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# DETERMINING THE OPTIMUM IRRIGATION INTERVALS AND PLANT DENSITIES FOR SUNFLOWER UNDER DRIP IRRIGATION SYSTEM.

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## ABSTRACT

Two field experiments were carried out in the modernized irrigation system network (drip irrigation technique) at the research farm at Sakha Agricultural Research Station, kafr El- Sheikh Governorate during the two successive growing seasons 2007 and 2008. The target of this present study was to investigate the impact of irrigation intervals on yield, its quality and some water relationships.

**Obtained data can be concluded as follows: -**

- Seed yield was clearly increased by decreasing irrigation interval where the highest means values were recorded under the shortest interval (4 days) and the values were 1.03 and 1.08 ton/ fed. (2.45 and 2.57 ton/ ha) in the first and second growing seasons, respectively. Also, data showed that there wasn't a pronounced difference among 8, 12 and 16 days irrigation intervals where the values were rather similar, but under 20 days irrigation interval, the value of seed yield was clearly decreased.
- Mean values of 1000 seed weight (g) were increased under irrigation interval each 4 days in comparison with other irrigation intervals 8, 12, 16 and 20 days where the highest mean values were 65.287 and 65.403 g in the first and second growing seasons, respectively. On the contrary, the lowest mean value was recorded under 20 days irrigation interval.
- In addition, data illustrated that the mean values of and head diameter was decreased by increasing irrigation interval up to 20 days. The highest mean values for the studied parameter was recorded under the shortest irrigation interval each 4 days in the two growing seasons, where the mean values for the studied parameter was 19.073 cm for head diameter.
- The highest mean values of plant height were recorded under 8 days interval in the first growing season, and under 12 days, in the second growing one and the mean values were 167.533 and 157.367 cm, respectively. On the other hand, presented data showed that there wasn't clear and standard relationship between plant densities and the studied parameters.
- Also, data illustrated that by elongation irrigation interval up to 20 days caused decreasing amount of water applied was found, where the highest mean values were recorded under the shortest interval of irrigation each 4 days and the values were1482.04 and 1556.8 $m^3$/ fed in the first and second growing seasons, respectively. On the contrary, the lowest values were recorded under the longest irrigation interval 20 days between watering and the values were 1135.64 and 1110.0 $m^3$/ fed. in the first and second seasons, respectively.
- Concerning the values of water utilization efficiency (W.Ut.E) which clearly affected by irrigation interval where the highest values were recorded under the shortest irrigation interval each 4 days where the values were 0.67 and 0.71 kg/ $m^3$ in the first and second growing seasons, respectively. Under the other irrigation intervals 8, 12, 16 and 20 days the values were low comparing with the first

treatment (interval of 4 days) but there wasn't a standard and clear relationship between the other irrigation intervals (8, 12, 16 and 20) days.
- Data also illustrated that the highest mean values for oil content in seeds were recorded under 16 days between irrigations.

**Keywords:** sunflower, irrigation interval, water utilization efficiency

## INTRODUCTION

Egypt suffers from a great deficiency in production of edible crops. So, we should pay attention to increase the productivity of edible crops. Sunflower is one of the most important crops because it has a high oil content which reached about 45%, this kind of oil has a high good physical and chemical characteristics. This crop can be grown well in new reclaimed lands and under the high level of salinity which may be reached 2000 ppm particularly under a good drainage system. Also, it can be cultivated three times a year and under different climatic conditions. There is a wide gap between oil production and consumption, therefore, efforts should be implemented to decrease this gap by increasing its production quantitively and qualititively.

In Egypt, water resources have become limited in relation to possible land reclamation (horizontal agricultural expansion).

Great efforts should be implemented to overcome the problem of water shortage that facing Egypt after along drought of Nile resources in Africa. Sunflower is one of the crops which is more sensitive for irrigation. So, we must treat this crop with a great care regarding irrigation to keep its high production and make saving for irrigation water. In this regard water per capita share is about 800 $m^3$ annually, and this considers below the poverty level of < 1000 $m^3$/ yearly (El– Quosy 1998)

There are a lot of ways which we can apply some of them to make rationalization for irrigation water through.

1-Elongation irrigation interval without any drastic reduction in yield.
2-Using modern irrigation techniques which have a high efficiency such as drip irrigation system of about 90%.
3-Increasing plant densities which give a high yield under the same amount of water applied.

Therefore, the main target of this present work was to find out the interaction impact of irrigation interval and plant densities on sunflower yield, its quality and some irrigation parameters under drip irrigation system in the North Middle Nile Delta region.

