EFFECT OF DIFFERENT SURFACE AND DRIP IRRIGATION SYSTEMS ON SUGAR BEET YIELD, IRRIGATION PERFORMANCES AND SOIL SALINITY AT NORTH DELTA.
Sonbol, H.A.1; E.M. El-Hadidi1; M.M. Said2 and H.M. Abo El- Soud2
1- Soil Sci. Dept., Fac. of Agric., Mansoura Univ.
2- Soil, Water and Environment Institute, Agricultural Research Center

ABSTRACT

A surface drip irrigation (single lateral, SSDI, or double laterals/plant row, DSDI), subsurface drip irrigation (single lateral, SSSDI, or double laterals/plant row, DSSDI), gated pipes (GP) and traditional surface irrigation (TSI) were applied with sugar beet (variety Raspoly) during the winter season 2007/2008 at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate, Egypt in order to study the effect of these irrigation systems on sugar beet yield, its quality, irrigation performances and soil salinity. Both drip irrigation systems included 16 mm diameter drip-lines, with emitters discharging about 2L/h and spacing 0.5 m. The subsurface drip irrigation system was installed before the crop seeding, where its laterals (16 mm drip-lines) were buried 0.6 m apart at 15cm below soil surface so that they are not affected by the cultivation practices during the current growing season. The aluminum gated pipes (150 mm diameter) were located at the head of the irrigated field and connected directly with the irrigation pump.

The design of this experiment was randomized complete blocks (RCB) with six replicates.

The following findings could be summarized as follows:

- The highest root, sugar yield, sucrose percentage and quality of juice were produced when sugar beet plants were irrigated by gated pipes. While the lowest root and sugar yield were achieved with irrigation by double line of subsurface drip irrigation.
- The highest content of K % was obtained when sugar beet plants received the lowest amount of irrigation water. While, the lowest one was recorded with plants received the highest amount of irrigation water.
- Na % and amino N % in Juice: The different irrigation systems had insignificant effect on Na and amino N % in Juice.
- Water applied was obviously affected by irrigation systems. The DSSDI system was more effective since it received the lowest amount of irrigation water (2074.8 m³/fed) followed by SSSDI (2230.2 m³/fed) DSSDI system (2255.4 m³/fed). On the other hand, TSI system received the highest amount of irrigation water (3150 m³/fed) followed by GP system (2692.2 m³/fed).
- The highest values of field water use efficiency are obtained with SSSDI or DSSDI, respectively. While, the lowest value is given by TSI system. Also, the highest values of crop water use efficiency are achieved with SSSDI, GP and DSSDI system. The lowest values of crop water use efficiency for root are recorded with SSDI, DSDI and TSI system.
- The irrigation by GP and SSDI systems achieved the highest values of water distribution efficiency. While, subsurface drip irrigation system (single or double laterals) recorded the lowest distribution efficiency. On the other hand, surface drip irrigation system achieved the highest values of distribution uniformity with single or double laterals/plant row respectively. While, the lowest distribution uniformity value is recorded with single subsurface drip laterals.
• The soil salinity values are increased with depth for surface drip irrigation (single or double laterals), gated pipes and traditional surface irrigation. While with subsurface drip irrigation (single or double laterals), the values are decreased with the depth to 60 cm and then increased again in the last deepest layer (60-90 cm).

**Keywords**: surface and drip irrigation, sugarbeet, salinity.

**INTRODUCTION**

The available water in Egypt is limited by Nile water agreement with Sudan in 1959 which allowed a share of 55.5 BCM at Aswan.

With the increase of population and food requirements, the greatest challenge is striking a balance between limited water supplies and obtaining higher yield. Therefore, to make best use of water for agriculture, improving irrigation efficiency is prerequisite for the future.

It is necessary to manage available irrigation water supplies as efficiently as possible; irrigation management is one way to achieve the goal of maximizing water use efficiency.

It is a must to improve surface irrigation systems by many options have high efficiencies such as gated pipes, on-surface and subsurface drip irrigation and sprinkler irrigation systems.

In this connection, Shalhevet (1984) found that the choice irrigation system may be guided three consideration i.e. the distribution of salts and waters in the soil, crop sensitivity to foliar wetting and the extent of the damage to yield and the ease with which high salt and matric potential can be maintained in the soil.

Moore and Fitschen (1990) reported that the subsurface trickle irrigation system caused better water distribution and better water management. They also added that the net yield increased, compared with that in furrow irrigation system.

Singh-Saggau and Kaushal (1991), found that the plant root zone under trickle system remained almost salt free, while the high EC values were recorded in it under the furrow system.

El-Marazky (1996) concluded that trickle irrigation decreased water requirement by 30-40 % from total seasonal consumptive use comparing to furrow system.

