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# Assessment of Skipping Irrigation on Yield, its Quality and Water Relations for Sunflower Crop

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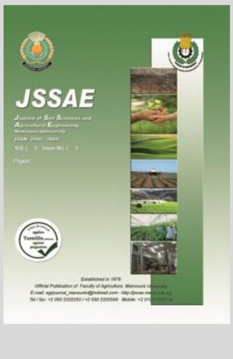


## ABSTRACT

Water is the basis of life. The plants have different water needs. Sunflower is one of the most important oil crop in Egypt and 3rd in the world. In light of the limited water resources available and the problems of marketing and export, studies are being conducted seriously to find solutions to get the maximum benefit from the crop and give the highest yield. In this study, the impact of skipping irrigation on sunflower yield, protein, oil, crop-water relations as well as crop-water functions was evaluated. Both productivity parameters were determined regarding seed yield, protein and oil content. Results showed that skipping the second irrigation following sowing (SIFS) recorded several advantages such as: nearly the same yield as obtained with full irrigation, 9% water saving and the highest water productivity in connection with consumptive use (WP) and productivity of irrigation water (PIW) with low effect on seed yield, protein and oil content.

***Keywords:*** Skipping irrigation, sunflower, protein &oil, water relations, productivity of water unit.

## INTRODUCTION

Presently, water shortages have led most of arid and semi-arid countries to increase food imports because the local agriculture sector is not able to produce sufficient food to fulfill the existing food gaps. Water scarcity is a global problem challenges sustainable development of expansion of cultivated areas to meet the increasing food requirements.

Egypt is one of the countries which facing great challenges, due to its limited water resources represented mainly by its fixed share of the Nile water, and as aridity is the general characteristic of the country (Abu Zeid, 1999). Among oil crops, the total production of sunflower (*Helianthus annuus L.*) is approximately 45 million metric tons and the area under its cultivation was 26 million hectares in the world ( Konyalı. 2017). Sunflower is an important agricultural crop in most of the sunflower growing countries. It is grown for its edible oil and fruits both for human and livestock consumption. The sunflower seed is the fruit of the sunflower ( Konyalı. 2017). Hussain *et al*. (2018) reported that sunflower is an important oilseed crop having 8% share in the world oilseed production. Egypt has a great deficiency in edible oil production. In that manner, sunflower is the most promising crop to partially overcome that gap. This fact is due to its high oil content with about 22- 55% as well as its suitable quality for human consumption (Gonzalez-Martin *et al*.2013). The higher oil percentage (42%) was recorded when applied full irrigation during the whole growing season, and the lower percentage of (37%) when plants subjected to water stress at flowering stage, while water stress occurred after seed filling stage had no significant effect on it (Bashir and Mohamed, (2014) and Eman Elsheikh *et al*. (2015).

Sunflower is moderately tolerant to water stress, but its growth and production are limited in drought and salt stress environments (Aziz *et al*. 2013). Hussain *et al*. (2018) stated that Drought stress affects the sunflower growth and productivity mainly by decreasing the water potential, cell division/expansion, owing to loss of turgor, leaf relative water contents as well as the water potential and its components. Safahani *et al*. (2014) included that Severe deficit irrigation significantly decreased water-use efficiency, radiation use efficiency, yield and yield-related components.

In situations where water resources are very limited, the best choice for deficit irrigation is to concentrate the irrigation water around flowering and early seed filling (Steduto *et al*,2012).

The objective of well-regulated deficit irrigation is to save water by subjecting crops to periods of moisture stress with minimal effects on yield while also identifying a particular cultivar under local conditions of climate and soil fertility which would allow irrigation scheduling to maximize crop yield and use scarce water resources most efficiently. (Panda *et al*., 2004).

Therefore, the objective of this study **is** to find out the role of skipping irrigation on sunflower yield, its components, protein and oil contents as well as crop- water functions.

In other words, "Sunflower-water productivity is mainly affected with amount of irrigation water or timing of irrigation event".

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## MATERIALS AND METHODS

### Location

A field experiment was carried out during the two sunflower summer seasons 2018 and 2019 at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate. The site is 31°-07' N latitude, 30°-57' E longitude and about 6 meters altitude. The site represents the circumstances and conditions of North Nile Delta area.

### Climatic conditions

Climatic elements were collected from Sakha Agro-meteorological Station for the two sunflower seasons and recorded as presented in Table 1.

