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Original research

Effect of Irrigation Intervals and Planting Methods on Yield of Sunflower under Upper Egypt Conditions

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Abstract:

Two field experiments were Carried out at in El-Mattana Agricultural Research Station, Luxor, Governorate during the (2020 and 2021) to investigate the effect of irrigation intervals (7, 15 and 21 days) and two planting methods (Ridge and Raised Bed planting) on the yield of two Cultivars sunflower under Upper Egypt condition, namely: (Sakha 53 and Giza 120 Cultivar) The design of experiment was Split-Split Blocks Design (Stripes) under (RCBD) included four Replications and three factors the first factor (irrigation intervals) which were placed in whole plots while the second factor (planting methods) were placed in subplots and the third factor (varieties) were placed in sub-sub plot. The results indicated that effect of irrigation intervals was significant for all studied traits in both seasons. the maximum values of plant height (cm), seed weight head (g), and seed yield (kg/fed $^{-1}$) were obtained from irrigation every 7 days and irrigation every 15 days gave the highest mean value of oil yield (kg/fed). While irrigation every 21days produced the highest mean values of oil percentage % and 50 % flowering (%). In terms of planting method, the results revealed planting ridge Give the highest mean of 100 seed weight, oil yield, oil percentage, seed yield, and seed weight /head in both seasons, whereas planting raised bed method produced the highest values for plant height, 50 % flowering, and seed yield, respectively. While the cultivars Giza 120 superior on the Sakha 53 Cultivar in all studied traits except 100 seed weight, 50 % flowering and oil percentage.

Keywords: sunflower, irrigation, planting method, Yield components, Egypt

1- Introduction

In at moment, Egypt is one of the largest countries imported oil on the world level, where it is importing more than 90% of the needs of the oil from abroad. Therefore, care must be taken to increase the production of oil crops. Sunflower is considering one of the most important oil crops the national oil production in Egypt is insufficient to meet local consumption. Therefore, Egypt consume above 2.5 million tons of oil annual.

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Therefore, increasing oil production could be possible via two ways: horizontal expansion through increasing the cultivated area and vertical expansion through the development of new cultivars having the high potentiality and subsequently implementing the proper cultural practices. So, choising the best irrigation intervals and planting methods

will helping in the increase productivity of Sunflower this will reflacting on the total production of oil in Egypt and decrease the gap between consumption and production **(Khlifa and Fakkar, 2020; El-Hamidi et al., 2020)**. It is the fifth-largest oilseed crop in the world after soybean, rapeseed, cottonseeds and groundnuts **(FAOSTAT, 2018)**. Often considered an eco-friendly and diversified crop as it needs a lower amount of nitrogen, a small quantity of irrigation water, small amounts of pesticide and insecticide **(Debaeke et al., 2017)**.

Sunflower is mainly grown in a wide range of soils. Grows in different climatic zones ranging from arid under irrigation to temperate under rainfed conditions. **(Elsheikh, 2015)**. Also characterized by its short duration and can be grown as a catch or an intercrop in multiple cropping systems. The extracted oil from Sunflower plants ranges between 40-52 percent and has priority because of its light color, high level of unsaturated fatty acids, lack of linoleic acid, bland flavor and high smoke points and it is also good for human consumption because of its ant cholesterol properties. Besides high oil content, its protein content ranges between 13- 20 percent with 0.9-1.7 percent methionine and 2.0-3.8 percent lysine content. Its meal is rich in protein content, which is well balanced in amino acids, making it a good feed for animals. Sunflower stems contain a fiber that may be used to make paper. **(Brar *et al*., 2016)**

Irrigation could be considered the limiting factor affecting crop production and agricultural expansion. So, irrigation optimization, i.e. applying the irrigation water timely and quantitatively will increase sunflower yield and save considerable amount of water. Many researchers proved the importance of irrigation treatment to maximize sunflower productivity. **(Saeed, 2015)**

Water is the most important factor in crop production. About 85% of total water resources in Egypt are consumed by the agricultural sector. Because of its scarcity, water always is the core attention of most agronomists and on-farm irrigation specialists. **(Elmahdy, 2020)**

The major challenge facing irrigated agriculture today is producing more food using less water per unit of output i.e. increasing water productivity in irrigated agriculture. All those involved in the irrigation process, namely farm managers, farmers, workers need to be guided, through appropriate policies and incentives, to save/conserve water and minimize wastage and mitigate negative environmental impacts. This goal will only be achieved if the appropriate water-saving technologies, management tools, and policies are in place. It will be necessary to see how innovative ideas and techniques are put in to practice **(Amer *et al*., 2017)**.

Moreover, planting method is one of the factors affecting on the yield of Sunflower . So, standard planting method of Sunflower has a beneficial role in affecting sunflower plants distribution in the field as well as water and nutrients use efficiencies for grown plants and subsequent optimum yield

Most of the oilseed species are sensitive to prolonged waterlogging and consequently suffer from plant cell injury, planting the seeds at the center of the single

row (ridge) can result in poor germination because of the influence of two wetting fronts from the furrows **(Paul, 2020)**. Raised bed planting method could be effective to avoid that, it can alleviate waterlogging, and accordingly cause better germination and early vigorous crop growth.