Abo Soliman et al (2008) reported that the grain yield of wheat and soybean crops were significantly increased with gated and concrete pipes and with shorter border length and width. Grain yield under gated and concrete pipes, respectively, were higher than under traditional field ditch by about 8.0 and 3.0 % of wheat and 9.0 and 7.0 % of soybean.

Saied et al (2008) found that irrigation by surface drip resulted in increasing the seed yield of soybean by 18.84 %, 37.68 %, 17.39 %, 11.59 % and 4.35 % compared to semi portable, gun, minisprinkler, floppy, and subsurface drip systems, respectively.

Sugar beet (*Beta vulgaris*, L.) plays a prominent role for sugar production in the world. However, this crop has attracted the attention in Egypt for sugar production in the last ten years only and the government is pushing hard to increase the areas those devoted to sugar beet as well as the root and sugar yield per unit area. This could be achieved through using
the best irrigation systems and adopting agricultural practices for this important crop.

Sugar beet could be efficiently grown under a wide range of irrigation water level where it is readily adapted to limited irrigation because plants utilize deep stored soil water and recover quickly following water stress (Winter, 1980). Mohamed et al. (2000) found that the maximum root and sugar yield as well as water use efficiency (kg root and / or sugar/m³ water) were significantly obtained when sugar beet watered constantly at 65% of the field capacity.

Osman (2000) found that a feasible practice to attain water conservation and increase irrigation water use efficiency by using gated pipes for irrigation.

Jibin and Faroud (2007) found that the gated pipes system for basin irrigation can improve the uniformity of salt leaching . There is a good potential for irrigation with saline water.

Abou El Alzem (2005) showed that total soluble salts are increased significantly with surface trickle, subsurface trickle and low pressure sprinkler systems. While it decreased significantly with medium pressure sprinkler and modified furrow system. It increased significantly also with increasing distances from the emitter the sprinkler or the bottom or furrow, soil layers depths and used time for all irrigation systems. The obtained results indicated that the maximum sugar beet root yield (35.1 ton/fed), sucrose (21.78%) and amount of consumptive use (559.91 mm/fed) were produced when using the minimum amount of irrigation water applied (559.9 mm/fed) as an average of both studied seasons with subsurface trickle irrigation system

The current work aims to evaluate some surface and drip irrigation systems to clarify their effects on sugar beet yield, some irrigation performances and salt distribution.

MATERIALS AND METHODS

Field experiment was conducted during winter season 2007/2008 in Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate ( 6 m altitude, 31° 07’ latitude and 30° 52’ longitude ). The area of 4400 m² experimental field was divided into six plots to be occupied by the studied irrigation systems (550 m² for drip each one of four systems and 1100 m² for gated pipes and the same area for traditional systems). Each experimental plot was 16 rows, of 0.60 m apart for each (across the crop rows) and 55 m long (along of the crop rows)

The subsurface laterals were buried at a depth of 0.15 m, so that they are not affected by plowing and other agricultural practices. The drip irrigation network consisted of a main delivery pipe (63 mm in diameter). The drip laterals were 16 mm polyethylene pipes with in-line self-regulated emitters with discharge rate of about 2 liter/hr. The gated pipes are 150 mm diameter aluminum pipes with slide gates at 0.75 m spacing (3.0 m³/h discharge for each).The pipes are located at the head of the irrigated field across the furrows and connected directly with the water pump.
So, the irrigation systems under this study are: Four drip irrigation systems and two surface irrigation systems were used in this study as follows:

2. Double surface drip irrigation laterals/crop row ………..(DSDI).
4. Double subsurface drip irrigation laterals/crop row………..(DSSDI).
5. Gated pipes………………………………………………..(GP).
6. Traditional surface irrigation as a control…………………..(TSI).

Some chemical analysis of soil paste extract were done according to Black (1965) and some physical properties of soil were determined according to Garcia (1987). The chemical, physical and moisture characteristics of the experimental soil are shown in Tables 1, 2 and 3.

**Table 1:** Some physical and chemical properties of the experimental soil.

<table>
<thead>
<tr>
<th>Soil depth (cm)</th>
<th>Particle size distribution (%)</th>
<th>Texture class</th>
<th>OM %</th>
<th>Total CaCO₃ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>Silt</td>
<td>Clay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 – 30</td>
<td>18.9</td>
<td>33.7</td>
<td>47.4</td>
<td>Clay</td>
</tr>
<tr>
<td>30 – 60</td>
<td>16.6</td>
<td>34.2</td>
<td>49.2</td>
<td>Clay</td>
</tr>
<tr>
<td>60 – 90</td>
<td>17.0</td>
<td>35.1</td>
<td>47.9</td>
<td>Clay</td>
</tr>
</tbody>
</table>

