SUGAR BEET RESPONSE TO ZINC-APPLICATION UNDER DIFFERENT WATER REGIMES IN NORTHERN DELTA SOILS
Abd El-Wahab, S.A.* and E.A.E. Nemeat Alla**

Field experiment was conducted at Sakha Agricultural Res. Station to study the effect of zinc application (2, 4 and 6 kg fed⁻¹) under different amounts of irrigation water (3317.6, 2792.6, and 2267.6 m³ fed⁻¹).

The obtained results could be summarized as follows:

- Root yield and sugar yield (ton fed⁻¹) were significantly increased as irrigation amounts and zinc application rates were increased.
- Sucrose percentage, impurities (Na, K, αN) in the roots decreased and purity increased with increasing irrigation water amounts, while the application rate of zinc had no significant effect on these characteristics up to 4 kg Zn fed⁻¹.
- Root diameter was increased significantly as water amount increased and not affected by application of Zn.
- Root length was increased significantly as water amount decreased and zinc fertilization level increased.
- Root yield, sugar yield, root diameter, sucrose percentage, root length as well as the purity were significantly affected by the interaction between studied treatments irrigation regime and zinc fertilization. The highest values of 44.72, 8.8 ton fed⁻¹ and 12.31 cm root and sugar yields and root diameter, respectively were obtained by treatment (I₁ x Zn₃) while the highest values (20.86%, 43.73 cm and 85.13%) for sucrose %, root length, and purity were recorded by treatments (I₃ x Zn₁), (I₃ x Zn₂) and (I₁ x Zn₂), respectively.
- The values of water consumptive use and the moisture uptake from the surface layer were increased with increasing the amount of water applied to the soil and vice versa.
- The values of seasonal KC were 0.82, 0.75, and 0.68 (using modified Penman equation) for treatments I₁, I₂, and I₃, respectively while its values were 0.87, 0.79 and 0.72 (using Radiation equation) for treatment I₁, I₂, I₃, respectively. Using Modified Blaney equation the KC values were 1.3, 1.19 and 1.08 from treatments I₁, I₂, and I₃, respectively.
- Water utilization efficiency (W.Ut.E.) for root yield was calculated to be 12.78, 13.79 and 10.10 kg/m³ for treatments I₁, I₂, and I₃, respectively while they were found to be 2.52, 2.72 and 2.07 kg/m³ for sugar yield, respectively.
- The values of W.U.E. were 17.53, 17.36 and 11.40 kg/m³ for root yield and 3.45, 3.43 and 2.34 kg/m² for sugar yield, with using treatments of I₁, I₂ and I₃, respectively.
- Treatment I₁ recorded the highest value of water application efficiency (88.55%). While the lowest value (72.89%) was recorded with I₁ treatment.

استجابة بنجر السكر للتسميد بالزنك تحت كميات رى مختلفة فى أراضى شمال الدلتا
صلاح على عبد الوهاب - **السيد أحمد السيد نعمت الله
معهد بحوث الأراضي والمياه والبيئة - مركز البحوث الزراعية - الجيزة
معهد المحاصيل السكرية - مركز البحوث الزراعية - الجيزة
أجريت تجربة حقلية بمحطة البحوث الزراعية في سخا عام 1998/1999، لدراسة تأثير كميات مختلفة من الماء والتنقيح بالزنك.  

ويمكن تلخيص النتائج المتحصل عليها كالتالي:

1- زيادة محصول الجذور ومحصول السكر بالفدان معنويًا بزيادة كميات الماء المضافة والتنقيح بالزنك.

2- زيادة نسبة السكر والمواد غير السكرية في الجذور ولكن الفائدة من تضخ ماء الري المضاف إلى الفدان لم تصبح معنوية بزيادة الماء المضافة أو التنقيح بالزنك بالفدان.

3- تأثير تنقيح الجذور بالفدان المائي على تأثير الماء المضاف إلى الفدان وتنقيح الجذور بالفدان المائي.

4- تأثير تنقيح الجذور بالفدان المائي على تأثير الماء المضاف إلى الفدان وتنقيح الجذور بالفدان المائي.