Therefore; objectives of this study were:(1) Saving the amount of water by determine the number of times the irrigation needed to produce the best crop from grain yield. (2) Selection the best planting methods that gave the highest grain yield and saving the amount of seed under upper Egypt condition.

2-Material and Methods

The field experiments were conducted at El-Mattana Agricultural Research Station, Luxor Governorate during two seasons

2.1- Location:

The experiment has been conducted at the experimental farm of El-Mattana Agricultural Research Station, Luxor Governorate, Upper Egypt, which is located at 25° 42 latitudes and 32 °53 longitudes, at altitude of about 82m above mean sea level

Figure (1): Map of the studied area

Table (1): Maximum and minimum temperature degrees for El-Mattana Agric. Res. Station, during the growing seasons of 2020 and 2021.

Seasons	2020		2021	
Temperature C°	Maximum C°	Minimum C°	Maximum C°	Minimum C°
July	40.38	25.70	41.4	27.2
Aug	40.66	24.60	41.7	26.2
Sept	39.76	25.92	38.9	24.6

The results of the soil analysis are shown in Table (2) Representative soil samples were taken from the experimental sites before sowing in the two seasons and were prepared and analyzed, according by **(FAO, 2013)**. Table (2) displays the soil analysis results.

Table (2): Soil analysis of the experimental site in the two growing seasons

Seasons	Properties											
	Texture		pH	EC dS/m.	$CaCO_3$ %	Available elements ppm						
						N	P	K	Fe	Mn	Zn	Cu	B
2020	Sand% =35 Silt% =29 Clay%=36	Clay loam	7.6	0.26	2.9	60	10	375	12.4	16.4	2.2	4.0	0.45
2021			7.7	0.22	3.1	58	10	326	13.5	8.6	1.7	3.3	0.40

2.2-Experiment Design :

The design of the experiment was Split-Split Blocks Design (Stripes) under (RCBD). The experiment included 3 factors, 12 treatments and 4 replicates (3I×2S×2V×4R) = 48 units. Surface area of 21 m^2 (1/200 fedan) isolated by a buffer zone of (1m) width to avoid horizontal water seepage.

Years of Implementation and the sowing date:

1- summer season 2020 (the sowing was 5th July)

2- summer season 2021 (the sowing was 3rd July)

Factors and Treatments:

1-Irrigation Every 7 days :- the number of irrigation from this treatment reached 11 irrigation Per season

2- Irrigation Every 15 days :- the number of irrigation from this treatment reached 6 irrigation per season

3- Irrigation Every 21 days:- the number of irrigation from this treatment reached 5 irrigation per season

4- Planting ridge method (P1) :- (Number of ridge per experimental unit = 8 ridges, ridge width = 60 cm and length = 4 m).

5- Planting raised bed method (P2) :- (Number of raised bed per experimental unit = 4 raised beds, raised bed width =120 cm and length =4 m).

In the two planting methods (ridge and raised–beds), Hills were spaced at 25 cm with each planting method and plants were thinned at 1 plant/ hill after 3 weeks from planting.

1-Variety Sakha 53

2-Variety Giza 120

2.3 - Studied characters:

2.3.1.-Vegetative growth characters:

1- 50% flowering data. Number of days until flowering 50 % of plants.

2- Plant height (cm). Length of the main stem from soil surface to plant apex has been measured using a ruler.

2.3.2.-Yield and yield component traits:

1-Seed weight head (g). The average seed weight of five heads (g).
2-Seed yield (kg/ fed). At maturity, the sunflower heads in each plot were harvested and threshed, and yield fed $^{-1}$ was calculated by the following formula:-
$\frac{Seed\ yield\ plot^{-1}}{Plot\ size\ (M^2)} \times 4200$
3-Heundrd seed weight (g). The average (g) of tow random 100 seed samples.

2.4.Chemical analysis:

1-Oil percentage (%):-Oil percentage in sunflower seeds was estimated by extraction using Soxhlet apparatus and petroleum ether (bp60-80 co).

2- Oil yield (kg/ fed): oil yield (kg/ fed) = seed yield fed^{-1}×oil percentage.

2.5.Statistical analysis:

Data obtained was analyzed using the statistical package **MSTAT-C Nissen (1983)**. Mean values were compared to each other using the least significant differences (LSD) at the probability level of 0.05.

3-Results and Discussion

3.1-Vegetative Growth Characters:

3.1.1 50 % flowering date:

The presented data in Figure (2) showed that 50% flowering date was significantly affected by the irrigation intervals in the two seasons. The highest mean values of 50 % flowering date (50.9 and 50.7 %) were obtained from irrigation every 15 days while the lowest values (44.1 and 43.9 %) were obtained from irrigation every 21 days in two seasons respectively. In the 1st season, irrigation intervals every 15 days increased 50 % flowering date by 0.39 and 14.96 %, and by 0.39 and 15.49 % in the 2nd season, compared to irrigation intervals every 7 and 21 days, respectively. Similar results were obtained by **Abass and Alag (2016)**. A long irrigation intervals (every 21 days) led to an increase in speed of 50 % flowering date in both seasons. This may be because the deficit irrigation led to an imbalance in the hormonal content of the plant. Days of flowering were shortened in non-irrigated plants, but irrigation delayed in considerably **(Kaya and Kolsarici, 2011)**. Scrutiny of data given indicated that planting sunflower by the raised-bed method led to an increase in speed of 50 % flowering date in both seasons. The fastest 50 % flowering date (47.3 and 49.4) obtained from raised bed method in the 2020 and 2021 seasons, respectively. The results indicated that the raised bed planting method enhanced 50 % of flowering date 5.49 % in the first season and 4.43 % in the second season compared to the ridge method in both seasons, respectively. Similar results were obtained by **Katanga *et al.* (2017)**. This may be due abundance of light, air and suitable conditions that accelerate the plant's physiological growth rate, so the plant appeared an early flowering. Concerning the performance of cultivars during the two seasons, data presented in the same figure (2) indicate Giza-120 variety exhibited the highest values for 50 % flowering date (50.5 and 50.1%), while the lowest values (46.7 and 46.6 %) were recorded from variety Sakha-53 in the 1st and 2nd seasons, respectively. The variety Giza 120 produced 50 % flowering date (8.14%) in 1st season and (7.51 %) in 2nd season compared to variety Sakha 53. Sunflower (*Helianthus annuus*, L.) variety Sakha 53, early variety (100 days crop age) due to the short period of his life, this led to hastening 50% flowering date **(Saeed *et al.*,**

2015).

Table 3.Means of 50 % flowering date, plant height, 100 seed weight and oil percentage by interaction between (irrigation intervals ×planting methods seasons 2020-2021.

50%flowering date (%)				Plant height (cm)		100 seed weight (g)		Oil percentage (%)	
T		Season 2020	Season 2021	Season 2020	Season 2021	Season 2020	Season 2021	Season 2020	Season 2021
I_7	PM_1	52.0	51.9	207.8	205.8	71.1	73.6	36.6	36.3
	PM_2	49.5	49.1	195.9	208.6	81.8	80.8	38.9	38.6
I_{15}	PM_1	51.3	50.7	205.3	206.2	71.2	72.9	41.3	40.9
	PM_2	50.4	50.7	187.3	188.8	73.8	73.8	38.6	38.2
I_{21}	PM_1	46.3	45.6	194.3	189.4	62.0	63.2	43.5	42.9
	PM_2	42.0	42.2	185.4	186.6	66.3	67.5	41.8	41.4
$LSD_{0.05}$		1.87	0.77	NS	4.79	1.22	1.12	1.30	0.27

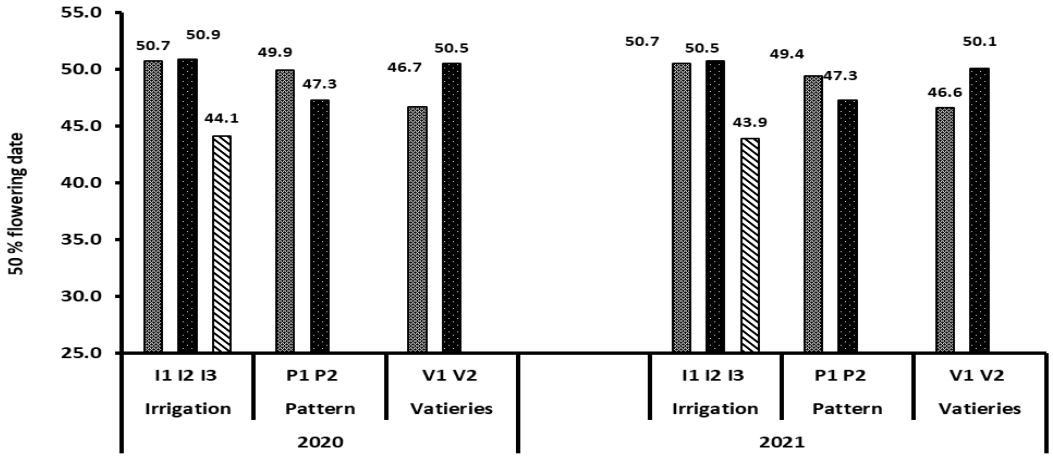

Figure (2): 50% flowering date as affected by irrigation periods, sowing methods and varieties in the two studied seasons

Interactions:

The results found that all interaction types had a significant effect on the trait of 50 % flowering date. Regarding the interaction between (I × PM), the highest mean values (52.0 and 51.9 %) of 50% flowering date were obtained from irrigation every 7 days and planting ridge method while it was the lowest mean value (42.0 and 42.2 %) obtained from treatment irrigation every 21 days and planting raised-bed method in the two seasons, respectively. Concerning the interaction between (I×V) the highest mean values of 50 % flowering date (53.1 and 52.8 %) in the first season and second seasons, respectively were recorded from treatment between irrigation every 15 days and variety Giza 120 while it was the lowest mean values (41.3 and 41.6%) were recorded from irrigation every 21 days and Sakha 53 in both seasons, respectively. As for the interaction between (PM × V), the highest mean values (51.2 and 59.4 %) were obtained from treatment planting ridge method and variety Giza 120. While the minimum mean values (44.8 and 44.9 %) were obtained from treatment planting raised-bed and variety Sakha 53 in the two seasons, respectively. Regarding the interaction between three factors (I×PM×V), the maximum mean values of this trait (53.4 and 53.8 %) were obtained from treatment (I_{15}× PM_2 ×V_2). While the minimum mean values (38.5 and 39.3 %) were obtained from treatment (I_{21} ×PM_2 × V_1) in both seasons, respectively.