### Soil characteristics

Soil samples were taken before sunflower cultivation from successive four depths, air dried, grounded and sieved for physical and chemical analysis as presented in Table 2. To find the soil texture, particle size distribution was done using the pipette method as described by Gee and Bauder,(1986). Bulk density was determined according to Black *et al*., 1965. Soil-water constants were according to (Klute 1986). Moreover, chemical analysis is tabulated in Table 2 as described by Jackson 1973.

**Table 1. Climatological data for Sakha agriculture research station during 2018 and 2019 sunflower seasons.**

| Month | T ($C^0$) Max | T ($C^0$) Min | T ($C^0$) Mean | RH (%) Mean | WS m $sec^{-1}$ | Pan Evap. mm. $day^{-1}$ |
|---|---|---|---|---|---|---|
| **2018** | | | | | | |
| May | 31.2 | 23.9 | 27.6 | 59.4 | 1.10 | 6.34 |
| June | 32.6 | 25.3 | 29.00 | 61.9 | 1.14 | 7.72 |
| July | 34.2 | 25.4 | 29.8 | 66.8 | 1.03 | 7.90 |
| August | 33.9 | 25.3 | 29.6 | 65.7 | 0.87 | 6.42 |
| **2019** | | | | | | |
| May | 31.9 | 25.4 | 28.7 | 57.2 | 0.79 | 6.83 |
| June | 33.0 | 28.0 | 30.5 | 65.8 | 1.19 | 8.46 |
| July | 33.5 | 28.4 | 31.0 | 69.9 | 0.97 | 8.08 |
| August | 34.2 | 25.9 | 30.5 | 72.7 | 0.80 | 6.82 |

**T: Temperature; R.H.: Relative Humidity; W.S.: Wind Speed at 2 m height; P.E.: Pan Evaporation; Max.: Maximum and Min.; Minimum.**

**Table 2. Soil physical properties, soil moisture constants and chemical properties for the studied area.**

| Soil depth, Cm | Particle Size Distribution % Clay | Silt | Sand | Texture Class | Soil- water constants [1]F.C (%,wt/wt) | [2]P.W.P (%,wt/wt) | [3]A.W (%,wt/wt) | Bulk Density ($Mg/m^3$) |
|---|---|---|---|---|---|---|---|---|
| 0 – 15 | 52.8 | 27.1 | 20.1 | Clay | 42.9 | 23.3 | 19.6 | 1.12 |
| 15 -30 | 52.4 | 27.4 | 20.2 | Clay | 39.7 | 21.6 | 18.1 | 1.16 |
| 30 -45 | 51.9 | 27.9 | 20.2 | Clay | 38.3 | 20.8 | 17.5 | 1.18 |
| 45 – 60 | 50.3 | 28.4 | 21.3 | Clay | 37.1 | 20.2 | 16.9 | 1.41 |
| Mean | 51.9 | 27.7 | 20.4 | Clay | 39.5 | 21.5 | 18.0 | 1.15 |

Soil Chemical characteristics

| | pH | Ec $dSm^{-1}$ | Soluble cations, $meqL^{-1}$ $Ca^{++}$ | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ | Soluble anions, $meqL^{-1}$ $CO_3^{-}$ | $HCO_3^{-}$ | $Cl^{-}$ | $SO_4^{-}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 – 15 | 8.0 | 2.9 | 6.4 | 5.7 | 16.2 | 0.2 | 0.00 | 4.5 | 11.4 | 12.6 |
| 15 -30 | 8.3 | 3.1 | 7.2 | 6.0 | 16.7 | 0.3 | 0.00 | 4.9 | 12.7 | 12.6 |
| 30 -45 | 8.5 | 3.6 | 9.1 | 8.3 | 19.4 | 0.3 | 0.00 | 5.1 | 14.3 | 17.7 |
| 45 – 60 | 8.6 | 4.0 | 10.5 | 9.1 | 21.1 | 0.4 | 0.00 | 5.3 | 15.0 | 20.8 |
| Mean | ---- | 3.4 | 8.3 | 7.3 | 18.4 | 0.3 | 0.00 | 5.0 | 13.4 | 15.9 |

**[1]FC = Field capacity, [2]PWP = Permanent wilting point and [3]AW = Available soil water.**

### Experimental layout

Sunflower crop (cv. Sakha 53) was cultivated during the two seasons of 2018 and 2019. The experiment was conducted in a complete randomized blocks design with three replicates. Dates of sowing were 12th and 15th May in the two seasons, respectively, while dates of harvesting were 10th and 14th August, respectively. Except irrigation, all cultural practices were done as recommended by Agricultural Research Center (ARC).