5- تأثير تنقيح الجذور بالفدان المائي على تأثير الماء المضاف إلى الفدان وتنقيح الجذور بالفدان المائي.

6- تأثير تنقيح الجذور بالفدان المائي على تأثير الماء المضاف إلى الفدان وتنقيح الجذور بالفدان المائي.

7- تأثير تنقيح الجذور بالفدان المائي على تأثير الماء المضاف إلى الفدان وتنقيح الجذور بالفدان المائي.

8- تأثير تنقيح الجذور بالفدان المائي على تأثير الماء المضاف إلى الفدان وتنقيح الجذور بالفدان المائي.

9- تأثير تنقيح الجذور بالفدان المائي على تأثير الماء المضاف إلى الفدان وتنقيح الجذور بالفدان المائي.

10- تأثير تنقيح الجذور بالفدان المائي على تأثير الماء المضاف إلى الفدان وتنقيح الجذور بالفدان المائي.

11- تأثير تنقيح الجذور بالفدان المائي على تأثير الماء المضاف إلى الفدان وتنقيح الجذور بالفدان المائي.

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INTRODUCTION

Sugar beet (Beta vulgaris L.) is considered one of the important economic crops in Egypt and was found to be the most suitable ancillary source of sugar compared to sugar cane. The total amount of sugar produced from sugar beet in 1999 season was 317470 tons and represents about 25% of the total amount (1242587 tons). Egyptian policy aims to increase the amount of sugar from beet to reach 500 000 tons by using proper varieties, irrigation and fertilizations Sobh (1985). Sugar beet is reasonably drought tolerant with yield roughly proportional to total water use (Carter et al., 1980, Miller and Aarstad, 1976, Nicholson et al., 1974, and Winter, 1980).

Water stress in almost cases decrease fresh root weight (Winter, 1980, Sobh, 1985, Gouda et al., 1993, Abd El-Wahab et al., 1996 and Emara, 1996). Foliar application of 0.6 kg Zn/ha increased roots and sugar yields (Stratieva et al., 1990). Besheit et al. (1992) reported that soaking sugar beet seeds before sowing in 40 ppm of Zn gave the maximum fresh and dry weights of leaves and roots. Also, zinc application to soil increased dry matter accumulation and sugar content in roots (Sun et al., 1994).

On the other hand, zinc uptake increased as application Zn rate increased but this increase was not affected on root yield (Sofronovskaya, 1998). Sucrose concentration in a fresh weight can be increased due to water stress (Loomis and Worker, 1963; Carter et al., 1980; Abd El Wahab et al., 1996).

The effects of irrigation on purity not well understood. Bauer et al., 1975; Reichman et al., 1977; Sobh, 1985; Attia and Sultan, 1987 and Abdel Wahab et al., 1996.

Monthly and seasonal consumptive water use were increased as the irrigation water amounts increased (Doorenbos et al., 1979; Sobh 1985 and Abdel Wahab et al., 1996).

The objective of this research is to determine the influence of zinc fertilization and the amount of seasonal irrigation water on sugar beet crop and its water consumptive use in Northern Delta soils.

MATERIALS AND METHODS

The effect of zinc fertilization and irrigation treatments on sugar beet during growing season 1998/1999 was tested in a split plot design three levels of seasonal irrigation water amounts used the main plots I$_1$ = 3317.6, I$_2$ = 2792.6, and I$_3$ = 2267.6 m$^3$/fed. these amounts including planting irrigation and effective rain off. Three levels of zinc fertilizer (Zn$_1$ = 2 kg fed$^{-1}$, Zn$_2$ = 4 kg Zn fed$^{-1}$, and Zn$_3$ = 6 kg Zn fed$^{-1}$) were added to the sub plots by soil application before the second irrigation. Both N-fertilizer (80 kg N/fed.) as urea (46.5% N) and K fertilizer in the form of K-sulfate (48% K$_2$O) at rate of 48 kg fed$^{-1}$ K$_2$O were applied for all plots in two equal doses at the thinning time and before the second irrigation P-fertilizer as superphosphate (15.5% P$_2$O$_5$) was added during tillage operation with the rate of 15 kg P$_2$O$_5$/fed. Sugar beet (Cawamera) variety was sown on 15 November. Plot area was 20 m$^2$ (4 x 5 m).
The soil characteristics of the experimental site (were determined according to Black (1965) and presented in Table (1).