3.1.2-Plant height (cm):

The presented data showed that the plant height was significantly affected by the tested irrigation intervals in the two growing seasons. The highest mean values of plant height (201.8 and 207.2 cm) were obtained from treatment irrigation every 7 days, while the lowest mean values of this trait (189.8 and 188.0 cm) were obtained from irrigation every 21 days in two seasons respectively. In the 1st season, irrigation intervals every 7 days increased plant height by 2.80 and 6.32 %, and by 4.91 and 10.21 % in the 2nd season, compared to irrigation intervals every 15 and 21 days, respectively. These results agreed with those reported by **Ebtessam *et al.*(2015); EL-Kotb and Borhan (2013); Hussain *et al* (2010)**. This may be due to the irrigation intervals decreasing, which led to water availability increase, the roots adsorbed more nutrients through the available water, which led to an increase in plant growth. Also, the exposure of the plant to deficit of irrigation affects the growth of cells and thus affects the size plant and leads to dwarfing. **Mukhesh and Raja (2015)** observed that the consequent result was an increase in plant height. Higher availability of moisture might have helped in better nutrient extraction by the crop which in turn resulted in assimilation of more photosynthesis. Lower plant height might be due to soil moisture stress condition. Drought is a physiological phenomenon that restricts water supply to fulfill its transpiration needs **(Sher *et al.*, 2021).** Drought stress limits regular growth and reduces morphological traits, such as plant height **(Sher *et al.*, 2021; Hussain *et al.*, 2010; Kaya *et al.*, 2016)**.The presented data proved that planting sunflowers by the ridge method gave the greatest increase for plant height trait. The highest plant height (202.4 and 200.4 cm) recorded with ridge method was 6.80 and 2.98 % higher than the raised bed method in the 2020 and 2021 seasons, respectively. These results agreed with those reported by **Katanga *et al*. (2017)**. This may be because planting sunflower under the raised bed method save more nutrients and light. In other hand, the increase in plant height under ridge system is mainly due to the competition for light and solar energy among the plants, which pushes the plants to grow up for obtaining enough light. Concerning the performance of cultivars during the two seasons, data presented in the same figure (3) indicate Giza-120 variety exhibited the highest values for plant height (209.2 and 207.3 cm), while the lowest values (182.7 and 187.8 cm) were recorded from variety Sakha-53 in the 1st and 2nd seasons, respectively. The variety Giza 120 produced higher plants (14.50%) in 1st season and (10.38 %) in 2nd season compared to variety Sakha 53. The superiority of variety Giza 120 may be due to genetic constituents and its interaction with environmental conditions.

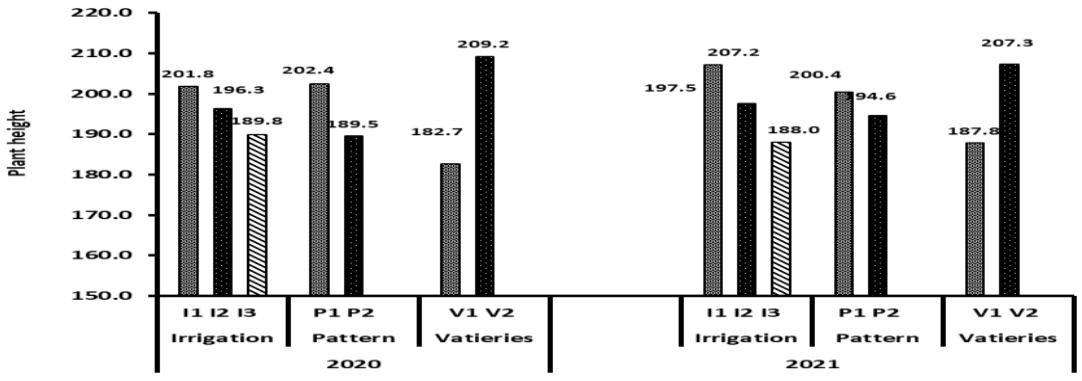

Figure (3): Plant height (cm) as affected by irrigation periods, sowing methods and varieties in the two studied seasons.

Interactions:

Regarding the interaction between (I×PM) the results indicated that was non-significant in the first season and it was significant in the second season the highest mean value of plant height (208.6 cm) was obtained from treatment irrigation every 7 days and planting raised-bed method. As for the interaction between (I×V) had an insignificant effect in two seasons, the highest mean values of this character (219.9 and 222.7 cm) were obtained from treatment irrigation every 7 days and variety Giza 120, while the lowest mean value (183.5 and 184.1cm) obtained from treatment irrigation every 21 days and variety Sakha 53 in both seasons, respectively. Concerning interaction between (PM×V) was non-significant in both seasons. Regarding the interaction between three factors (I ×PM ×V), it was significant in both seasons, highest mean values (228.8 and 220.5 cm) obtained from treatment (I_{15} × SM_{1}× $V_{2)}$ in the first and second seasons, respectively.