### Irrigation treatments

**Irrigation treatments were executed as follows:**

**Treatment A.** Given full irrigation (control) i.e., all irrigations.

**Treatment B.** Skipping 2nd irrigation after sowing (IAS)

**Treatment C.** Skipping 3rd IAS

**Treatment D.** Skipping 4th IAS

**Treatment E.** Skipping 2nd and 4th IAS.

### Data collected

### Irrigation water (IW)

Irrigation water was controlled and measured by the contracted rectangular weir as follows (Michael, 1978).

$$Q = 0.0184\ (L-0.2H)\ H^{3/2}$$

**Where:**

**Q = discharge, L/s**
**L = width of the crest, cm**
**H = water head over the crest, cm.**

### Soil moisture depletion (SMD)

Soil moisture depletion (SMD) was calculated by the following equation (Hansen *et al*. 1979):

$$SMD = Eta = \quad Cu = \frac{\theta_2 - \theta_1}{100} * Db * d$$

**Where:**

**SMD = ETa = soil moisture depletion i.e., actual consumed water by the growing plants,**
**Ө2 = soil moisture on weight basis,48 hrs. following irrigation, %**
**Ө1 = soil moisture on weight basis, before irrigation &at harvest, %**
**Db = bulk density ($Mgm^{-3}$) for 0.6 m soil depth, and**
**d = soil irrigated depth i.e., effective root zone of 0.6 m.**

### Yield and its components:

1.Plant height, cm
2.100 seed weight, gm
3.Seed yield, $kgfed^{-1}$
4.Protein percentage, %
5.Oil percentage, %

For determining protein and oil, samples of about 50 gm of air-dried seeds with three replicates for all treatments were chosen randomly and were fine grounded for that determinations. Nitrogen percentage was determined using micro-kildahl method (AOAC, 2005). Crude protein percentage was calculated by multiplying nitrogen percentage by 6.25. Oil percentage was determined using Soxhlet apparatus and hexane as a solvent.

**Crop-water functions**

Crop-water functions reflect the capability of either consumed or applied irrigation water in producing marketable yield as follows (Bos, 1981):

**Water productivity (WP)**

Water productivity (WP) reflects the capability of the consumed water by the growing crop in producing the marketable yield as:

$$WP = Y/CU$$

**as:**

**WP = water productivity, kg m$^{-3}$ consumed water**
**Y = marketable yield, kg**
**CU = SMD = ETa = seasonal consumed water, m$^3$.**

**Productivity of irrigation water (PIW)**

Productivity of irrigation water (PIW) reflects the capability of applied irrigation water in producing the marketable yield as:

$$PIW = Y/IW$$

**Where:**

**PIW = productivity of irrigation water, kg m$^{-3}$irrigation water**
**Y = marketable yield, kg**
**IW = irrigation water, m$^3$irrigated water**

**Statistical design and analysis**

The experimental design was a complete randomized (CRD) with three replicates. Statistical analysis was performed with Costat (version 6.3030) and Microsoft Office Excel 2010 programs.

## RESULTS AND DISCUSSION

**Irrigation water (IW, cm&m$^3$fed$^{-1}$)**

Tabulated data of IW in the two seasons of study are presented in Table 3. It is cleared from the obtained results that full irrigation with no skipping watering during the growing season i.e., the control treatment A (Given full irrigation (control) i.e., all irrigations.) has the highest values of IW. On the contrary, treatment E (Skipping 2nd and 4th irrigations following sowing) recorded the lowest values of IW. Mean values of IW as shown in Fig.1 could be arranged in descending order as: 50.3, 45.4, 43.0, 42.7 and 40.8 cm, respectively for treatments A, D, B, C and E. The stated depths are equaled 2112.6, 1906.8, 1806.0, 1793.4 and 1713.6 m3 /fed (1cm=42 m$^3$fed$^{-1}$ = 100 m3/ha & 1fed = 0.42 ha).

Decreasing number of irrigation water applied (water stress) recorded decreased amount of IW. These findings are in a good agreement with those obtained by Ibrahim *et al.* (2009) and Emara *et al.* (2005).