The climatological data of the studied area during the growing season are recorded in (Table 2). The plants were harvested on May 31 and the following parameters were recorded:
1. Sugar beet yield (root and sugar ton/fed.).
2. Yield component (root length and diameter).
3. Yield quality [sucrose %, impurities (K, Na, αN) and purity] was determined in Delta Sugar Company Limited Laboratories at Kafr El-Sheikh Governorate.

Soil water relations were determined as follows:
A) Water consumptive use (Cu) in each irrigation was calculated according to (Hansen et al., 1979). as follows:
\[
Cu = \sum \frac{Pw_2 - Pw_1 \times BD_i \times D_i}{100}
\]

Where:
- \( Cu \) = Water consumptive use (cm) for the effective root zone (0-60 cm).
- \( i \) = Number of soil layers.
- \( Pw_2 - Pw_1 \) = Percentage of soil moisture content 48 hours after irrigation and before irrigation for the specified soil layer.
- \( BD_i \) = Bulk density for specified layer.
- \( D_i \) = Depth of layer (15 cm).

B) The amounts of water applied to each plot was measured using small siphon according to FAO (1974).

C) Water efficiencies:
1. Water utilization efficiency (W.Ut.E) was calculated according to Doorenbos and Pruitt (1975) as follows:
\[
W.Ut.E. = \frac{\text{Root or sugar yield in kg fed}^{-1}}{\text{Total water applied in m}^3\text{fed}^{-1}}
\]
2. Water use efficiency (W.U.E.):
\[
W.U.E. = \frac{\text{Root or sugar yield in kg fed}^{-1}}{\text{Actual evapotranspiration m}^3\text{fed}^{-1}}
\]
3. Water application efficiency (W.A.E.):
\[
W.A.E. = \frac{\text{Total water stored in root zone \times 100}}{\text{Total water applied}}
\]

D) Crop coefficient (KC):
It was calculated according to Doorenbos and Pruitt (1975) as follows:
\[
KC = \frac{\text{Actual evapotranspiration ETA}}{\text{Potential evapotranspiration ETP}}
\]

ETP was calculated by using, modified Penman, Radiation and Modified Bliny-Criddle equations.

Statistical analysis was carried out according to Snedecor and Cochran (1967), and treatment means were compared by least significant differences (L.S.D.) at the levels of 1% and 5% probability.
Table (1): Mechanical and chemical analysis of experimental soil (0-60 cm)*.

<table>
<thead>
<tr>
<th>Particle size distribution</th>
<th>Texture class</th>
<th>E.C 1: 2.5 dSm⁻¹</th>
<th>pH</th>
<th>Available nutrients ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand %</td>
<td>Silt %</td>
<td>Clay%</td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>17.53</td>
<td>30.34</td>
<td>49.95</td>
<td>Clayey</td>
<td>1.32</td>
</tr>
</tbody>
</table>

* Mechanical analysis was determined according to the International Method Piper, (1950).
Available N, and K according to Black (1965)
Available P according to Olsen et al. (1954)
Available Zinc was determined according to Lindsay and Norvell (1978).