## MATERIALS AND METHODS

The present trials were conducted at Sakha Agricultural Research Station, Kafr El- Sheikh Governorate during the two successive growing seasons 2007 and 2008 to study the impact of irrigation intervals and plant densities on sunflower production (CV. Sakha 53) and some water relationships under drip irrigation technique. The some soil physical, chemical

characteristics and chemical properties of irrigation water are tabulated in Tables (1, 2 and 3).

**Table 1: Soil physical and chemical properties and soil – water constants.**

| Soil depth, cm | Physical properties | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Particle size distribution | | | Texture | F.C* % | P.W.P**% | Available water % | Bulk density, g/ cm$^3$ |
| | Sand % | Silt % | Clay % | | | | | |
| 0-20 | 19.50 | 23.45 | 57.05 | Clayey | 43.00 | 22.00 | 21.00 | 1.14 |
| 20-40 | 18.22 | 22.19 | 59.05 | Clayey | 40.00 | 21.00 | 19.00 | 1.24 |
| 40-60 | 17.37 | 22.31 | 60.32 | Clayey | 39.00 | 21.00 | 18.00 | 1.32 |

**Table 2: Soil chemical properties of the experiments.**

| Soil depth cm | SAR | ESP | E.C, dS/m | Soluble cations, meq/ l | | | | Soluble anions, meq/ l | | | | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $Ca^{++}$ | $Mg^{++}$ | $Na^{++}$ | $K^{+}$ | $CO_3^{--}$ | $HCO_3^{-}$ | $CL^{-}$ | $So4^{--}$ | |
| 0-20 | 7.13 | 8.45 | 1.92 | 4.04 | 2.22 | 12.62 | 0.18 | 0.0 | 5.5 | 8.8 | 4.76 | 7.9 |
| 20-40 | 7.16 | 8.46 | 1.89 | 4.08 | 2.20 | 12.68 | 0.18 | 0.0 | 5.4 | 8.9 | 4.84 | 8.0 |
| 40-60 | 7.19 | 8.59 | 1.93 | 4.16 | 2.28 | 12.90 | 0.16 | 0.0 | 5.5 | 9.0 | 5.00 | 8.1 |

**Table 3: Chemical properties of irrigation water**

| E.C, dS/m | Soluble cations, meq/l | | | | Soluble anions, meq/l | | | |
|---|---|---|---|---|---|---|---|---|
| | $Ca^{++}$ | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ | $CO_3^{--}$ | $HCO_3^{-}$ | $CL^{-}$ | $SO_4^{--}$ |
| 0.44 | 2.48 | 1.17 | 0.84 | 0.154 | 0.0 | 2.00 | 0.96 | 1.68 |

*F.C: soil field capacity **P.W.P: permanent wilting point.

The drip irrigation system consists of a pumped unit which contains a pump, control unit, groups of pipes which differ in its diameter and distribution lines. The control unit of the system contains a venture injector (25.4 mm), fertilizer tank, disk filters, control valves and a water flow meter. Distribution lines consists of polyethylene (PE) pipes manifolds (display and discharge) laterals of 16 mm in diameter and 40 m in length had in– line emitters spaced 0.5 m apart, each delivering 4 l $h^{-1}$ at a pressure of 1 bar. Drip irrigation lines were spaced 0.8 m apart equally spaced between every other row of sunflower. Water was applied from a pressurized hydrant and filtered through gravel and refiltered through disk filters. The texture of the experimental field soil is heavy clay. Water table level is a bout 150 cm.

The treatments were arranged in split plot design with four replicates as follows: -

- **Main treatments (irrigation intervals)**
  $I_1$ – Irrigation every 4 days. $I_2$ – Irrigation every 8 days.
  $I_3$ – Irrigation every 12 days. $I_4$ – Irrigation every 16 days.
  $I_5$ – Irrigation every 20 days.
- **Sub main treatments (plant densities)**

$D_1$- Planting on one lateral with one plant from each side adjusted with the emitter.

$D_2$- Planting on one lateral with two plants from each side adjusted each the emitter.

$D_3$- Planting on one lateral with two plants adjusted with the emitter, one plant from each side.

$D_4$- Planting on one lateral with four plants on the two sides from the emitter, two plants from each side.

$D_5$- Planting on one lateral with four plants on the two sides of the emitter, two plants from each side. In addition, two plants were planted in the middle of the two adjacent emitters one plant in each side.

In the two seasons, sunflower as a summer crop was planted on June, 18 and harvested on September 18. All agronomic practices and fertilization were done as recommended for the crop and the area except the treatments under study.

**Data collection:**

1- **Irrigation water applied (IW).**

The amount of applied water at each irrigation was measured by using flow meter.