**Table 2:** Soil moisture characteristics of the experimental soil.

<table>
<thead>
<tr>
<th>Soil depth(cm)</th>
<th>Field capacity (%)</th>
<th>Wilting point(%)</th>
<th>Available water(%)</th>
<th>Bulk density (g cm⁻³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-30</td>
<td>42.6</td>
<td>20.4</td>
<td>22.2</td>
<td>1.14</td>
</tr>
<tr>
<td>30-60</td>
<td>39.2</td>
<td>22.5</td>
<td>16.7</td>
<td>1.24</td>
</tr>
<tr>
<td>60-90</td>
<td>35.7</td>
<td>20.6</td>
<td>15.1</td>
<td>1.28</td>
</tr>
<tr>
<td>Average</td>
<td>39.17</td>
<td>21.17</td>
<td>18.00</td>
<td>1.22</td>
</tr>
</tbody>
</table>

**Table 3:** Chemical analysis of soil paste extract of the experimental soil.

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>ECE dSm⁻¹</th>
<th>Soluble cations meq L⁻¹</th>
<th>Soluble anions meq L⁻¹</th>
<th>SAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>K⁺</td>
<td>Ca²⁺</td>
<td>Mg²⁺</td>
<td>CO₃⁻</td>
</tr>
<tr>
<td>0-30</td>
<td>2.48</td>
<td>14.8</td>
<td>0.5</td>
<td>7.2</td>
</tr>
<tr>
<td>30-60</td>
<td>2.36</td>
<td>13.9</td>
<td>0.5</td>
<td>6.9</td>
</tr>
<tr>
<td>60-90</td>
<td>2.68</td>
<td>16.5</td>
<td>0.6</td>
<td>7.2</td>
</tr>
</tbody>
</table>

Sugar beet (Variety Raspoly) was planted on December, 4ᵗʰ, 2007 and harvested on May, 20ᵗʰ, 2008.

All agricultural practices and fertilization rates were performed according to the traditional recommendations in North Delta area. The recommended dose of NPK chemical fertilizers for sugar beet were added(80 kg N, 15.5 kg P₂O₅ and 48 kg K₂O fed⁻¹) from the same fertilizers forms.

All plots were irrigated when 50% of the available water was depleted using TDR apparatus. The yield of each replication (three crop rows by 2.33 m long) was collected manually and weighed making a total harvested area of 4.2 m² for each replication.
Root yield of sugar beet plants was determined for all treatments at maturity stage as ton/ha.

Sucrose concentration and juice purity (%) were determined in Delta Sugar Limited Company at El-Hamouli, Kafr El-Sheikh Governorate for all treatments.

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

Statistical analysis: the yield and yield qualities of sugar beet were subjected to the statistical analysis according to Snedecor and Cochran (1967) and the mean values compared by LSD test.

**Studied characters:**

1. **Irrigation water applied (wd) and irrigation time:**
   - The amounts of irrigation water applied and irrigation time (hr/plot) for each irrigation system were measured using soil moisture content just before irrigation for the required soil depth, field capacity of soil and available water discharge for each irrigation systems. The net depth of water applied for drip irrigation was determined according to Phocaides (2001) as follow:
     
     Net depth of irrigation water (DWs) in mm = \( f \times (fc - wp) \times db \times Ds \times P \).

     While the net depth of water applied for surface irrigation was determined according to the following equation:
     
     Net depth of irrigation water (DWs) in mm = \( f \times (fc - wp) \times db \times Ds/100 \).

     Where:
     
     \( fc \) = field capacity (%).
     
     \( wp \) = wilting point (%).
     
     \( f \) = permissible depletion
     
     \( db \) = bulk density (g cm\(^{-3}\))
     
     \( Ds \) = soil layer (cm)
     
     \( P \) = ground cover (%)

     In addition, the discharge of the dripper, gates (of gated pipes) and water pump were measured to calculate the irrigation time for each irrigation system.

2. **Water consumptive use (CU):**
   - It was calculated according to Hansen et al., (1979)
     
     \[ CU = \frac{\theta_2 - \theta_1}{ Db \times D } \times 100 \]

     Where:
     
     \( CU \) = Actual water consumptive use of the growing plants, cm depth
     
     \( \theta_1 \) = Mean Soil moisture percentage for the 60 cm soil depth, 48 hours before the next irrigation.
     
     \( \theta_2 \) = Soil moisture content (%) after irrigation.
     
     \( Db \) = Bulk density (g cm\(^{-3}\)).
     
     \( D \) = Layer depth in cm.

3. **Irrigation application efficiency (Ea):**
   - Irrigation application efficiency for each treatment was computed according to Downy (1970) using the following equation:
     
     \[ Ea (\%) = \frac{Ws}{Wd} \times 100 \]
Where:
- $E_a =$ water application efficiency (\%).
- $W_s =$ water stored in the effective root zone (cm).
- $W_d =$ water applied with different treatments (cm).