<table>
<thead>
<tr>
<th>Month</th>
<th>Temperature, °C</th>
<th>Relative humidity %</th>
<th>Wind sp., km/hr</th>
<th>Rain, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov. 1998</td>
<td>26.0</td>
<td>12.0</td>
<td>75.4</td>
<td>42.5</td>
</tr>
<tr>
<td>Dec. 1998</td>
<td>21.30</td>
<td>8.2</td>
<td>72.20</td>
<td>41.9</td>
</tr>
<tr>
<td>Jan. 1999</td>
<td>19.33</td>
<td>8.8</td>
<td>69.83</td>
<td>46.69</td>
</tr>
<tr>
<td>Feb. 1999</td>
<td>17.73</td>
<td>6.73</td>
<td>67.46</td>
<td>46.00</td>
</tr>
<tr>
<td>March 1999</td>
<td>21.13</td>
<td>10.71</td>
<td>67.84</td>
<td>44.90</td>
</tr>
<tr>
<td>April 1999</td>
<td>25.43</td>
<td>9.22</td>
<td>73.57</td>
<td>45.77</td>
</tr>
<tr>
<td>May 1999</td>
<td>29.27</td>
<td>15.5</td>
<td>70.06</td>
<td>41.42</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

1) Root yield (ton fed⁻¹):
Data in Table (3) indicated that root yield was significantly increased with increasing the amounts of irrigation water and the maximum yield (42.39 ton fed⁻¹) was obtained when 3317.6 m³ water per feddan was added to the soil. The magnitude of the increase was 85.1% as compared to the treatment received 2267.6 m³ water per feddan that gave the lowest value of root yield (22.90 ton fed⁻¹). This may be due to the direct effect of the availability of soil water in the effective root zone. These results are in agreement with those obtained by Sobh (1985) Gaber et al. (1986); Cucci and Caro (1986); Emara (1990, 1996) and Abd El-Wahab et al. (1996). With respect to zinc effect on the root yield. Data in Table (3) showed that zinc fertilization treatments gave significant synergistic effect on root yield. The maximum root yield 35.82 ton

Table (3): Effect of irrigation and zinc fertilization on sugar beet characteristics.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Root quality</th>
<th>Root component</th>
<th>Root yield (ton fed⁻¹)</th>
<th>Sugar yield (ton fed⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sucrose pol. %</td>
<td>K</td>
<td>Na</td>
<td>αN</td>
</tr>
<tr>
<td>A. irrigation m³ fed⁻¹</td>
<td>19.69</td>
<td>6.38</td>
<td>1.52</td>
<td>2.21</td>
</tr>
<tr>
<td>I₁ =3317.6</td>
<td>19.74</td>
<td>7.05</td>
<td>1.88</td>
<td>2.72</td>
</tr>
<tr>
<td>I₂ =2792.6</td>
<td>20.50</td>
<td>6.76</td>
<td>1.69</td>
<td>2.73</td>
</tr>
<tr>
<td>I₃ =2267.6</td>
<td>**</td>
<td>**</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>B. Zinc fer. kg fed⁻¹</td>
<td>20.04</td>
<td>6.67</td>
<td>1.69</td>
<td>2.49</td>
</tr>
<tr>
<td>Z₁ =2</td>
<td>20.05</td>
<td>6.80</td>
<td>1.77</td>
<td>2.56</td>
</tr>
<tr>
<td>Z₂ = 4</td>
<td>19.80</td>
<td>6.61</td>
<td>1.63</td>
<td>2.62</td>
</tr>
<tr>
<td>Z₃ = 6</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>n.s</td>
</tr>
</tbody>
</table>
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fed\(^{-1}\), using 4 kg Zn fed\(^{-1}\) while the lowest yield was recorded with 2 kg Zn fed\(^{-1}\), (32.76 ton fed\(^{-1}\)) which achieved an increment of 9.4%.

These results are in harmony with those obtained by Stratieva \textit{et al.} (1990); Besheit \textit{et al.} (1992) and Sun \textit{et al.} (1994).

2.  
**Gross sugar yield (ton fed\(^{-1}\)):**

Sugar yield per unit area is the main goal of sowing any sugar crop and it is the sum product of sugar extractable \% and root yield per unit area. Data in Table (3) revealed that decreasing the amounts of irrigation water applied to the soil (3317.6 to 2267.6 m\(^3\) water fed\(^{-1}\)) resulted in 76\% decrease in gross sugar yield may be due soil moisture stress as shown before. These results supported the results obtained by Carter \textit{et al.} (1980); Roberts \textit{et al.} (1980); Sobh (1985); Cucci and Caro (1986) and Abd El-Wahab (1996).