2- **Water utilization efficiency (W.Ut.E)**

It was calculated according to the following equation (Michael, 1978).

$$W.Ut.E. = \frac{Y}{IW}$$

where: Y = seed yield (kg/ feddan)

IW = irrigation water applied, $m^3$ /fed.

- Yield and its components
- Seed yield (ton/ fed)
- Plant height (cm)
- Stem diameter (cm)
- Head diameter (cm)
- Weight of 1000 seed (g)
- Head weight (g) .

## RESULTS AND DISCUSSION .

**Seed yield (ton/ fed)**

Presented data in Tables (4 through 7) clearly showed that under all plant densities, mean values of sunflower seed yield were greatly affected by irrigation intervals from 4 to 20 days. In the two growing seasons the highest mean values were recorded under the shortest irrigation interval every 4 days and the values were 1.03 and 1.08 ton/ fed. On the other hand the lowest mean values were registered under the longest irrigation interval every 20 days and the mean values were 0.56 and 0.58 ton/ fed in the first and second growing seasons, respectively .

Increasing seed yield under the shortest irrigation interval (4days) comparing with the other irrigation intervals may be due to under the amount of water applied is enough to increase the availability of nutrients. Which caused increasing its uptake by plants and hence, increasing seed yield. These findings are in a great harmony with those obtained by Ashoub *et al.*,

2000, they reported that decreasing irrigation intervals from 21 to 14 or from 14 to 7 days gave significant increasing in seed yield. These results are in a great harmony with those obtained by Omar *et al.* (2008).

**Table 4: Effect of irrigation interval and plant densities on sunflower seed yield (ton/ fed) grown under drip irrigation system in the Nile Delta in 2007 growing season.**

| Plant density | Irrigation interval (I) | | | | |
|---|---|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ | $I_4$ | $I_5$ |
| $D_1$ | 1.37a | 0.73 b | 0.83 a | 0.70a | 0.57a |
| $D_2$ | 1.07b | 0.67b | 0.77a | 0.80a | 0.57a |
| $D_3$ | 1.03b | 1.13a | 0.73a | 0.70a | 0.47a |
| $D_4$ | 0.67c | 0.47c | 0.50a | 0.70a | 0.57a |
| $D_5$ | 1.03b | 0.73b | 0.77a | 0.70a | 0.63a |
| I – mean | 1.03 | 0.75 | 0.72 | 0.72 | 0.56 |

**CV (a) = 14.2 % CV (b) = 15.8%**

**In a column, means followed by a common letter are not significantly different at the 5% level by DMRT .**

**Table 5: Interaction effect between irrigation intervals and plant densities on seed yield (ton/ fed) in 2007 growing season.**

| Plant density | D – mean |
|---|---|
| $D_1$ | 0.84 |
| $D_2$ | 0.77 |
| $D_3$ | 0.81 |
| $D_4$ | 0.58 |
| $D_5$ | 0.77 |
| I – mean | 0.76 |

| Comparison | S.E.D. | LSD 5% | LSD 1% |
|---|---|---|---|
| 2- I means at each D | 0.10 | 0.20 | 0.27 |
| 2- D mans at each I | 0.10 | 0.20 | 0.26 |

**Table 6: Effect of irrigation intervals and plant densities on sunflower seed yield (ton/ fed) grown under drip irrigation system in the Nile Delta in 2008 growing season .**

| Plant density (D) | Irrigation interval (I) | | | | |
|---|---|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ | $I_4$ | $I_5$ |
| $D_1$ | 1.30a | 0.92a | 0.83a | 0.79a | 0.66a |
| $D_2$ | 1.10b | 0.68c | 0.82a | 0.75a | 0.63ab |
| $D_3$ | 1.07bc | 0.72c | 0.69b | 0.71ab | 0.56bc |
| $D_4$ | 1.00cd | 0.76bc | 0.66b | 0.71ab | 0.53c |
| $D_5$ | 0.95 d | 0.81b | 0.68b | 0.65b | 0.50c |
| I – mean | 1.08 | 0.78 | 0.74 | 0.72 | 0.58 |

**CV (a) = 9.9 % ; CV (b) = 6.3 %**

**In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.**

**Table 7: Interaction effect between irrigation intervals and plant densities on seed yield (ton/ fed) in 2008 season.**

| Plant density (D) | D - mean |
|---|---|
| $D_1$ | 0.90 |
| $D_2$ | 0.80 |
| $D_3$ | 0.75 |
| $D_4$ | 0.73 |
| $D_5$ | 0.72 |
| I – mean | 0.78 |

| Comparison | S.ED | LSD 5% | LSD 1% |
|---|---|---|---|
| 2-I means at each D | 0.05 | 0.10 | 0.13 |
| 2- D means at each I | 0.04 | 0.08 | 0.11 |

Results can be concluded that irrigation every 4 days caused saving water gives healthy and good plants and therefore, good and high seed yield. On the other hand, under shortage or limited of irrigation water we recommend that irrigation interval may be reached to16 days between irrigations because there isn't a significant difference between 8, 12 and 16 days in yield.