**Table 3. Seasonal irrigation water (IW, cm& m$^3$ fed$^{-1}$) as affected with irrigation treatments in the two seasons.**

| Treatments | 1st season | | 2nd season | | Mean | |
|---|---|---|---|---|---|---|
| | cm. | m$^3$ fed$^{-1}$ | cm. | m$^3$ fed$^{-1}$ | cm. | m$^3$ fed$^{-1}$ |
| A (full irrigation control) | 50.0 | 2100.0 | 50.5 | 2121.0 | 50.3 | 2112.6 |
| B 2nd SIFS | 42.9 | 1801.8 | 43.1 | 1810.2 | 43.0 | 1806.0 |
| C 3rd SIFS | 42.4 | 1780.8 | 42.9 | 1801.8 | 42.7 | 1793.4 |
| D 4th SIFS | 45.2 | 1898.4 | 45.6 | 1915.2 | 45.4 | 1906.8 |
| E 2nd & 4th SIFS | 40.5 | 1701.0 | 41.0 | 1722.0 | 40.8 | 1713.6 |

**SIFS= skiping irrigation following sowing, 1 cm= 42 m$^3$ fed$^{-1}$**


**Fig. 1. Mean seasonal irrigation water (IW, m$^3$ fed$^{-1}$) as affected with skipping irrigation treatments for sunflower crop.**

**A= Given full irrigation (control) i.e., all irrigations, B= Skipping 2nd irrigation after sowing (IAS), C= Skipping 3rd IAS, D= Skipping 4th IAS and E= Skipping 2nd and 4th IAS.**

**Consumptive use (CU, cm&m$^3$fed$^{-1}$) and its rate (mm/day)**

The presented findings in Table 4 for sunflower seasonal CU and its rate emphasized that such values took the same trend with that of IW. In other words, the higher applied irrigation water, the higher crop water consumption and vice versa. Therefore, abundance soil moisture content which resulted from the full irrigation treatment A increased the available water in the root zone to be consumed by the growing plants and the highest CU could be obtained comparing to the skipping irrigation treatments. As shown in Figure 2, mean seasonal CU values could be descending ordered as; 42.7> 38.9> 36.8> 36.4 >34.9 cm for full irrigation Treatment A and skipping irrigation treatments D, B, C and E, respectively.

Increasing CU resulted in increasing IW and decreased CU obtained to water stress. These findings are in the same direction with that concluded by Steduto *et al.* (2007).

**Table 4. Seasonal consumptive use (CU, cm& m$^3$ fed$^{-1}$) and its rate (mm day$^{-1}$) as affected with irrigation treatments in the two seasons.**

| Treatments | 1st season | | 2nd season | | Mean | | |
|---|---|---|---|---|---|---|---|
| | cm. | m$^3$ fed$^{-1}$ | cm. | m$^3$ fed$^{-1}$ | cm. | m$^3$ fed$^{-1}$ | Rate, mm day$^{-1}$ |
| A (full irrigation control) | 42.5 | 1785.0 | 42.9 | 1801.8 | 42.7 | 1793.4 | 4.7 |
| B 2nd SIFS | 36.7 | 1541.4 | 36.9 | 1549.8 | 36.8 | 1545.6 | 4.1 |
| C 3rd SIFS | 36.2 | 1520.4 | 36.6 | 1537.2 | 36.4 | 1528.8 | 4.0 |
| D 4th SIFS | 38.7 | 1625.4 | 39.0 | 1638.0 | 38.9 | 1633.8 | 4.3 |
| E 2nd & 4th SIFS | 34.7 | 1457.4 | 35.1 | 1474.2 | 34.9 | 1465.8 | 3.9 |

**SIFS= skiping irrigation following sowing, 1 cm= 42 m$^3$ fed$^{-1}$**

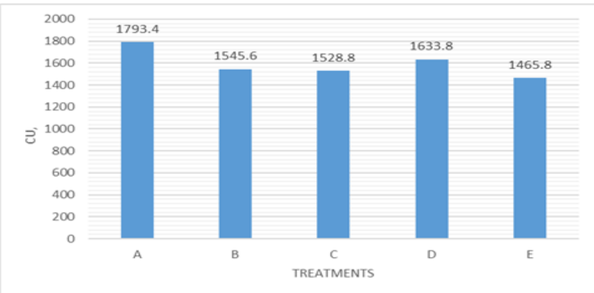


**Fig. 2. Mean seasonal consumptive use (CU, m$^3$ fed$^{-1}$) as affected with skipping irrigation treatments for sunflower crop.**