Dealing with the effect of zinc fertilization on gross sugar yield, data clarify that gross sugar yield was significantly increased with increasing zinc levels applied to the soil up to 4 kg Zn fed\(^{-1}\) which gave the maximum yield 7.18 ton fed\(^{-1}\) compared with 6.57 and 6.97 ton fed\(^{-1}\) given by of 2 and 6 kg Zn fed\(^{-1}\), respectively. These results are in agreement with those obtained by Sun \textit{et al.} (1994).

The impact of the interaction between irrigation and zinc levels on sugar beet yield (root and sugar yields) was clear. The optimum yield of root and sugar yields (44.14 and 8.59 ton fed\(^{-1}\)), respectively were obtained with application of 3317.6 m\(^3\) water fed\(^{-1}\) and adding 4 kg Zn fed\(^{-1}\).

3.  
**Sucrose percentage:**

Data in Table (3) demonstrate that there was a significant negative relation between sucrose \% and the amount of water added to the soil consequently the maximum value 20.54\% was given by 2267.6 m\(^3\) water fed\(^{-1}\) (I\(_2\)). These results stand in the same line with those obtained by Carter \textit{et al.} (1980), Roberts \textit{et al.} (1980); Abd El-Wahab \textit{et al.} (1996). In this regard Loomis and Hadock (1967) attributed the increase in sucrose percentage with increasing soil moisture stress to slower accumulations of dry matter and more rapid accumulation of sucrose.

As concerns zinc fertilization effect, data showed that sucrose \% was not significantly affected by 2 or 4 kg zinc while it significantly affected by 6 kg Zn fed\(^{-1}\).

4.  
**Impurities (Na, K and \(\alpha\)N):**

Impurities in the roots were increased and the purity was decreased with decreasing irrigation water amounts applied to the soil (Table, 3). The highest values of the impurity and the lowest purity value were detected with 27926 m\(^3\) water fed\(^{-1}\) (I\(_2\)). These results are in accordance with the findings of Winter (1980).

On the other hand, purity was not significantly affected by Zn, while there was a significant effect on alkalinity of sugar juice.

The interaction between irrigation and zinc not significantly affected on \(\alpha\)N and alkalinity while its effect was significant for Na and K contents and juice purity. The maximum purity value 85.13\% was achieved by the combination between application of 3317.6 m\(^3\) water (I\(_1\)) and 4 kg Zn fed\(^{-1}\).
5) Root diameter (cm):
With respect to root diameter, data in Table (3) showed that decreasing the amounts of irrigation water added to the soil significantly decreased root diameter especially at the irrigation water level of 2267.6 m³ water fed⁻¹ (I₁) which gave the lowest diameter of 9.71 cm, the diameter 12.16 cm was recorded with 33176 m³ water fed⁻¹ (I₃) which gave the lowest diameter of 9.71 cm, the diameter 12.16 cm was recorded with 33176 m³ water fed⁻¹ (I₃). This may be due to the availability of soil water which had the direct effect on the growth of root. In this regard, Sorour (1995) attributed the reduction in root diameter at low soil moisture level to decreasing leaf area index which might decrease light interception and in turn decrease dry matter accumulation and root dimensions. These results are similar to those obtained by Attia and Sultan (1987); Emara (1990, 1996) and Abd El-Wahab (1996). For zinc effect where there was no significant effect on root diameter as zinc fertilizer applied to the soil.

The interaction between irrigation and zinc treatments recorded significant effect on root diameter and the best value of interaction was obtained by combination of 33176.6 m³ water fed⁻¹ (I₁) and 6 kg Zn fed⁻¹ (Zn₃) (Table 4).