4. Water distribution efficiency:
Water distribution efficiency was calculated according to James (1988) as follows:

$$Ed = (1 - y / d) \times 100.$$  

Where:
- $Ed =$ water distribution efficiency (\%).
- $d =$ average depth of soil water stored along the furrow during the irrigation.
- $y =$ average numerical deviation from $d$.

5. Crop water use efficiency (CWUE):
It was calculated in kg/m$^3$ for different irrigation systems as follows:

$$CWUE = \frac{Y}{W_{cu}}.$$  

Where:
- $Y =$ grain yield (kg / fed.).
- $W_{cu} =$ total water consumed in m$^3$ / fed.

6. The field water use efficiency (FWUE):
It was calculated in kg/m$^3$ for different irrigation systems to clarify how much kg yield is produced from one cubic meter applied (Michael, 1978) as follows:

$$FWUE = \frac{Y}{W_a}.$$  

Where:
- $Y =$ total yield produced (kg / fed.).
- $W_a =$ total applied water (m$^3$ / fed.).

7. Soil salinity distribution.
Soil salinity distribution was evaluated for each treatment.

RESULTS AND DISCUSSION

Sugar beet yield and it’s quality

1- yield of root and sugar:
Results presented in Table 4 show the root yield in ton/fed and sugar yield in ton/fed, as affected by different irrigation systems. It is obvious from the results that root yield and sugar yield were increased significantly when sugar beet was subjected to irrigation with gated pipes method followed by traditional surface irrigation and the reduction in root and sugar yield were more pronounced with irrigation by double lines of surface drip irrigation and single line of surface drip irrigation and double line of sub surface drip irrigation, respectively. Moreover, the highest root yield (19.27 ton/fed) and sugar yield (2.57 ton/fed) were produced when sugar beet plants were irrigated by gated pipes. While, the lowest root and sugar yield were achieved with irrigation by double line of subsurface drip irrigation. The increase in root

412
yield by irrigation with gated pipes might be attributed to be the favorable effect of maintaining soil moisture in the effective root zone.

2- **Sucrose percentage:**

The sucrose percentage in sugar beet roots is significantly affected by the different irrigation systems. The highest sugar content in the roots is achieved with gated pipes (13.32%) and traditional surface irrigation (13.42%). While the lowest sugar content is recorded with single lateral of surface drip irrigation (12.13%).

These results are in a good agreement with those obtained by Abo Soliman et al. (2008) and Saied et al. (2008).

3. **K% in juice :**

Data in Table 4 show that the different irrigation systems had highly significant effect on K%. The obtained data revealed that the highest value is recorded with SSDI system (6.88%). While the lowest values of K content in root juice were found with surface irrigation systems (5.85% with GP and 5.95% with TSI system).

It is clear that the highest content of K% was obtained when sugar beet plants received the lowest amount of irrigation water. While, the lowest one was recorded with plants received the highest amount of irrigation water.

4. **Na and amino N% in juice :**

Data in Table 4 declared that the different irrigation systems had insignificant effect on Na and amino N % in juice.

5. **Quality of juice :**

The obtained results in Table 4 indicate that the quality of juice is highly significantly affected by irrigation systems. Irrigation by gated pipes (67.3%) and traditional surface irrigation (66.3%) have the highest quality level, respectively. While the lowest juice quality is recorded with SSDI system (56.9%). It could be observed from the data that positive relation is found between sucrose content (%) and juice quality while a negative relation is found between both K% and Na % with both of sucrose content and the quality of juice. Also, the values of these parameters with different irrigation systems may be related to the amounts of water applied with each system.

The obtained results are in a close agreement with those found by Winter (1990) and Abo Soliman et al (1996).

**Table 4: Sugar beet yield and its quality as affected by studied irrigation systems.**

<table>
<thead>
<tr>
<th>Irrigation systems</th>
<th>Root (ton/ha)</th>
<th>Sugar (%)</th>
<th>Sugar (ton/ha)</th>
<th>K (%)</th>
<th>Na (%)</th>
<th>Amino N (%)</th>
<th>Quality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSDI</td>
<td>16.93</td>
<td>12.13</td>
<td>2.054</td>
<td>6.88</td>
<td>5.67</td>
<td>2.94</td>
<td>56.9</td>
</tr>
<tr>
<td>DSDI</td>
<td>16.82</td>
<td>12.81</td>
<td>2.155</td>
<td>6.14</td>
<td>5.42</td>
<td>2.88</td>
<td>64.6</td>
</tr>
<tr>
<td>SSSDI</td>
<td>18.83</td>
<td>12.92</td>
<td>2.430</td>
<td>6.57</td>
<td>5.40</td>
<td>2.89</td>
<td>58.8</td>
</tr>
<tr>
<td>DSSDI</td>
<td>16.25</td>
<td>12.43</td>
<td>2.028</td>
<td>6.22</td>
<td>5.36</td>
<td>2.84</td>
<td>61.9</td>
</tr>
<tr>
<td>GP</td>
<td>19.27</td>
<td>13.32</td>
<td>2.567</td>
<td>5.85</td>
<td>5.20</td>
<td>2.92</td>
<td>67.3</td>
</tr>
<tr>
<td>TSI</td>
<td>18.39</td>
<td>13.42</td>
<td>2.478</td>
<td>5.95</td>
<td>5.51</td>
<td>3.00</td>
<td>66.3</td>
</tr>
<tr>
<td>F test</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>ns</td>
<td>ns</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>LSD 0.05</td>
<td>1.16</td>
<td>0.521</td>
<td>0.207</td>
<td>0.435</td>
<td>-</td>
<td>-</td>
<td>2.208</td>
</tr>
<tr>
<td>LSD 0.01</td>
<td>1.60</td>
<td>-</td>
<td>0.286</td>
<td>0.602</td>
<td>-</td>
<td>-</td>
<td>3.053</td>
</tr>
</tbody>
</table>
Some water relations:
1- Amount of water applied:

Data in Table 5 indicated the amount of water applied to different irrigation systems. These values were found to be 2310, 2255.4, 2230.2, 2074.8, 2692.2, and 3150 m³/fed for SSDI, DSDI, SSSDI, DSSDI, GP and TSI systems, respectively. The lowest values are achieved under DSSDI system.

On the other hand, the highest value was recorded with TSI system. The reduction in water applied may be due to the drip irrigation method which reduces the deep percolation, evaporation and runoff.

It is worthy to mention, that water saving percentages were 26.67, 28.40, 29.20, 34.13 and 14.53% under SSDI, DSDI, SSSDI, DSSDI and GP compared to TSI. These results are in agreement with those obtained by El-Marazky (1996) who concluded that trickle irrigation decreased water requirements by 30 – 40% comparing to furrow irrigation system.

2- Actual water consumptive use for sugar beet:

From the obtained data, it could be noticed that the highest value of water consumptive use by sugar beet is recorded with traditional surface irrigation system, while the lowest value is detected with DSSDI system.

The mean values of water consumptive use were found to be 2041.2, 1995.0, 1839.6, 2125.2 and 2146.2 m³/fed for SSDI, DSDI, SSSDI, DSSDI, GP and TSI systems, respectively (Table 5).

Table 5: Some water relations as affected by different irrigation systems

<table>
<thead>
<tr>
<th>Irrigation system</th>
<th>Root yield (kg fed⁻¹)</th>
<th>Water applied (m³ fed⁻¹)</th>
<th>Water saving %</th>
<th>Water consum. use (m³ fed⁻¹)</th>
<th>FWUE* (kg m⁻³)</th>
<th>CWUE** (kg m⁻³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSDI</td>
<td>16930</td>
<td>2310</td>
<td>26.67</td>
<td>2041.2</td>
<td>7.33</td>
<td>8.29</td>
</tr>
<tr>
<td>DSDI</td>
<td>16820</td>
<td>2255.4</td>
<td>28.4</td>
<td>1995</td>
<td>7.46</td>
<td>8.43</td>
</tr>
<tr>
<td>SSSDI</td>
<td>18830</td>
<td>2230.2</td>
<td>29.2</td>
<td>1965.6</td>
<td>8.44</td>
<td>9.58</td>
</tr>
<tr>
<td>DSSDI</td>
<td>16250</td>
<td>2074.8</td>
<td>34.13</td>
<td>1839.6</td>
<td>7.83</td>
<td>8.83</td>
</tr>
<tr>
<td>GP</td>
<td>19270</td>
<td>2692.2</td>
<td>14.53</td>
<td>2125.2</td>
<td>7.16</td>
<td>9.07</td>
</tr>
<tr>
<td>TSI</td>
<td>18390</td>
<td>3150</td>
<td></td>
<td>2146.2</td>
<td>5.84</td>
<td>8.57</td>
</tr>
</tbody>
</table>

* FWUE: Field water use efficiency.
** CWUE: Crop water use efficiency.

3-Field and crop water use efficiencies:

Data of field and crop water use efficiencies are presented in Table 5. These efficiencies determine the capability of plants to convert the applied or consumed water to crop yield. The average values of field water use efficiency (FWUE) are 7.33, 7.46, 8.44, 7.83, 7.16 and 5.84 kg root/m³ of water applied for SSDI, DSDI, SSSDI, DSSDI, GP and TSI systems, respectively. So, the highest value of FWUE (8.49 kg/m³) is obtained with SSSDI. While, the lowest value (5.84 kg m⁻³) is given by TSI system.

Concerning the crop water use efficiency (CWUE) in terms of kg root/m³ of water consumed, the data revealed that the highest values are achieved with SSSDI, GP and DSSDI systems (9.58, 9.07 and 8.84 kg/m³), respectively.