**A= Given full irrigation (control) i.e., all irrigations, B= Skipping 2nd irrigation after sowing (IAS), C= Skipping 3rd IAS, D= Skipping 4th IAS and E= Skipping 2nd and 4th IAS.**

**Seed yield and its components**

Data of sunflower seed yield in kg/fed as tabulated in Table 5 showed that a highly significant effect of skipping watering on such parameter. The highest yield was recorded under the full irrigation treatment A, while the lowest yield was obtained with the two skipping watering treatment E (2nd &4th SIFS). The mean decrease in seed yield of skipping treatments compared to Treatment A are; 9.4, 14.4, 18.3 and 31.3% for treatments B, C, D and E, respectively.

The obtained results are in a good agreement with that reported by Karam *et al*. (2007), who reported that irrigation limitation at early and mid flowering should be avoided, while it can be acceptable at seed formation. In addition, Steduto *et al*. (2012) reported that the reproductive stages (flowering and ripening stages) are more sensitive to water stress than the vegetative stages.

Regarding plant height in cm, data also showed a highly significant effect of skipping irrigation on such trait. The highest plant height was recorded under the full irrigation of Treatment A, while the lowest plant height was registered with treatment E of the two skipping irrigations.

For 100-seed weight in gm, results in that Table 5 clearly showed a very highly significant effect of skipping irrigation on such important trait. Skipping irrigation has a negative effect on that yield component. The mean values of sunflower 100-seed weight can be arranged in descending order as; 11.0> 9.84> 9.28> 8.59> 6.9 gm for treatments A, B, C, D and E, respectively.

The best treatment was B 2nd SIFS the percentage of yield reduction did not exceed 10 percent from the treatment A (full irrigation control). These findings are in the same direction with that reported by Pejic *et al*. (2009) and Ibrahim *et al*. (2009).

**Table 5. Effect of skipping irrigation treatments on seed yield and yield component for sunflower.**

| Treatment | Plant height, cm | | | 100-seed weight, gm | | | Seed yield, kg fed$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1ST season | 2nd season | Mean | 1ST season | 2nd season | Mean | 1ST season | 2nd season | Mean |
| A (full irrigation control) | 191.7a | 192.0a | 191.9 | 10.88a | 11.11a | 11.0 | 1220.4a | 1179.1a | 1199.7 |
| B 2nd SIFS | 181.7b | 186.7a | 184.2 | 10.11ab | 9.56b | 9.84 | 1098.1b | 1074.9b | 1086.5 |
| C 3rd SIFS | 175.0bc | 175.0b | 175.0 | 9.44bc | 9.11bc | 9.28 | 1033.0b | 1020.5bc | 1026.7 |
| D 4th SIFS | 171.7cd | 165.0b | 168.4 | 8.81c | 8.37c | 8.59 | 1009.43b | 951.2c | 980.3 |
| E 2nd & 4th SIFS | 163.3d | 153.3c | 158.3 | 6.63d | 7.17d | 6.90 | 813.53 c | 835.5d | 824.5 |
| LSD 5% | 3.3587 | 7.4325 | ------ | 1.16045 | 0.9295 | ---- | 60.26936 | 58.2383 | ---- |
| F-test | ** | ** | ------ | ** | ** | ---- | ** | ** | ---- |

**SIFS= skiping irrigation following sowing**

**Protein and Oil content**

Data of the two technological parameters of protein and crude edible oil in percent and kg fed$^{-1}$ for sunflower are presented in Table 6. The impact of skipping irrigation on protein percentage has no effect in the first season, while it is highly significant in the second season. The highest protein percent was recorded under the two skipping irrigations of Treatment E, while the lowest values were registered with the full irrigation with no missing watering of Treatment A. Therefore, full irrigation resulted in low protein and vice versa regarding skipping watering. In other words, the higher soil moisture content produced the lower protein percent i.e., increasing soil-water has the reverse effect of protein percent. By multiplying the seed yield in kgfed$^{-1}$ from Table 5 by protein percent, sunflower protein yield could be obtained as shown in Table 6 which took the same trend with that of protein percent.