Table (4): Sugar beet characteristics as affected by irrigation and zinc fertilization interaction.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Root quality</th>
<th>Root component</th>
<th>Sugar yield (ton fed⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water regime</td>
<td>Zn application</td>
<td>Sucrose pol. %</td>
<td>Impurities (mg/100 g)</td>
</tr>
<tr>
<td>I₁</td>
<td>Zn₁ 19.67</td>
<td>6.42 1.64 2.15</td>
<td>3.71 83.60</td>
</tr>
<tr>
<td>I₁</td>
<td>Zn₂ 19.47</td>
<td>6.52 1.49 2.21</td>
<td>3.53 85.13</td>
</tr>
<tr>
<td>I₁</td>
<td>Zn₃ 19.67</td>
<td>6.19 1.42 2.27</td>
<td>3.38 84.93</td>
</tr>
<tr>
<td>I₂</td>
<td>Zn₁ 20.04</td>
<td>6.98 1.84 2.67</td>
<td>3.33 82.58</td>
</tr>
<tr>
<td>I₂</td>
<td>Zn₂ 19.82</td>
<td>7.02 2.04 2.68</td>
<td>3.38 81.43</td>
</tr>
<tr>
<td>I₂</td>
<td>Zn₃ 19.37</td>
<td>7.15 1.76 2.80</td>
<td>3.31 82.10</td>
</tr>
<tr>
<td>I₃</td>
<td>Zn₁ 20.41</td>
<td>6.60 1.60 2.64</td>
<td>3.08 82.63</td>
</tr>
<tr>
<td>I₃</td>
<td>Zn₂ 20.86</td>
<td>6.86 1.78 2.78</td>
<td>3.10 82.95</td>
</tr>
<tr>
<td>I₃</td>
<td>Zn₃ 20.35</td>
<td>6.51 1.71 2.78</td>
<td>3.05 82.05</td>
</tr>
<tr>
<td>L.S.D. 0.01</td>
<td>** ** **</td>
<td>n.s n.s</td>
<td>** ** **</td>
</tr>
</tbody>
</table>

6. Root length (cm):
Data in Table (3) revealed that decreasing irrigation water amounts significantly promoted increasing the root length to reach maximum value 43.47 cm at 2267.6 m³ water fed⁻¹ level.

The results showed also that the roots grow longer under water stress than that excessive water status. The water stress enhanced deep rooting. These results are in line with those obtained by Winter (1980); Emara (1990-1996) and Abd El-Wahab et al. (1996).

With relation to the effect of zinc on root length, data clarify that application of zinc fertilizer to the soil gave significant pronounced positive effect on root length recording maximum value 40.03 cm when the zinc fertilizer applied at the rate of 6 kg Zn fed⁻¹.
Also, the interaction between irrigation and zinc achieved significant synergistic effect and continued to increase the root length to reach the maximum value 43.54 cm by using 2267.6 m$^3$ water fed$^{-1}$ level and 4 kg Zn fed$^{-1}$ (Table 4).

7. **Consumptive water use (Cu):**

Data in Table (5) shows that both monthly and seasonal Cu values were increased with increasing the amounts of irrigation water applied to the soil. For monthly values the rate of Cu were gradually increased with crop development and reached its beaks in April and then reduced during ripening stage (May).

<table>
<thead>
<tr>
<th>Irrigation treatment</th>
<th>Layer depth, cm</th>
<th>Monthly and seasonal consumptive use cm</th>
<th>Total pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>I$_1$</td>
<td>0-15</td>
<td>0.736</td>
<td>2.073</td>
</tr>
<tr>
<td></td>
<td>0-30</td>
<td>0.482</td>
<td>1.359</td>
</tr>
<tr>
<td></td>
<td>0-45</td>
<td>0.213</td>
<td>0.601</td>
</tr>
<tr>
<td></td>
<td>0-60</td>
<td>0.092</td>
<td>0.259</td>
</tr>
<tr>
<td>I$_2$</td>
<td>0-15</td>
<td>0.566</td>
<td>1.596</td>
</tr>
<tr>
<td></td>
<td>0-30</td>
<td>0.403</td>
<td>1.136</td>
</tr>
<tr>
<td></td>
<td>0-45</td>
<td>0.208</td>
<td>0.586</td>
</tr>
<tr>
<td></td>
<td>0-60</td>
<td>0.082</td>
<td>0.230</td>
</tr>
<tr>
<td>Total</td>
<td>1.259</td>
<td>3.548</td>
<td>4.637</td>
</tr>
<tr>
<td>I$_3$</td>
<td>0-15</td>
<td>0.549</td>
<td>1.548</td>
</tr>
<tr>
<td></td>
<td>0-30</td>
<td>0.371</td>
<td>1.045</td>
</tr>
<tr>
<td></td>
<td>0-45</td>
<td>0.132</td>
<td>0.372</td>
</tr>
<tr>
<td></td>
<td>0-60</td>
<td>0.035</td>
<td>0.101</td>
</tr>
<tr>
<td>Total</td>
<td>1.087</td>
<td>3.066</td>
<td>3.92</td>
</tr>
</tbody>
</table>