3.2-Yield and its components

3.2.1- Seed weight head (g):

The presented data showed that seed weight was significantly affected by the tested irrigation intervals in the two growing seasons. The highest mean values of seed weight head (76.4 and 77.2g) were obtained from irrigation every 7 days while the lowest mean value (64.1 and 65.4g) were obtained from irrigation every 21 days in two seasons respectively. In the 1st season, irrigation intervals every 7 days increased seed weight by 5.38 and 19.19%, and by 5.18 and 18.04 % in the 2nd season, compared to irrigation intervals every 15 and 21 days, respectively. These results agreed with those reported by **Abd El-Lattief (2015)**. This may be due to a long irrigation intervals (every 21 days), which led to a decrease in the process of photosynthesis, thus a decrease in the filling of the seeds, which affects the seed weight per head. The significant decrement in yield and yield components (except total carbohydrate %) caused by drought stress may be due to the loss of which affects the rate of cell expansion, and ultimate size **(Ebtessam *et al.*, 2015)**. Loss of turgidity is probably the sensitive process of water stress. This may be referring to the effect of water deficit, which in turn reduced plant growth and all yield components **(Abdou *et al.*, 2011)**. Scrutiny of data given indicated that planting sunflowers by the raised-bed method gave the greatest increase for seed weight head trait. The highest seed weight head (74.0 and 74.1g) recorded with raised bed method was 8.66 and 6.01 % higher than the ridge method in the 2020 and 2021 seasons, respectively. This may be due to planting sunflower by raised-bed method increases in head diameter and number of seeds per head. Hence the increase in seed weight head (g). Concerning the performance of cultivars during the two seasons, data presented in the same figure (4) indicate significant differences between the two varieties of sunflowers. Giza-120 variety exhibited the highest values for seed weight head (74.9 and 75.0g), while the lowest values (67.2 and 69.0g) were recorded from variety Sakha-53 in the 1st and 2nd seasons, respectively. The variety Giza 120 produced more head diameter (8.66 %) in 1st season and (6.01 %) in 2nd season compared to variety Sakha 53. This May be due to genotype, which has a great head diameter and more seeds which was reflected on seed weight head (g).

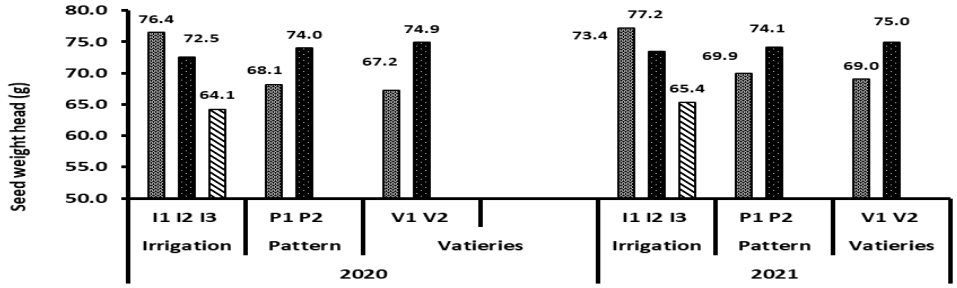

Figure (4): Seed weight head (g) as affected by irrigation periods, sowing methods and varieties in the two studied seasons.

Table 4. Means of 50 % flowering date, plant height, 100 seed weight oil percentage and oil yield by interaction between (irrigation intervals × varieties seasons 2020-2021.

50%flowering date (%)				Plant height (cm)		100 Seed weight (g)		Oil percentage (%)		Oil yield (kg/fed)	
T		Season 2020	Season 2021	Season 2020	Season 2021	Season 2020	Season 2021	Season 2020	Season 2021	Season 2020	Season 2021
I_7	V_1	50.0	49.6	183.8	191.6	6.57	6.61	38.3	37.9	618.9	640.7
	V_2	51.5	51.3	219.9	222.7	6.30	6.35	37.3	37.0	681.7	650.5
I_{15}	V_1	48.7	48.6	180.9	187.6	6.92	6.96	40.3	39.9	618.8	639.2
	V_2	53.1	52.8	211.6	207.3	6.45	6.46	39.6	39.2	687.0	668.3
I_{21}	V_1	41.3	41.6	183.5	184.1	6.68	6.60	43.7	43.1	531.8	530.9
	V_2	47.0	46.2	196.2	191.9	6.10	5.54	41.5	41.2	666.8	553.6
$LSD_{0.05}$		1.37	0.63	4.71	2.89	0.14	0.08	NS	0.27	12.83	NS

interactions:

Data presented in table (3) found that interaction between (I× PM) was significant in both seasons. The maximum mean values (81.8 and 80.8 g) were obtained from irrigation every 7 days and planting raised bed while the minimum mean values (62.0 and 63.2 g) were obtained from irrigation every 21 days and planting ridge method in both seasons, respectively. Regarding the interaction between (I × V), it was non-significant in both studied seasons. Concerning interaction between (PM×V) was significant in two seasons the highest mean values (78.7 and 78.3 g) were obtained from treatment planting raised-bed method and variety Giza 120. While the lowest mean values (65.2 and 68.1 g) were obtained from treatment planting ridge methods and variety Sakha 53 in the first and second seasons, respectively. Regarding the interaction between three factors (I ×PM× V), it was significant in both seasons. The highest mean values (90.0 and 87.3g) were obtained from treatment (I_1 ×PM_2× V_2), while the lowest mean values (58.5 and 61.0 g) were obtained from treatment (I_{21} ×PM_1× V_1) in both seasons, respectively.