Concerning plant densities, results showed that no significant differences between all treatments. So, we can recommend that, cultivation with one plant at each dripper is preferable in comparison with other plant densities. Using this method in cultivation always makes saving water for seeds through planting.

**1000-seed weight (g)**

Presented data in Tables (8 through 11) showed that the mean values of 1000 seed weight were clearly affected by irrigation interval under all plant densities. The highest mean values for 1000 seed weight were increased by decreasing irrigation interval, where, the highest mean values were recorded under 4 days treatment in comparison with the other treatments 8, 12, 16 and 20 days between irrigations. The mean values were 65.287, 64.660, 57.187, 55.753 and 54.500 (g) under 4, 8, 12, 16 and 20 days between irrigations in the first growing season, respectively. Data in the same tables illustrated that the same trend was obtained in the second growing season and the mean values were rather similar to the first season. In the two growing seasons the lowest mean values were recorded under the longest irrigation interval 20 days. Data in the same tables clearly showed that plant densities decleared a great effect on weight of 1000 seed where the highest mean values were recorded under cultivation one plant at each dripper in one side in comparison with the other methods of plantings.

Increasing weight of 1000 seed under the shortest irrigation interval might be due to increasing amount of water applied. So, increasing solubility and availability of nutrients, raised uptake of these nutrients by plants forming filling seeds with more weight comparing with the other treatments. Increasing 1000 seed weight under the lowest plant density might be due to, a low competition between plants on their nutritional needs, therefore, forming good and healthy seeds with more weight. These results are in a great harmony with

those obtained by Krogman *et.al.* 1980 who reported that seed yield or seed index was significantly increased by increasing the amount of irrigation upon depletion of 40, 60 and 75 % of available water. Also, these results are in a great harmony with those obtained by Maksimovic (2005).

**Table 8: Effect of irrigation interval and plant densities on sunflower 1000 seed weight (g) of sunflower grown under drip irrigation system in the Nile Delta in 2007 growing season.**

| Plant density (D) | Irrigation interval (I) | | | | |
|---|---|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ | $I_4$ | $I_5$ |
| $D_1$ | 64.433a | 73.067a | 67.567a | 59.933ab | 57.833a |
| $D_2$ | 72.767a | 60.967a | 57.767ab | 67.267a | 57.767a |
| $D_3$ | 63.200a | 57.100a | 57.833ab | 55.333ab | 56.700a |
| $D_4$ | 61.933a | 64.567a | 47.233b | 48.800b | 47.567a |
| $D_5$ | 64.100a | 67.600a | 55.533ab | 47.433b | 52.633a |
| I – mean | 65.287 | 64.660 | 57.187 | 55.753 | 54.500 |

CV (a) = 11.1% CV (b) = 15 .5 % .

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

**Table 9: Interaction effect between irrigation intervals and plant densities on 1000 seed weight (g) in 2007 growing season.**

| Plant density (D) | D – mean |
|---|---|
| $D_1$ | 64.567a |
| $D_2$ | 63.307a |
| $D_3$ | 58.033ab |
| $D_4$ | 54.020b |
| $D_5$ | 57.460 ab |
| I – mean | 59.477 |

| Comparison | SED | LSD 5% | LSD 1% |
|---|---|---|---|
| 2 – I means at each D | 7.137 | 14.655 | 19.828 |
| 2- D means at each I | 7.514 | 15.187 | 20.322 |
| 2- D means | 3.360 | 6.792 | 9.088 |
| 2- I means | 2.402 | 5.539 | 9.058 |

**Table 10: Effect of irrigation intervals and plant densities on 1000 seed weight (g) of sunflower grown under drip irrigation system in the Nile Delta in 2008 growing season.**

| Plant density (D) | Irrigation interval (I) | | | | |
|---|---|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ | $I_4$ | $I_5$ |
| $D_1$ | 74.167a | 67.167a | 62.900a | 60.000a | 52.867a |
| $D_2$ | 62.267b | 65.567a | 61.500a | 57.367ab | 54.867a |
| $D_3$ | 64.000bc | 64.500a | 60.800a | 57.000ab | 54.700a |
| $D_4$ | 63.800bc | 63.200a | 58.867a | 54.300b | 53.067a |
| $D_5$ | 60.233c | 57.133b | 54.830b | 54.100 | 53.100a |
| I – mean | 65.493 | 63.513 | 59.779 | 56.553 | 53.720 |