Sowing irrigation = 520.4 m$^2$ fed$^{-1}$
Rain off = 172.2 m$^2$ fed$^{-1}$

In relation to seasonal Cu of sugar beet plants the maximum value 57.58 cm which corresponding to 0.29 cm/day was obtained when 3317.6 m$^3$ water fed$^{-1}$ (or water regime I$_1$) was applied, whereas the minimum one (47.81 cm) that corresponding to 0.24 cm/day was recorded at 2267.6 m$^3$ water fed$^{-1}$ (or at water regime I$_3$). These results are in harmony with those obtained by Doorenbos et al. (1979); Sobh (1985); Abd El-Wahab et al. (1996) who stated that the seasonal values may be differ due to climate, availability of soil water and length of the total growing period.

8. **Water uptake patterns of sugar beet:**

The prediction of the degree of root distribution among different depths of the effective root zone can be realized by using the parameter of water uptake patterns. Thus, data in Table (5) revealed that the uptake of soil water was decreased with the soil depth and the greater uptake values were 32.8, 31.8 and 33.62% for the surface layer of the water treatments I$_1$, I$_2$ and
respectively. While less water was extracted from the subsurface layers. The relatively higher water uptake from the upper layers compared to the deepest ones was attributed to the concentrated roots in the upper layer (Ibrahim et al., 1988).

9. Crop coefficient KC of sugar beet:

Data in Table (6) shows that the seasonal crop coefficient values (KC) increased with increasing Cu value. The theoretical values of evapotranspiration (ETo) was calculated to be 705.23 mm from Modified Penman equation (with KC values of 0.82, 0.75 and 0.68), 664.64 mm from Radiation equation (with KC values 0.87, 0.79, and 0.72) and 442.93 mm from Modified Blaney-Criddle equation (with KC values of 1.30, 1.19 and 1.08) for water regimes I1, I2, I3, respectively.

Table (6): Effect of different water regimes on consumptive use indices of sugar beet

<table>
<thead>
<tr>
<th>Water treat.</th>
<th>Cu m³ fed⁻¹</th>
<th>Added water m³ fed⁻¹</th>
<th>Ke* ET₀ = 705.23 mm</th>
<th>Ke** ET₀ = 664.64 mm</th>
<th>Ke*** ET₀ = 442.93 mm</th>
<th>Root yield kg fed⁻¹</th>
<th>Sugar yield kg fed⁻¹</th>
<th>W.Ut.E kg/m³</th>
<th>W.U.E. kg/m³</th>
<th>W.A.E. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1</td>
<td>2418.4</td>
<td>3317.6</td>
<td>0.82</td>
<td>0.87</td>
<td>1.30</td>
<td>8347</td>
<td>12.78</td>
<td>17.53</td>
<td>3.45</td>
<td>72.89</td>
</tr>
<tr>
<td>I2</td>
<td>2218.0</td>
<td>2792.6</td>
<td>0.75</td>
<td>0.79</td>
<td>1.19</td>
<td>7600</td>
<td>13.79</td>
<td>17.36</td>
<td>3.43</td>
<td>79.42</td>
</tr>
<tr>
<td>I3</td>
<td>2008.0</td>
<td>2267.6</td>
<td>0.68</td>
<td>0.72</td>
<td>1.08</td>
<td>4704</td>
<td>10.10</td>
<td>11.40</td>
<td>2.34</td>
<td>88.55</td>
</tr>
</tbody>
</table>

* Calculated evapotranspiration values from Modified Penman Equation.
** Calculated evapotranspiration values from Radiation Equation.
*** Calculated evapotranspiration values from Modified Blaney-Criddle equation.