3.2.2- Seed yield (kg fed^{-1}):

The presented data in figure (5) showed that seed yield was significantly affected by the tested irrigation intervals in the two growing seasons. In the 1st season, irrigation intervals every 7 days increased seed yield by 3.56 and 30.58%, and by 4.01 and 33.78% in the 2nd season, compared to irrigation intervals every 15 and 21 days, respectively. These results agreed with those reported **by Abdou *et al*. (2011);Kaya and Kolsarici (2011); Abdul Rauf *et al*. (2012); Brar *et al*. (2016); Buriro *et al*.(2015); Abd El-Lattief (2015); EL-Kotb and Borhan (2013); Mukhesh and Raja (2015)**. A short irrigation intervals (every 7 days) led to an adequate water supply in the root zone, especially at plant critical stages might have increased the

capacity of the sunflower plant in photosynthesis, assimilating from source to sink during seed formation and seed ripping stages as well as helping the plants to rapid cell division and elongation and thus increased yield. The irrigation intervals every 7 days gave (1672.9 and 1723.1 kg fed^{-1}) in the 1st and 2nd seasons, respectively. The increase in the seed yield from the irrigation treatment every 7 days is expected because this treatment led to an increase in all the characteristics of the components of the crop and its various contributions, thus increasing the seed yield per feddan. These results are the same as the findings of **Buriro *et al*. (2015)** who noted that the crop receiving 5 irrigations produced maximum values for seed yield (2200.0 kg ha^{-1}),while the lowest value for seed yield (960.33 kg ha^{-1}) recorded from plots which receiving 2 irrigations. **Bapir and Hamad (2022)** indicated that a shortage of water irrigation at various growth phases, particularly during the reproductive stage, reduces seed output by lowering the mobilization of assimilates to seeds thus yield losses. In connection, long periods of severe soil water deficit at any growth period cause leaf-drying with subsequent reduction in seed yield **(FAO, 2013)**. Scrutiny of data given indicated that planting sunflowers by the raised-bed method gave the greatest increase for seed yield trait. The highest seed yield (1581.1 and 1633.4 kg fed^{-1}) recorded with raised bed method were 7.92 and 10.48% higher than the ridge method in the 2020 and 2021 seasons, respectively. These results agreed with those reported by **Bakheet *et al*. (2022); Brar *et al*. (2016); Abdul Rauf *et al* (2012)**. This might be because raised bed planting method provided good soil conditions for proper root development, and ensured efficient use of irrigation water, thereby enabling plants to uptake more nutrients to produce more dry matter production leading to higher seed yield. The greater seed yield was obtained from raised bed planting method due to higher values of yield attributing traits *i.e*., head diameter, seed weight head, and 100-seed weight which ultimately increased the final yield. Concerning the performance of cultivars during the two seasons, data presented in the same figure (5) indicate Giza-120 variety exhibited the highest values for seed yield (1558.7 and 1603.9 kg fed^{-1}), while the lowest values (1457.6 and 1508.0 kg fed^{-1}) were recorded from variety Sakha-53 in the 1st and 2nd seasons, respectively. The variety Giza 120 produced a higher seed yield (8.99%) in 1st season and (6.36%) in 2nd season compared to variety Sakha 53. The genetic makeup of the Giza-120 variety promoted the growth efficiency of plants, which reflected positively on leaf growth and seed filling period than the Sakha-53 variety. The variability in seed yield in cultivars under water deficit could be attributed to a differential rate of the minimization of water loss that can be achieved either by lowering leaf area, transpiration per unit leaf area (stomatal conductance) or by reducing the energy load of the plant (extinction coefficient) **Soriano *et al*. (2004)**, increasing the activity of all antioxidant enzymes and proline. **Langeroodi *et al*. (2014)**.

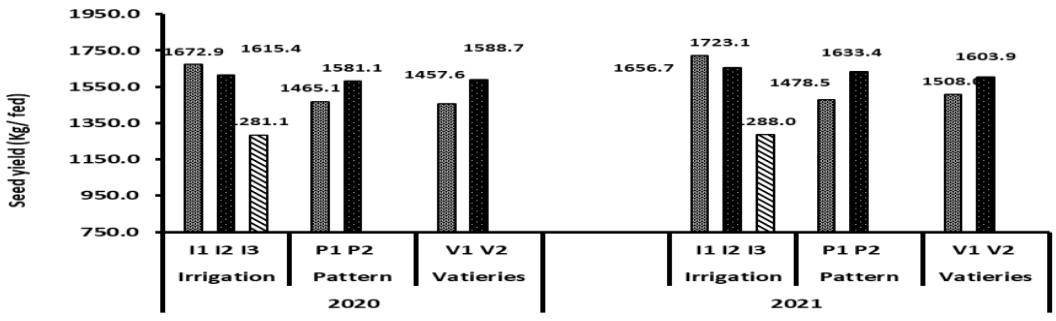

Figure (5): Seed yield (Kg/ fed) as affected by irrigation periods, sowing methods and varieties in the two studied seasons.

Table 5.Means of 50 % flowering date, seed weight head, seed yield, 100 seed weight and oil percentage by interaction between (planting methods× varieties) seasons 2020-2021.