CV (a) = 6.7 % CV (b = 4.0%

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

**Table 11: Interaction effect between irrigation intervals and plant densities on 1000 seed weight (g) of sunflower in 2008 growing season.**

| Plant density (D) | D – mean |
|---|---|
| $D_1$ | 63.420 |
| $D_2$ | 60.913 |
| $D_3$ | 60.200 |
| $D_4$ | 58.647 |
| $D_5$ | 55.879 |
| I – mean | 59.812 |

| Comparison | S.E.D | LSD 5% | LSD 1% |
|---|---|---|---|
| 2 – I means at each D | 2.274 | 4.867 | 6.768 |
| 2- D means at each I | 1.940 | 3.920 | 5.246 |

**Head diameter (cm)**

Data in Tables (12 through 15) clearly showed that under all plant densities the mean values were greatly affected by irrigation intervals where the highest mean values were obtained under the shortest irrigation interval every 4 days in the two growing seasons and the highest mean values were 19.07 and 17.47 cm in the first and second growing seasons respectively. On the other hand, the lowest mean values were recorded under the longest irrigation interval every 20 days and the mean values were 15.45 and 15.36 cm in the first and second growing seasons, respectively. These results are in a great harmony with those obtained by Jana *et. al.* (1982) who found that irrigation increased head diameter. Also, these results are in a great agreement with those obtained by Omer *et al.* (2008).

Concerning the effect of plant densities on head diameter, the results in the same tables the mean values of head diameter were increased under the lowest plant density (one plant at each dripper) comparing with the other plant densities, where the highest mean values were 21.67 and 19.0 cm in the first and second growing seasons, respectively.

**Table 12: Effect of irrigation intervals and plant densities on head diameter of sunflower under drip irrigation system in the Nile Delta in 2007 growing season.**

| Plant density (D) | Irrigation interval (I) | | | | |
|---|---|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ | $I_4$ | $I_5$ |
| $D_1$ | 21.667a | 18.433a | 19.967a | 17.200a | 17.267a |
| $D_2$ | 19.900ab | 18.667a | 18.000ab | 15.433a | 16.300a |
| $D_3$ | 21.233a | 18.800a | 18.200ab | 14.900a | 14. 200a |
| $D_4$ | 17.333bc | 18.100a | 15.733b | 15.000a | 14.567a |
| $D_5$ | 15.233c | 19.567a | 17.900ab | 14.900a | 14.900a |
| I – mean | 19.073 | 18.713 | 17.960 | 15.487 | 15.447 |

**CV (a) = 107%** **CV (b) = 11.7%**

**In a column means followed by a common letter are not significantly different at the 5% level by DMRT**

**Table 13: Interaction effect between irrigation intervals and plant densities on head diameter in 2007growing season.**

| Plant density (D) | D – mean |
|---|---|
| $D_1$ | 18.907a |
| $D_2$ | 17.660ab |
| $D_3$ | 17.467ab |
| $D_4$ | 16.147b |
| $D_5$ | 16.500b |
| I – mean | 17.33 |

| Comparison | S.E.D | LSD 5% | LSD 1% |
|---|---|---|---|
| 2 – I means at each D | 1.626 | 3.366 | 4.500 |
| 2- D means at each I | 1.654 | 3.342 | 4.472 |
| 2 – D means | 0.740 | 1.495 | 2.000 |
| 2- I means | 0.676 | 1.558 | 2.267 |

**Table 14: Effect of irrigation intervals and plant densities on head diameter of sunflower grown under drip irrigation system in the Nile Delta in 2008 growing season.**

| Plant density (D) | Irrigation interval (I) | | | | |
|---|---|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ | $I_4$ | $I_5$ |
| $D_1$ | 19.000a | 17.933a | 17.000a | 16.167ab | 15.600a |
| $D_2$ | 17.700ab | 17.067ab | 16.067a | 16.933a | 15.500a |
| $D_3$ | 17.833ab | 17.400ab | 17.267a | 16.733a | 15.967a |
| $D_4$ | 16.000b | 15.600b | 17.333a | 14.100b | 14.900a |
| $D_5$ | 16.800ab | 16.000ab | 16.067a | 15.667ab | 14.833a |
| I – mean | 17.467 | 16.800 | 16.747 | 15.920 | 15.360 |