On the contrary, the lowest values of CWUE for root are recorded with SSDI, DSDI and TSI systems (8.30, 8.44 and 8.57 kg m⁻³, respectively).
These results are in somewhat agree with those obtained by Osman (2000) and El-Hendawy et al. (2008).

4- Irrigation application efficiency (%):

Water application efficiency is one of the most important criteria used to describe field irrigation efficacy. The high value of water application efficiency means less values of deep percolation below the crop root zone and surface runoff at the tail end of furrows. Generally, irrigation application efficiency value increases as the amount of water applied decreases each irrigation.

The calculated values of water application efficiency as affected by different irrigation systems are presented in Table 6. The average values are 90.6, 92.3, 90.8, 96.2, 79.5 and 71.7 % for SSDI, DSDI, SSSDI, DSSDI, GP and TSI systems, respectively (Table 6). It is obvious from the data that the maximum values of water application efficiency (96.2%) are obtained from DSSDI system. The minimum irrigation application efficiency (71.7 %) is obtained from TSI system. These findings are for somewhat in harmony with those obtained by Osman (2002).

5-Water distribution efficiency (DE%) and distribution uniformity(DU %):

Water distribution efficiency and distribution uniformity as affected by different irrigation systems are listed in Table 6. The obtained results revealed that the gated pipes system achieved the highest value of DE (92.6). While subsurface drip irrigation system (single or double laterals) recorded the lowest DE value (74.5%).

Table 6: Irrigation application efficiency, water distribution efficiency and distribution uniformity as affected by different irrigation systems.

<table>
<thead>
<tr>
<th>No</th>
<th>Irrigation systems</th>
<th>Irrigation application efficiency (%)</th>
<th>DE %</th>
<th>DU %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single surface drip irrigation (SSDI)</td>
<td>90.6</td>
<td>88.8</td>
<td>94.4</td>
</tr>
<tr>
<td>2</td>
<td>Double surface drip irrigation (DSDI)</td>
<td>92.3</td>
<td>87.3</td>
<td>97.2</td>
</tr>
<tr>
<td>3</td>
<td>Single subsurface drip irrigation (SSSDI)</td>
<td>90.8</td>
<td>74.5</td>
<td>82.6</td>
</tr>
<tr>
<td>4</td>
<td>Double subsurface drip irrigation (DSSDI)</td>
<td>96.2</td>
<td>75.3</td>
<td>87.7</td>
</tr>
<tr>
<td>5</td>
<td>Gated pipes (GP)</td>
<td>79.5</td>
<td>92.6</td>
<td>89.0</td>
</tr>
<tr>
<td>6</td>
<td>Traditional surface irrigation (TSI)</td>
<td>71.7</td>
<td>89.0</td>
<td>86.0</td>
</tr>
</tbody>
</table>

On the other hand, surface drip irrigation system achieved the highest values of DU (94.4 and 97.2% with single or double laterals/plant row, respectively). Meanwhile, the lowest DU value is recorded with single subsurface drip laterals (82.6%). Therefore, surface drip irrigation is the suitable system especially with double laterals/plant row since it achieved a typical soil moisture uniformity (DE or DU values). While the soil moisture distribution value is not satisfied with subsurface drip irrigation systems where low values of DE and DU parameters are obtained.

This trend of these results are in agreement with those obtained by Jibin and foroud (2007).

6. Soil salinity:

The results of soil salinity after harvesting of sugar beet at head, middle and end of fields as affected by different irrigation systems are shown in
Sonbol, H.A. et al.

Table 7 and Figs 1-6. The obtained data revealed that the ECe values in different soil depths under different irrigation systems are lower than 4dSm\(^{-1}\). It could be observed from the obtained data that the differences in ECe mean values for different irrigation systems are relatively small. The values of ECe are increased with the depth for surface drip irrigation (single or double laterals), gated pipes and traditional surface irrigation while with subsurface drip irrigation (single or double laterals) the ECe values are decreased with the depth to 60 cm and then increased again in the last deepest layers (60-90 cm).

Table 7: Soil salinity distribution under different irrigation systems after harvesting of sugar beet crop.