Regarding crude edible oil percent and its yield in kg fed$^{-1}$, which presented in Table 6 showed a highly significant effect of skipping irrigation on such trait in the two seasons of study. Mean values of oil percent can be arranged in descending order as: 45.69> 42.30> 40.18> 37.66> 33.57, respectively for treatments A, B, C, D and E. The highest value of oil percent was recorded with full control irrigation of treatment A, while the skipping irrigation treatments have the lower values. In other words, increasing soil moisture, increasing oil percent and consequently sunflower oil yield and vice versa.

Therefore, in conclusion for sunflower crop, skipping irrigation compared to full irrigation led to increasing protein and decreasing oil contents. These findings are in the same direction with that reported by (Bashir and Mohamed, (2014) and Eman Elsheikh *et al*. (2015).

**Table 6. Effect of skipping irrigation treatments on protein and oil contents for sunflower.**

| Treatment | Protein percentage (%) | | | | Oil content (%). | | | |
|---|---|---|---|---|---|---|---|---|
| | 1ST season | 2nd season | Mean | | 1ST season | 2nd season | Mean | |
| | | | % | Protein yield, Kg fed$^{-1}$ | | | % | Oil yield, Kg fed$^{-1}$ |
| A (full irrigation control) | 19.17a | 19.67b | 19.42 | 233.0 | 44.92a | 46.46a | 45.69 | 548.1 |
| B 2nd SIFS | 19.33a | 20.50b | 19.92 | 216.4 | 42.80a | 41.80ab | 42.30 | 459.6 |
| C 3rd SIFS | 20.50a | 23.00ab | 21.75 | 223.3 | 40.87ab | 39.48ab | 40.18 | 412.5 |
| D 4th SIFS | 21.17a | 25.00ab | 23.09 | 226.4 | 38.22ab | 37.10b | 37.66 | 369.2 |
| E 2nd & 4th SIFS | 22.17a | 26.30a | 24.24 | 200.0 | 32.93b | 34.20b | 33.57 | 276.8 |
| LSD 5% | ---- | 3.5653 | ---- | ---- | 5.7173 | 5.4839 | ---- | |
| F-test | Ns | ** | ---- | ----- | ** | ** | ---- | |

**Ns and ** : Not significant and significant at p ≤ 0.05, 0.01, respectively. Means separated at P≤ 0.05, LSD test.**

**Crop-water functions**

Crop-water functions consist of the two parameters of water productivity (WP, kg m$^{-3}$ consumed water) and productivity of irrigation water (PIW, kg m$^{-3}$ irrigation water). Each parameter was computed in connection with the three economic yields of seeds, protein and oil for sunflower crop.

Regarding WP, data as shown in Table 7 revealed that skipping the second irrigation following sunflower sowing i.e., Treatment B produced nearly the highest WP values of seed, protein and crude edible oil. These findings are in the same direction with that reported by Safahani *et al.* (2014)**.**

Therefore, as sketched in Figure 3, one $m^3$ consumed water produced 0.7 kg sunflower seeds, 0.14 kg protein and/or 0.30 kg oil. In other words, to produce one kg of sunflower seeds, protein and/or oil need 1.4, 7.1 and/or 3.3 $m^3$ as consumed water, respectively.

**Table 7. Skipping irrigation impact on water productivity (WP, kg $m^{-3}$) and productivity of irrigation water (PIW, kg $m^{-3}$) seeds, protein and oil yields of sunflower.**

| Treatments | Mean WP kg $m^{-3}$ | | | Mean PIW kg $m^{-3}$ | | |
|---|---|---|---|---|---|---|
| | Seeds | Protein | Oil | Seeds | Protein | Oil |
| A (full irrigation control) | 0.67 | 0.13 | 0.31 | 0.57 | 0.11 | 0.26 |
| B 2nd SIFS | 0.70 | 0.14 | 0.30 | 0.60 | 0.12 | 0.25 |
| C 3rd SIFS | 0.67 | 0.15 | 0.27 | 0.57 | 0.12 | 0.23 |
| D 4th SIFS | 0.60 | 0.14 | 0.23 | 0.51 | 0.12 | 0.19 |
| E 2nd & 4th SIFS | 0.56 | 0.14 | 0.19 | 0.48 | 0.12 | 0.16 |