**CV (a) = 8.3%** **CV (b) = 7.5%**

**In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.**

**Table 15: Interaction effect between intervals and plant density on head diameter of sunflower in 2008 growing season .**

| Plant density (D) | D – mean |
|---|---|
| $D_1$ | 17.140a |
| $D_2$ | 16.653ab |
| $D_3$ | 17.040a |
| $D_4$ | 15.587c |
| $D_5$ | 15.873 |
| I – mean | 16.459 |

| Comparison | S.E.D | LSD 5% | LSD 1% |
|---|---|---|---|
| 2 – I means at each D | 1.034 | 2.159 | 2.954 |
| 2- D means at each I | 1.011 | 2.043 | 2.734 |
| 2- D means | 0.452 | 0.914 | 1.222 |
| 2- I means | 0.501 | 1.156 | 1.682 |

## Plant height

Data in Tables (16 through 20) clearly demonstrated that the mean values of plant height were greatly affected by irrigation intervals under the same plant densities where the highest mean values were recorded under treatment of 12 days between irrigations in the first growing season and 8 days in the second season and the mean values were 157.37 and 167.53 cm in the first and second growing seasons, respectively. These findings agree with that of Al- Ghamad *el .al* . (1991) who found that water depletion

significantly affected plant height which decreased by increasing soil moisture depletion. Also, these results are in a great agreement with those obtained by Omer *et al.* (2008).

**Table 16: Effect of irrigation intervals and plant densities on plant height of sunflower grown under drip irrigation system in the Nile Delta in 2007 growing season.**

| Plant density (D) | Irrigation interval (I) | | | | |
|---|---|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ | $I_4$ | $I_5$ |
| $D_1$ | 157.467bc | 156.000b | 149.033b | 152.900a | 139.000a |
| $D_2$ | 155.567c | 158.100b | 148.200b | 152.100a | 145.733a |
| $D_3$ | 172.400ab | 168.333ab | 168.967a | 152.700a | 145.433a |
| $D_4$ | 183.100a | 176.800a | 168.233a | 157.833a | 146.767a |
| $D_5$ | 161.900bc | 178.433a | 167.433a | 153.267a | 135.967a |
| I – mean | 166.087 | 167.533 | 160.373 | 153.760 | 142.580 |

**CV (a) = 7.7 %** **CV ( b ) = 5.9 %**

**In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.**

Concerning the effect of plant densities on plant height there wasn't any clear relationship between plant density and plant height but, generally the highest mean values were achieved under high plant densities.

**Table 17: Effect of irrigation intervals and plant densities on plant height of sunflower grown under drip in 2008 growing season.**

| Plant density (D) | D – mean |
|---|---|
| $D_1$ | 150.880b |
| $D_2$ | 151.940b |
| $D_3$ | 161.567a |
| $D_4$ | 166.547a |
| $D_5$ | 159.400a |
| I – mean | 158.067 |

| Comparison | S.E.D | LSD 5% | LSD 1% |
|---|---|---|---|
| 2 – I means at each D | 8.150 | 17.161 | 23.616 |
| 2- D means at each I | 7.637 | 15.436 | 20.655 |
| 2- D means | 3.416 | 6.903 | 9.237 |
| 2- I means | 4.444 | 10.249 | 14.909 |

**In a column, means followed by a common letter are not significantly at the 5% level by DMRT.**

**Table 18: Interaction effect between irrigation intervals and plant density on plant height of sunflower in 2008.**

| Irrigation (I ) | I – mean |
|---|---|
| $I_1$ | 151.087a |
| $I_2$ | 152.707a |
| $I_3$ | 157.367a |
| $I_4$ | 149.407a |
| $I_5$ | 148.878a |
| D– mean | 1510888 |

**Table 19: Effect of irrigation intervals and plant densities on plant height of sunflower grown under drip irrigation system in the Nile Delta in 2008 growing season.**

| Plant density (D) | Irrigation (I) | | | | |
|---|---|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ | $I_4$ | $I_5$ |
| $D_1$ | 143.000b | 149.800a | 161.567a | 147.133a | 146.767a |
| $D_2$ | 148.600ab | 148.867a | 154.333a | 152.300a | 148.300a |
| $D_3$ | 151.800ab | 150.967a | 154.267a | 153.533a | 148.867a |
| $D_4$ | 153.833ab | 153.367a | 153.000a | 141.767a | 149.567a |
| $D_5$ | 158.200a | 160.533a | 163.663a | 152.300a | 150.867a |
| I – mean | 151.087 | 152.707 | 157.367 | 149.407 | 148.873 |

CV (a) = 15.1% CV (b) = 5.4 %

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

**Table 20: Interaction effect between irrigation intervals and plant density on plant height of sunflower in 2008.**

| Plant density (D) | D – mean |
|---|---|
| $D_1$ | 149.653 b |
| $D_2$ | 150.480b |
| $D_3$ | 151.887ab |
| $D_4$ | 150.307b |
| $D_5$ | 157.113a |
| I – mean | 151.888 |

**Water applied (WI), ( $m^3$/fed)**

Sunflower is a summer crop, which grows in Egypt under irrigation conditions because there is no rainfall during summer months in Egypt. Presented data in Table (21) showed that the amounts of water applied were decreased by increasing irrigation intervals where the highest values of water applied were recorded at the shortest irrigation interval every 4 days and the values were 1482.04 and 1556.80 $m^3$/ fed in the first and second growing seasons, respectively. On the contrary, the lowest values were recorded under the longest irrigation interval every 20 days and the values were 1135.64 and 1110.0 $m^3$/fed in the first and second growing seasons, respectively.