The data also indicate that ETo values calculated using Blaney-Criddle equation is lower than the actual consumptive use of water (Cu). However, Modified Penman or Radiation equations agree well with the value of Cu determined under the present study.

10. Water efficiencies:

The optimum water management is achieved by obtaining the greatest consumptive use of water with increasing the grain yield per unit area. Thus with respect to the effect of different irrigation treatments on water use efficiency (W.U.E.), water utilization efficiency (W.Ut.E) and water application efficiency (W.A.E.) are shown in (Table 6). The data showed that the irrigation regime (I2) seemed to be superior in increasing the value of W.Ut.E for both root and sugar yields (13.79 and 2.72 kg/m3, respectively followed by I1 and I3. The highest values of W.U.E. for root and sugar (17.53 and 3.45 kg/m³), respectively, were achieved with I1 (3317.6 m³ fed⁻¹) followed by I2 (2792.6 m³/fed⁻¹) treatment.

This trend may be due to the severe reduction in yield (root and sugar) as a result of soil moisture stress. In relation to water application efficiency (W.A.E.) data indicated that its values were increased as the amount of irrigation water decreased and reached to the maximum value (88.55%) with treatment (I3). It can be said that as the total irrigation water delivered increased, the application efficiency decreased and vice versa. These results are supported those obtained by Abd El-Wahab (1996).
Abd El-Wahab, S.A. and E.A.E. Nemeat Alla

However, the treatment gave the suitable values of W.Ut.E and W.U.E., indicating that the water regime which utilize reasonable amount of water with suitable Zn application resulted in a great yield, W.Ut.E. and W.U.E.

It could be concluded that for sugar beet production the suitable water regime (3317.6 and 2792.6 m³ fed⁻¹) and zinc application (4 kg Zn fed⁻¹) which should be adopted in clayey soils in Northern Delta.

REFERENCES


استجابة بنجر السكر للتسميد بالزنك تحت كميات رية مختلفة في أراضي شمال الدلتا

صلاح علي عبدالوهاب .. السيد أحمد السيد نعمت الله

معهد بحوث الأراضي والمياه والبيئة .. مركز البحوث الزراعية .. الجيزة
معهد المحاصيل السكرية .. مركز البحوث الزراعية .. الجيزة

أجريت تجربة حقلية بمحطة البحوث الزراعية بسخا عام 1998/1999م لدراسة تأثير كميات مختلفة من الماء والتسميد بالزنك على بنجر السكر. وتضمنت التجربة تأثير زراعة بنجر السكر بالزنك بمعدلات 2، 4، 6 كجم زنك/لفد.

ويمكن تلخيص النتائج المتحصل عليها كالآتي:
1. زيادة محصول الجذور ومحصول السكر باللفد معنويًا بزيادة كميات الماء المضافة ومعدل التسميد بالزنك.
2. زيادة نسبة السكر والمواد غير النقية في الجذور ونقص النقاوة بنقص كمية الماء المضافة بينما لم يتأثر التسميد بالزنك.
3. زيادة قطر الجذور بالسم معنويًا مع زيادة كميات الماء المضافة بينما لا يوجد تأثيرًا معنويًا للتسميد بالزنك.
4. زيادة طول جذر البنجر (بالسم) معنويًا بنقص كمية الماء الرية والمعدلات النسبية للزنك.
5. أثر تفاعلي بين الماء والزنك على—not mentioned in the text.
6. ارتفاع نسبة الاستهلاك المائي السنوي إلى 57.58 سم بزيادة الماء الرية إلى 2625 ملم/لفد، بينما كانت الأقل في 47.81 سم عند الماء الرية 1575 ملم/لفد.
7. ارتفاع كفاءة استخدام المياه بـ 12.78 كجم/مكعب من تكلفة تنفيذ الحوت، بينما كانت في 10.10 كجم/مكعب.

1954