water distribution efficiency took the same trend of two planting seasons for all the other variables under study. The values of water distribution efficiency in cases of using irrigation perforated tubes system with LASER land leveling technique at 0.1% slope at three cases of ridges (double furrows) lengths increased of 8.6, 8.4 and 11.6 % than conventional irrigation system respectively.

As regards irrigation method, it is worthy to mention that using irrigation perforated tubes system with LASER land leveling technique at 0.1% slope (T2) and ridge (double furrow) L_{50} m achieved the highest values of water distribution efficiency, while the lowest one was obtained from the conventional irrigation system (T1) at ridge (double furrows) L_{100} m. It could be concluded that from the previous discussion that using irrigation perforated tubes system with LASER land leveling of 0.1% slope and the ridge irrigation (double furrows) L_{50} m recorded the maximum values of water distribution efficiency. This is due to decrease the water losses by deep percolation at this conditions compared with the other ranges from this variables.

Yield and yield component:

Under the traditional irrigation method (T1) the average highest values during the two planting seasons (2006/2007) and (2007/2008) of roots volume, roots and sugar yield were achieved in case of L_{50} ridge (double furrows), as shown in Table (5).

Table 5: Effect of irrigation systems and ridges (double furrows) lengths on sugar beet yield and yield component.

Treat.	Furrow length	Root volume, m^3			Root yield, Mg /fed			Sucrose ratio, %			Sugar yield, Mg /fed		
		S_1	S_2	Av.	S_1	S_2	Av.	S_1	S_2	Av.	S_1	S_2	Av.
T_1	L_{50}	580.3	520.4	550.35	26.3	25.8	26.05	18.3	18.2	18.25	4.6	4.8	4.7
	L_{75}	533.1	502.1	517.6	24.4	23.6	24.0	18.6	18.2	18.4	4.4	4.6	4.5
	L_{100}	512.2	483.3	497.75	21.6	21.1	21.35	18.7	18.5	18.6	4.3	3.7	4.0
T_2	L_{50}	750.2	733.6	741.9	30.5	29.6	30.05	18.8	18.6	18.7	5.6	5.5	5.55
	L_{75}	773.6	751.0	7621.3	33.8	32.1	32.95	18.95	18.8	18.875	6.26	5.94	6.1
	L_{100}	683.8	644.6	664.2	32.1	29.0	30.0	19.12	19.0	19.06	5.91	5.4	5.5

S_1: planting season 2004/2005. S_2 : planting season 2005/2006.

The average values of (T1) during the two seasons of roots volume, roots and sugar yield at ridge (double furrows) L_{50} were 550.35 cm^3, 26.05 ton/fed and 4.70 Mg/fed, respectively. On the other hand increasing ridges (double furrows) L_{75} and L_{100} in case of (T1) decreasing the average values during the two seasons of roots volume, roots and sugar yield of about 6 % and 9 %, 8 % and 18 % and 4.3 % and 15.0 % respectively.

Dealing at case of (T2) the irrigation with perforated tubes system using LASER technique in land leveling at 0.1% slope, the average highest values during the two planting seasons (2006/2007) and (2007/2008) of roots volume, roots and sugar yield were achieved in case of L_{75} ridge (double furrows) L_{75}. The averages values of (T2) during the two seasons of roots volume, roots and sugar yield at ridge (double furrows) L_{75} were 751.0 cm^3, 32.95 ton/fed and 6.1 Mg/fed, respectively. The average lowest values of roots volume, roots and sugar yield were achieved in case of L_{100} ridge (double furrows). Therefore, in case of (T2) ridges lengths L_{50} and L_{100} the average values of roots volume, roots and sugar yield decreasing of about 2.7 and 13.0%, 8.8% and 9.0% and 9% and 10% respectively.