Data also clearly show that elongation of irrigation interval decreased the amount of water applied, this is preferable to make saving for irrigation water, but there is a great shortage of seed yield where the values of seed yield under the shortest irrigation interval were 1.03 and 1.08 ton /fed, but for the longest interval were 0.56 and 0.58 ton/ fed in the first and second growing seasons under irrigation every 4 days and 20 days, respectively. Increasing amount of water applied under the shortest irrigation interval in comparison with the longest ones may be due to increasing the number of irrigations in comparison with the other treatments. Amounts of water applied in this study are within the range reported by Dubbelde *et. al.* (1982), who concluded that total crop water use for sunflower under semiarid conditions varied from 1033 to 4019 $m^3$/ feddan. Also, these results are in a great agreement with those obtained by Omer *et al.* (2008).

**Table 21: Effect of irrigation intervals and plant densities on amount of water applied during the two growing seasons .**

| Irrigation interval (day) | Water applied ($m^3$/fed) | |
|---|---|---|
| | 2007 | 2008 |
| 4 | 1482.04 | 1556.80 |
| 8 | 1413.04 | 1363.60 |
| 12 | 1335.32 | 1248.80 |
| 16 | 1292.64 | 1130.00 |
| 20 | 1135.64 | 1110.00 |

**Water utilization efficiency (kg /$m^3$)**

Data presented in Table (22) showed that the values of water utilization efficiency were clearly affected by irrigation intervals where the highest values were recorded under the shortest irrigation interval every 4 days and the values were 0.67 and 0.71 kg/ $m^3$ in the first and second growing seasons, respectively. On the other hand, the lowest values where recorded under the longest irrigation interval every 20 days between irrigations and the values were 0.5 and 0.52 kg / $m^3$ in the first and second growing seasons, respectively.

**Table 22: Effect of irrigation intervals and plant densities on water utilization Efficiency during two growing seasons.**

| Irrigation interval ( day ) | Water utilization efficiency (W.Ut.E.), kg/ $m^3$ | |
|---|---|---|
| | 2007 | 2008 |
| 4 | 0.67 | 0.71 |
| 8 | 0.50 | 0.57 |
| 12 | 0.52 | 0.58 |
| 16 | 0.54 | 0.64 |
| 20 | 0.53 | 0.52 |

**Oil content**

Data in Table (23) clearly showed that the mean values of oil content in sunflower seeds were greatly affected by irrigation interval where the highest mean values were recorded under 16 days between irrigations in the two growing seasons and the highest mean value was 37.513%. Also, data in the same Table illustrated that the mean values for all treatments of irrigation were nearly similar except 16 days treatment it was the highest.

Increasing oil content under 16 days is a good result. So, we recommend that irrigation in this area under study will be every 16 days without any drastic effect on oil content in seeds of sunflower.

**Table (23): Effect of irrigation intervals and plant densities on oil content of sunflower seeds under drip irrigation system**

| Irrigation interval | 1st season | | | | | 2nd season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ |
| 4 days | 36.22 | 36.34 | 35.60 | 36.37 | 37.32 | 37.89 | 36.68 | 37.28 | 37.80 | 37.73 |
| Mean | 36.57 | | | | | 37.476 | | | | |
| Total mean | 37.023 | | | | | | | | | |
| 8 days | 35.88 | 36.61 | 35.57 | 35.61 | 37.45 | 37.35 | 37.89 | 37.33 | 37.53 | 37.69 |
| Mean | 36.224 | | | | | 37.558 | | | | |
| Total mean | 36.891 | | | | | | | | | |
| 12 days | 36.60 | 37.18 | 37.24 | 37.0.4 | 37.16 | 36.81 | 37.90 | 37.32 | 37.87 | 37.80 |
| Mean | 37.044 | | | | | 37.54 | | | | |
| Total mean | 37.292 | | | | | | | | | |
| 16 days | 36.18 | 37.62 | 37.19 | 37.73 | 36.93 | 38.00 | 37.96 | 37.95 | 38.07 | 37.50 |
| Mean | 37.13 | | | | | 37.896 | | | | |
| Total mean | 37.513 | | | | | | | | | |
| 20 days | 37.20 | 36.59 | 37.30 | 36.96 | 36.37 | 36.33 | 37.59 | 36.88 | 38.22 | 37.02 |
| Mean | 36.884 | | | | | 37.208 | | | | |
| Total mean | 37.046 | | | | | | | | | |

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## تحديد فترة الري المثلي تحت كثافات نباتيه مختلفة لمحصول عباد الشمس تحت نظام الرى بالتنقيط في منطقة شمال وسط الدلتا.