<table>
<thead>
<tr>
<th>Irrigation system</th>
<th>Depth (cm)</th>
<th>Field head</th>
<th>Middle</th>
<th>End</th>
<th>Mean</th>
<th>Water applied M(^3)/fed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single surface drip (SSDI)</td>
<td>0-30</td>
<td>2.55</td>
<td>1.89</td>
<td>2.21</td>
<td>2.22</td>
<td>2308</td>
</tr>
<tr>
<td></td>
<td>30-60</td>
<td>2.73</td>
<td>2.70</td>
<td>2.19</td>
<td>2.54</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60-90</td>
<td>2.19</td>
<td>2.48</td>
<td>2.25</td>
<td>2.31</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>2.49</td>
<td>2.35</td>
<td>2.22</td>
<td>2.35</td>
<td>2308</td>
</tr>
<tr>
<td>Double surface drip (DSDI)</td>
<td>0-30</td>
<td>2.55</td>
<td>1.77</td>
<td>1.58</td>
<td>1.97</td>
<td>2255</td>
</tr>
<tr>
<td></td>
<td>30-60</td>
<td>1.95</td>
<td>2.78</td>
<td>1.94</td>
<td>2.22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60-90</td>
<td>1.71</td>
<td>3.00</td>
<td>1.89</td>
<td>2.20</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>2.07</td>
<td>2.52</td>
<td>1.80</td>
<td>2.13</td>
<td>2255</td>
</tr>
<tr>
<td>Single subsurface drip (SSSDI)</td>
<td>0-30</td>
<td>3.57</td>
<td>1.25</td>
<td>3.12</td>
<td>2.65</td>
<td>2231</td>
</tr>
<tr>
<td></td>
<td>30-60</td>
<td>2.19</td>
<td>2.01</td>
<td>1.71</td>
<td>1.97</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60-90</td>
<td>3.09</td>
<td>2.17</td>
<td>2.68</td>
<td>2.65</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>2.95</td>
<td>1.81</td>
<td>2.50</td>
<td>2.42</td>
<td>2231</td>
</tr>
<tr>
<td>Double subsurface drip (DSSDI)</td>
<td>0-30</td>
<td>3.15</td>
<td>3.18</td>
<td>2.63</td>
<td>2.99</td>
<td>2074</td>
</tr>
<tr>
<td></td>
<td>30-60</td>
<td>2.76</td>
<td>1.75</td>
<td>2.05</td>
<td>2.19</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60-90</td>
<td>3.59</td>
<td>1.66</td>
<td>1.95</td>
<td>2.40</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>3.17</td>
<td>2.20</td>
<td>2.21</td>
<td>2.52</td>
<td>2074</td>
</tr>
<tr>
<td>Gated pipe (GP)</td>
<td>0-30</td>
<td>1.59</td>
<td>1.65</td>
<td>1.88</td>
<td>1.71</td>
<td>1999</td>
</tr>
<tr>
<td></td>
<td>30-60</td>
<td>2.00</td>
<td>2.10</td>
<td>1.91</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60-90</td>
<td>3.15</td>
<td>1.59</td>
<td>2.04</td>
<td>2.26</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>2.25</td>
<td>1.78</td>
<td>1.94</td>
<td>1.99</td>
<td>2694</td>
</tr>
<tr>
<td>Traditional surface irrigation(TSI)</td>
<td>0-30</td>
<td>1.46</td>
<td>1.67</td>
<td>1.65</td>
<td>1.59</td>
<td>3250</td>
</tr>
<tr>
<td></td>
<td>30-60</td>
<td>2.51</td>
<td>1.76</td>
<td>1.50</td>
<td>1.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60-90</td>
<td>2.37</td>
<td>1.43</td>
<td>1.32</td>
<td>1.71</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>2.11</td>
<td>1.62</td>
<td>1.49</td>
<td>1.74</td>
<td>3250</td>
</tr>
</tbody>
</table>

In the top layer, the highest ECe values are observed with the subsurface drip system with single or double laterals/plant row (2.65 and 2.99 dSm\(^{-1}\), respectively), but the lowest ECe values are detected with the traditional surface irrigation and gated pipes systems (1.59 and 1.71 dSm\(^{-1}\), respectively). In case of the mean values of ECe for each irrigation system (as the mean of the three layers), the highest mean values are obtained with subsurface drip irrigation (2.42 and 2.52 dSm\(^{-1}\) for the single or double laterals/plant row, respectively).
Fig 1-6: Soil salinity distribution under different irrigation systems after harvesting of sugar beet.
Meanwhile, the lowest mean values of ECe are achieved with the gated pipes and traditional surface irrigation systems (1.74 and 1.99 dSm⁻¹, respectively). On the other hand, the mean value of ECe with the surface drip irrigation system is slightly lower than that recorded with the subsurface drip system (2.24 and 2.47 dSm⁻¹, respectively). This trend may be attributed to the amounts of irrigation water applied with each irrigation system.

These findings are in a good agreement with those observed by El-Sharkawy, Amal (2001), and Saied et al. (2008).

**Conclusion**

It can be recommended to use gated pipes as modified surface irrigation method to irrigate heavy clay soils especially under condition of salt affected soils, while subsurface drip irrigation can be used properly in case of water shortage.