**SIFS= skiping irrigation following sowing.**

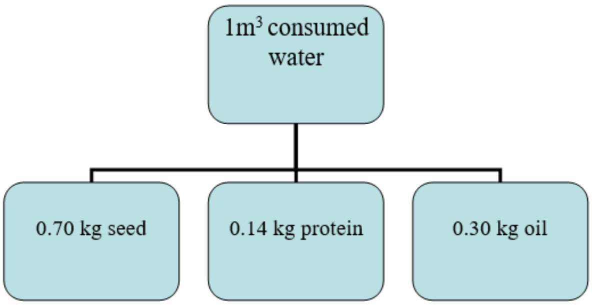


**Fig. 3. Water productivity of treatment B (2nd SIFS) for sunflower seeds, protein and oil.**

Regarding PIW, obtained results as tabulated in Table 7 indicated that values of such parameter took the same trend with that of WP. The nearly highest values of PIW for sunflower seeds, protein and crude edible oil were recorded with Treatment B.

Therefore, as sketched in Figure 4, one $m^3$ irrigation water under Treatment B (2nd SIFS) produced 0.6 kg seeds, 0.12 kg protein and/or 0.25 kg oil. In other words, to produce one kg of sunflower seeds, protein and/or oil need 1.7, 8.3 and/or 4.0 $m^3$ as irrigation water, respectively.

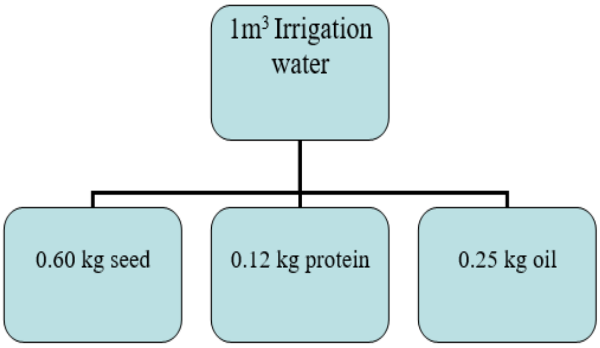


**Fig. 4. Productivity of irrigation water under treatment B (2nd SIFS) for sunflower seeds, protein and oil.**

## CONCLUSION

- Implementing skipping the second irrigation following sunflower sowing (2nd SIFS), has several advantages such as:
- Nearly same yield as recorded with full irrigation.
- About 10% water saving
- Highest values of the capability of water consumed and/or irrigation water in producing the marketable yield i.e., WP&PIW.
- Both WP and PIW computed regarding seeds, protein and crude edible oil.
- Further studies should be done to find out the suitable timing of irrigation event for different crops.

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## الحرمان من الرى وأثر ذلك على محصول عباد الشمس وكذا البروتين والزيت والعائد المحصولى لوحدة المياه

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**[1]قسم بحوث المقننات المائية والرى الحقلى- معهد بحوث الاراضى والمياه والبيئة –مركز البحوث الزراعية-الجيزة-مصر.**

**[2]قسم اختبار مبيدات افات القطن-معهد بحوث وقاية النباتات-مركز البحوث الزراعيه-الجيزه-مصر.**

**[3]قسم بحوث تكنولوجيا البذور- معهد بحوث المحاصيل الحقلية-مركز البحوث الزراعية-الجيزة-مصر.**

أقيمت هذه الدراسة بمحطة البحوث الزراعية بسخا-كفرالشيخ-شمال دلتا النيل خلال موسمى الزراعة 2018&2019 لبحث منع الرى (الحرمان من الرى) على محصول عباد الشمس وكذا البروتين والزيت بالاضافة الى العائد المحصولى من وحدة المياه. وقد أوضحت الدراسة ما يلى: * عدم الحرمان من الرى أعطى أعلى محصول وكذا وزن ال 100 بذرة وأيضا طول النبات عند الحصاد. *الحرمان من الرية الثانية بعد الزراعة قد أدت الى النتائج التالية: - نقص بسيط فى محصول البذور مقارنة بالكنترول (عدم الحرمان). - وفر فى كمية مياه الرى بحوالى 9%.- أعلى عائد محصولى لوحدة المياه سواء المستهلكة أو المضافة وذلك بالنسبة لمحصول البذور-البروتين-الزيت. وعليه: توصى الدراسةبالحرمان أو منع الرية الثانية بعد الزراعة لمحصول عباد الشمس أى الرية التالية للمحاياة ( مرحلة النمو الخضرى) وذلك تحت ظروف الشح أو العجز المائى.