Concerning the effect of (T1) and (T2) the average highest values during the two planting seasons (2006/2007) and (2007/2008) of roots volume, roots and sugar yield were achieved in case of using irrigation perforated tubes technique with leveling by LASER technique 0.1 % slope at three cases of ridges lengths

(L_{100}, L_{75} and L_{50}). The average values of roots volume, roots and sugar yield at (T1) in cases of L_{100}, L_{75} and L_{50} increases than (T2) at three cases of ridges lengths by about (25.8, 32.1 and 125.1), (13.3, 27.2 and 28.8) and (15.3, 26.2 and 27.3) respectively which may be due to the improved water distribution along the furrow. From the above mentioned discussion, it could be concluded that using perforated tubes system at ridge (double furrows) L_{75} and after LASER land leveling with 0.1 % slope for the monogerm sugar beet gives the highest values of root volume, sugar and root yield of sugar beet crop.

5- Water use efficiency (WUE)

The average values of water use efficiency (WUE) of two seasons through replicates of sugar beet yield for traditional irrigation method (T1) and irrigation using perforated tubes system (T2) were affected by different ridges (double furrows) lengths as shown in Fig. (11).

The average values of WUE in the case of traditional irrigation affected by ridges (double furrows) lengths were 8.2, 7.1 and 5.8 kg/m^3 at L_{100}, L_{75} and L_{50} respectively. Dealing with the irrigation using perforated tubes system, the average values of WUE, affected by ridges (double furrows) lengths, were 16.81, 18.12 and 17.5 kg/m^3 at L_{100}, L_{75} and L_{50} respectively. The results revealed that the maximum value of WUE for traditional irrigation was achieved in the case of L_{50}. However, the maximum value of WUE for the irrigation with perforated tubes system was achieved in the case of L_{75}. The minimum value of WUE for the irrigation with perforated tubes in the case of L_{100}. Concerning the effect of using perforated tubes system or irrigation traditional method on the WUE, the results showed that the best WUE obtained in the case of perforated tubes over traditional irrigation due to decreased water irrigation losses by deep-percolation, evaporation and run-off by fine land leveling of 0.1 % slope, closed conduit to carry water to the field and good water distribution along the upper part of the field through perforated tubes system. On this basis, data revealed (T1) decreased the WUE of sugar beet yield by 51.2, 60.8 and 66.9 % at L_{100}, L_{75} and L_{50} respectively compared with the irrigation perforated tubes. The results revealed that irrigation with perforated tubes improved yield WUE for sugar beet crop at three treatments of ridges (double furrows) lengths compared to the traditional irrigation.

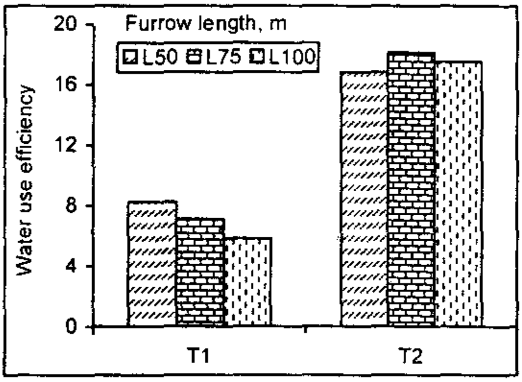

Fig. 11: Effect of irrigation systems and ridges (double furrows) lengths on the water use efficiency.

CONCLUSION

From the obtained results can be recommended that using irrigation perforated tubes system with LASER land leveling technique at 0.10 slope and the ridge (double furrows) length of 75 m gives a highest values of sugar beet production (values of root volume, sugar and root yield of sugar beet crop) and also, a highest values of WAE, WDE and WUE and saving about 46.3% of water application than conventional irrigation methods with traditional land leveling at 0.0% slope under three treatments of ridges (double furrows) lengths because of good laser technique land leveling at 0.1 % slop, closed conduit to carry water to the field and good uniformity of water application gives good water distribution from outlets along the ridges (double furrows) width over the upper part of the field through outlets decreased the water losses by seepage, deep percolation and runoff due to the advance time and opportunity time decreased and also, decreased losses by evaporation.