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أجريت تجربتين حقليتين تحت نظام الرى بالتنقيط في المزرعة البحثية بمحطة البحوث الزراعية بسخا – محافظة كفر الشيخ خلال موسمي الدراسة ٢٠٠٧ ، ٢٠٠٨. وكان الهدف الرئيسي من هذه التجربة هو دراسة تأثير فترات الرى والكثافة النباتية على انتاجية عباد الشمس ، وكذلك بعض العلاقات المائية والخصائص التكنولوجية وجودة المحصول .

**ويمكن تلخيص البيانات المتحصل عليها فيما يلي :**

- زاد محصول البذور بصورة واضحة بنقص فترة الرى حيث سجلت أعلى متوسطات للقيم مع الري كل ٤ أيام وكانت القيم ١,٠٣ ، ١,٠٨ طن/ فدان (٢,٤٥ ، ٢,٥٧ طن/ هكتار) في الموسم الأول والثاني على الترتيب. كذلك أوضحت النتائج انه لا توجد فروق واضحة بين فترات الري كل ٨ ، ١٢ ، ١٦ يوم حيث كانت القيم الى حد ما متشابهة ولكن مع فترة الري كل ٢٠ يوم حيث تناقصت القيم بشكل واضح.
- زادت متوسط القيم لوزن الـ ١٠٠٠ بذرة مع الري كل ٤ يوم بالمقارنة ببباقى الفترات ٨ ، ١٢ ، ١٦ ، ٢٠ يوم ، حيث كانت أعلى المتوسطات للقيم ٦٥,٢٨٧ ، ٦٥,٤٩٣ جرام في الموسم الأول والثاني على الترتيب وعلى العكس من ذلك سجلت أقل القيم مع الري كل ٢٠ يوم بين الريات.
- بالإضافة الى ذلك أوضحت النتائج تناقص متوسط القيم لقطر القرص بزيادة فترة الرى حتى ٢٠ يوم. أعلى متوسطات للقيم بالنسبة من الصفه الدراسة سجلت مع الري كل ٤ أيام بين الريات وكانت قيمة قطر القرص ١٩,٠٧٣.
- سجلت أعلى المتوسطات بالنسبة لطول النبات مع فترة الرى كل ٨ يوم في الموسم الأول، ١٢ يوم في الموسم الثاني، وكانت متوسطات القيم ١٦٧,٥٣٣ ، ١٥٧,٣٦٧ سم على الترتيب وعلى الجانب الأخر أوضحت البيانات انه لا توجد علاقة ثابتة واضحة بين الكثافات النباتية وعناصر الدراسة .
- أيضا أوضحت الدراسة ان إطالة فترة الرى أدت الى نقص كمية المياه المضافة حيث سجلت أعلى القيم مع الري كل ٤ أيام بين الريات وكانت القيم ١٤٨٢,٠٤ ، ١٥٥٦,٨ م$^3$/فدان في الموسم الأول والثاني على الترتيب. وعلى العكس من ذلك سجلت أقل القيم مع الري كل ٢٠ يوم بين الريات وكانت القيم ١١٣٥,٦٤ ، ١١١٠,٠ م$^3$/فدان في الموسم الأول والثاني على الترتيب .
- تأثرت كفاءة استخدام المياه بصورة ملحوظة بفترات الرى حيث سجلت أعلى القيم مع الري كل ٤ أيام بين الريات حيث كانت ٠,٦٧ ، ٠,٧١ كجم/ م$^3$ فى الموسم الأول والثاني على الترتيب ولكن مع الرى كل ٨ ، ١٢ ، ١٦ ، ٢٠ يوم كانت القيم أقل بالمقارنة بالفترة الأولى ٤ أيام بين الريات ولم يكن هناك علاقة ثابتة وواضحة بين فترات الرى الأخرى ٨ ، ١٢ ، ١٦ ، ٢٠ يوم .
- أوضحت النتائج كذلك أن اعلى القيم بالنسبة لمحتوى الزيت سجلت تحت المعاملة ١٦يوم بين الريات مقارنة بباقي المعاملات موضع الدراسة.

**قام بتحكيم البحث**

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