**REFERENCES**


http://www.geocities.com/ResearchTriangle/Thinktank/2097/gatedpipe.htm 06/04/22
تأثّر بعض نظم الري السطحى والري بالتنقيط على محصول بنجر السكرر وراكاتا
الري وملوحة التربة في منطقة شمال الدلتا
حسن أحمد سبئيل، السيد محمود الريحى، محمود محمد سعىد و
هشام محمود أبو السعد

* قسم الأراضي، كلية الزراعة، جامعة المنصورة
** قسم بحوث تحسين وصيانة الأراضى، معهد بحوث الأراضى والبيئة، مركز البحوث الزراعية

استخدمت نظم الري بالتنقيط السطحى أو تحت سطحى (خط أو خطين نقاط لكل خط
نبات) وأيضا الري السكلى المباشر باستخدام الري السكلى التقليدى من
 хозяйى الري الطينى (صنف راسىلى) وكفاءة الري وملوحة التربة.

وبقد اقتمت التجربة في الموسم الزراعى الشتوى 2007/2008 في المراعى الهادئة بشما
بمحمية الري الزراعى بتقى الكتبة واستخدم في نظام الري بالتنقيط خطوط نقاط قطر 16 سم
على مسافات 60 سم على سطح التربة أو تحت سطح التربة بعمق 15 سم حتى تكون بعضاً
من تأثير العمليات الزراعية وكانت النقاط على بعد 50 سم وذات تصرف حوالي 2 لتر/ساعة
والانسيابية عبارة عن موانع الري بالمليم. فحص 150 سم ذات واقى قابلة للطقس والفتح
وصغر كل منها حوالي 3 سم لكل ساعة. وقد استخدمت الطبقات الكاملاة العرضية في ستة
مكررات.

ويمكن تتلخيص النتائج المحصول عليها فيما يلي:
- تم الحصول على أعلى محصول لجذر بنجر السكرى ومحصول السكرى نسبة الري البوبية
العصرى من الري بالمواسير المستديرة بينما أقل القيمة تحقّص عليها من الري بالتنقيط تحت سطحى
باستخدام 2 خط نقاط لكل صف نبات.
- أعلى نسبة من محتوى البوتاسيوم تحقّص عليها من العمليات التي أضيف لها أقل القيمة لفترة
الري البوبية بينما أقل نسبة من محتوى البوتاسيوم كانت مع أعلى القيمة لفترة الري المتغيرة succession.
- أتى لنظام الري المستمر مثلى على محتوى البوتاسيوم والنيتروجين العامى في عصير
بنجر السكرى.
- تأثّر كفاءة ماء الري المشاكله بنظام الري البوبية حيث استقبل نظام الري بالتنقيط تحت
سطحى ذو خطين نقاط لكل خط نبات أقل القيمة لفترة الري المشاكله بينما الري بالتنقيط
السحلى ذو خطين نقاط لكل خط نبات.

ومن جهة أخرى فإن الري السطحى التقليدى حقّص أعلى القيمة من كفاءة ماء الري
المشاعلة بقى الري بالمواسير المستديرة.
- تحقّص على أعلى القيمة من الكفاءة العالية لإستخدام مياه الري المتغيرة من نظام الري البوبية
تحت سطحى ذو خط نقاط أو خطين نقاط لكل خط نباتاً، بينما كانت أقل القيمة مع
الري السكلى التقليدى أيضا أعلى القيمة للكفاءة المحصولية لاستخدام الري البوبى المستحكمة تحت
مع الري بالتنقيط تحت سطحى ذو خط أو خطين نقاط لكل خط نبات بينما أعلى القيمة سجلت مع
الري السكلى التقليدى سواء كان خط أو خطين نقاط لكل خط نبات وأيضا الري السكلى
التقليدى.
- الري بالمواسير المستديرة والري بالتنقيط السطحى ذو خطين نقاط حقّص أعلى القيمة للكفاءة توزيع
مياه الري بينما الري البوبية تحت سطحى سواء كان خط نقاط أو خطين سجل أقل القيمة لفاءة
توزيع المياة. ومن الجهة الأخرى فإن نظام الري بالتنقيط السطحى حقّص أعلى القيمة لمعامل
انظامية توزيع مياة الري مع خط أو خطين نقاط لكل خط نبات بينما أعلى القيمة لمعامل
انظامية توزيع مياة الري سجلت مع الري بالتنقيط تحت سطحى ذو خط نقاط.
- زادت قيم الملوحة التربية مع عمق القطاع لنظام الرى بالнутьقيط السطحي (فردى أو مزدوج) لخطوط
النقاط (، المواسير المربوة، الرى السطحي التقليدي) بينما في نظام الرى بالнутьقيط تحت سطحي
(فردى أو مزدوج) فإن قيم الملوحة انخفضت مع العمق حتى 60 سم ثم زادت في الطبقات
العميقة.

قام بتحكيم البحث

أ.د / أحمد عبد القادر طه
كلية الزراعة – جامعة المنصورة
أ.د / محمد إبراهيم مليحة
مركز البحوث الزراعية