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انتاجية محصول بنجر السكر تحت نظام الانابيب المثقبة في الوادي

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يعتبر بنجر السكر من المحاصيل الهامة التي تتجه الدولة الي التوسع في زراعته ورفع انتاجيته لزيادة إنتاج السكر, نظرا لقصر موسم نموه وقلة احتياجاته المائيه مقارنة بقصب السكر. ويعد محصول بنجر السكر من المحاصيل الحساسة جدا للماء وذلك من حيث الزيادة أو النقص, فزيادة كميات المياه تؤدي الي موت البادرات, وفي مرحلة تكوين الجذور تؤدي الي تعفن الجذور, وفي كثير من الحالات تؤدي الي اختناق النبات وتشعب الجذور وبالتالي انخفاض انتاجية المحصول والجودة. لذا فانه من الاهمية توفير مياه الري واحكام عمليات الري في جميع مراحل نمو المحصول. لذلك يهدف البحث الي دراسة تأثير استخدام كل من نظامي الري السطحي التقليدي تحت ظروف التسوية التقليدية ونظام الري بالأنابيب المثقبة تحت ظروف التسوية الدقيقة بإستخدام أشعة الليزر عند نفس المستويات من أطوال مصاطب (خط مزدوج) الري وذلك علي انتاجية محصول بنجر السكر وحيد الاجنة وخصائص محصول بنجر السكر.

أجريت التجارب البحثية بمحطة البحوث الزراعية بسخا- (مركز البحوث الزراعية) – محافظة كفر الشيخ خلال موسميين زراعيين متتالين (٢٠٠٦/٢٠٠٧)، (٢٠٠٧/٢٠٠٨) في أرض طينية القوام، لمحصول بنجر السكر، وإشتملت على: تصميم نظام الري بالانابيب المثقبة الذي يتلائم مع ري محصول بنجر السكر المزروع علي المصاطب علي مسافات ١,٠ متر حتي يمكن التنبؤ باقطار فتحات المخارج علي امتداد نظام الري بالانابيب المثقبة لتعطي التصرف المطلوب لكل متر عرض (٢ لتر/ث). وتجارب حقلية لمعايرة النظام المصمم تحت عوامل دراسة الرى السطحي التقليدي مع التسويه بالطرق التقليدية افقيا تماما اي بميول صفر% باستخدام القصابيات الهيدروليكية من خلال الري بالمصاطب (خط مزدوج) تحت مستويات مختلفة لأطوال مصاطب (خط مزدوج) الري. ونظام الري بالانابيب المثقبة مع التسوية الدقيقة بالليزر بميول ٠,١% تحت نفس المستويات من أطوال مصاطب (خط مزدوج) الري. ودراسة التأثير علي انتاجية محصول بنجر السكر وحيد الاجنة (حجم الجذور- الانتاجية لمحصول الجذور للفدان- انتاجية محصول السكر للفدان) وكذلك علي كل من زمنى التقدم والانحسار وإجمالي كمية مياه الري المضافة وكلا من كفاءات الإضافة والاستخدام والتوزيع المائي لمحصول بنجر السكر.

ومن النتائج المتحصل عليها يمكن التوصية بأن إستخدام نظام الري بالانابيب المثقبة والتسوية الدقيقة بأشعة الليزر بميول ٠,١% عند أطوال مصاطب ٧٥ مترا يعطي أعلي قيمة للمحصول سواء الجذور أو السكر وكذلك حجم الجذور كما وأنه يعطي أعلي كفاءة اضافه مياه وأعلي كفاءة توزيع واستخدام للمياه ويرجع ذلك الي التسوية الدقيقة للتربة باسخدام اشعة الليزر بميول ٠,١% واستخدام نواقل للمياه مغلقة وتوزيعها بواسطة نظام الري بالانابيب المثقبة التي تعمل علي خروج المياه المتماثلة علي امتداد عرض الحقل مما يؤدي الي نقص الفقد في المياه عن طريق البخر ويؤدي توزيع المياه علي امتداد عرض الحقل عند رأسه الي زيادة تماثل توزيع المياه وزيادة كفاءة الري.