50%flowering date (%)				Seed weight head (g)		Seed yield (kg/fed)		100 Seed weight (g)		Oil percentage (%)	
T		Season 2020	Season 2021	Season 2020	Season 2021	Season 2020	Season 2021	Season 2020	Season 2021	Season 2020	Season 2021
PM_1	V_1	48.6	48.3	65.2	68.1	1376.0	1451.1	6.81	6.86	40.8	40.3
	V_2	51.2	50.4	71.1	71.7	1554.3	1505.8	6.13	6.14	40.1	39.7
PM_2	V_1	44.8	44.8	69.2	69.9	1539.2	1564.9	6.54	6.59	40.7	40.3
	V_2	49.8	49.8	78.7	78.3	1623.0	1702.0	6.06	6.10	38.3	38.5
$LSD_{0.05}$		1.37	1.88	1.28	1.12	31.44	31.29	NS	0.08	NS	0.27

Interactions:

Data found that interaction between (I×PM) was not significant in the two growing seasons. Regarding the interaction between (I ×V), it was non-significant in the two seasons. As for the interaction between (PM× V), it was significant in both seasons the highest mean values (1623.0 and 1702.0 kg fed $^{-1}$) were obtained from sowing raised-bed method and variety Giza 120. While the lowest mean values (1376.0 and 1451.1 kg fed $^{-1)}$ were obtained from sowing ridge method and variety Sakha 53 in both seasons, respectively. Concerning interaction between (I ×PM ×V) was significant in both season. The highest mean values (1737.5 and 1873.5 kg fed $^{-1}$) were obtained from ($I_7 \times PM_2 \times V_2$), while the lowest mean values (1165.4 and 1161.9 kg fed^{-1}) were obtained from ($I_{21} \times PM_1 \times V_1$) in two seasons, respectively.

3.2.3- Hundred Seed weight (g)

The presented data in figure (6) showed that hundred seed weight was significantly affected by the tested irrigation intervals in the two growing seasons. The maximum mean values (6.68 and 6.71 g) were obtained by irrigation every 15 days but the minimum mean values (6.04 and 6.06 g) were obtained by irrigation every 21 days in two seasons, respectively. In the 1st season, irrigation intervals every 15 days increased 100 seed weight by 3.88 and 6.45 %, and by 3.55 and 10.54 % in the 2nd season, compared to irrigation intervals every 7 and 21 days, respectively. Similar results were obtained by **Abd El-Lattief (2015); EL-Kotb and Borhan (2013)**.This may be due to the deficit irrigation led to falling leaves and their small size, which is the source of nutrients, represented formation through photosynthesis, this led to a transmission deficit of processed nutrients from the source to the sink decreases, and this affects hundred seed weight. Water deficit conditions during flowering lead to reduced fertilization and seed-set due to dehydration of pollen grain that may result in reduced 1000-seed weight **(Yagoub *et al.*, 2010; EL-Kotb and Borhan, 2013)**. Scrutiny of data given indicated that the maximum average values of 100 seed weight (6.47 and 6.50 g) were obtained from planting ridge. While, the minimum average values (6.30 and 6.34 g) were obtained from planting raised beds in both seasons, respectively. The result indicated that the ridge planting method produced 100 seed weight (g) (2.69 %) in the first season and (2.52 %) in the second season. Similar results were obtained by **Abdul Rauf *et al* (2012)**. This may be due to the presence of loose surface fertile soil around the rhizosphere which might have improved the root growth, soil aeration, and uptake of water and nutrients in the ridge- sown sunflower **(Sher *et al.*, 2018)**. Concerning the performance of cultivars during the two seasons, data presented in the same figure (6) indicate Sakha-53 variety exhibited the highest values for 100 seed weight (6.68 and 6.72 g), while the lowest values (6.10 and 6.12 g) were recorded from variety

Giza-120 in the 1st and 2nd seasons, respectively. Results indicated that the variety Sakha 53 produced 100 seed weight (9.51 %) in the first season and (9.80 %) in the second season. This may be due to the interaction between genetic makeup and environmental conditions compared to the Sakha 53 variety which was reflected on mean100 seed weight (g).

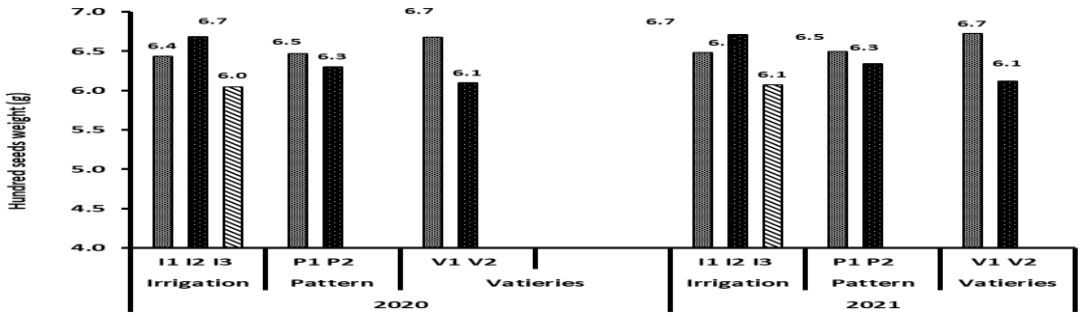

Figure (6): Hundred seeds weight (g) as affected by irrigation periods, sowing methods and varieties in the two studied seasons.

interactions:

Concerning, the interaction between (I×PM), it was non-significant in both studied seasons. Regarding the interaction between (I ×V), it was significant in two seasons, highest mean values of hundred seed weight (6.92 and 6.96 g) obtained from treatment irrigation every 15 days and variety Sakha 53. While the lowest mean values (6.30 and 6.35 g) were obtained from treatment irrigation every 7 days and variety Giza 120 in both seasons, respectively. As for the interaction between (PM× V), it was non- significant in the first season and it was significant in the second season, the highest mean values (6.86 g) were obtained from treatment planting ridge method and variety Sakha 53 in the second studied season. While the lowest mean value (6.10 g) was obtained from treatment planting raised- bed and variety Giza 120 in the second season. The results presented found that interaction between (I×SM ×V) was significant in both seasons the highest mean values of 100 seed weight (7.01 and 7.05 g) obtained from treatment (I_{15} ×SM_1 ×V_1) while the lowest mean values (5.42 and 5.47 g) obtained from treatment (I_{21} ×SM_2×V_2) in two seasons, respectively.

3.3- Chemical analysis:-

3.3.1-Oil percentage (%)

The presented data in figure (7) showed that oil percentage (%) was significantly affected by the irrigation intervals. The maximum mean values (42.6 and 42.1 %) were obtained from irrigation every 21 days while the minimum mean values (37.8 and 37.4 %) were obtained from irrigation every 7 days in both seasons, respectively. In the 1st season, irrigation intervals every 21 days increased oil percentage (%) by 12.9 and 6.7%, and by 12.6 and 6.5% in the 2nd season, compared to irrigation intervals every 7 and 15 days, respectively. These results agreed generally with those of **Elsheikh, Eman R. A. (2015)**.Oil percentage is an important criterion for determining sunflower quality, and it can be influenced by irrigation deficits. Higher moisture availability had an inverse relationship with oil content of seed. This might be due to improved seed yield which would have caused dilution effect of accumulated fatty acids in the seed under a higher frequency of irrigation **(Mukhesh and Raja 2015)**. Scrutiny of data given indicated that planting sunflowers by the raised bed method gave the greatest increase for oil percentage (%) trait. The highest

oil percentages (40.4 and 40.0%) were recorded with raised-bed method which was 1.7 and 1.6 % higher than the ridge method in the 2020 and 2021 seasons, respectively. similar results were obtained by **Sher *et al*. (2018)**. This may be due to the method of planting raised-bed methods had led to the optimum conditions of good standing, better field air circulation and such effects
increased plant vegetative growth this will reflacting on the the percentage of oil in seed, data presented in the same figure, indicate Sakha-53 variety exhibited the highest values for oil percentage (40.7 and 40.3 %), while the lowest values (39.4 and 39.1 %) were recorded from variety Giza-120 in the 1st and 2nd seasons, respectively. The variety Sakha-53 produced oil percentage 3.3% in the first season and 3.1% in the second season compared to the variety Giza-120 in two seasons. This may be due to genotypic behavior in combination with the environmental conditions which may be suitable for Sakha 53 variety compared to Giza 120 variety.

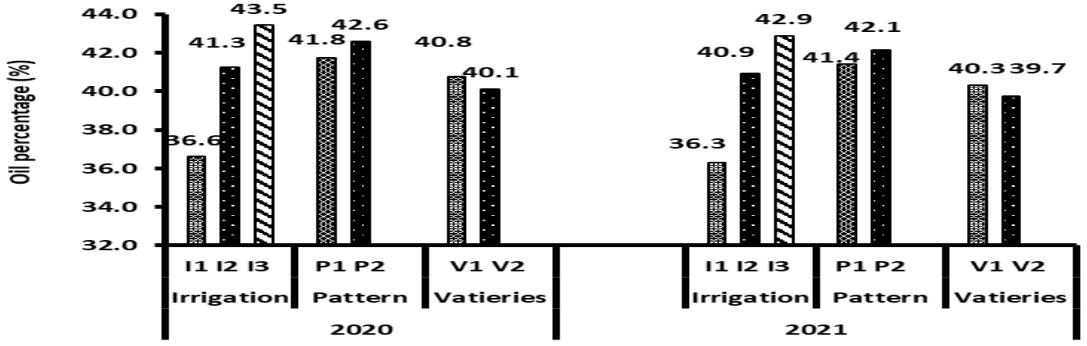

Figure (7): Oil percentage (%) as affected by irrigation periods, sowing methods and varieties in the two studied seasons.

interactions:

Data presented found that (I× PM) at the 1st season and all interaction types in 2nd season had a significant effect on the trait of oil percentage.

Regarding the interaction between (I× PM), the highest mean values of oil percentage (43.5 and 42.9 %) were obtained from treatment irrigation every 21 days and planting ridge method while the lowest mean values (36.6 and 36.3 %) were obtained from treatment irrigation every 7 days and planting ridge methods in both seasons, respectively. Concerning interaction between (I×V) the highest mean value of oil percentage (43.1 %) was obtained from treatment irrigation every 21 days and variety Sakha 53 while the lowest mean value (35.9 %) was obtained from treatment irrigation every 7 days and variety Giza 120 in 2nd season. As for the interaction between (PM ×V), the highest mean value (40.3 %) was obtained from treatment planting ridge method and variety Sakha 53 while the lowest mean value (38.5 %) was obtained from treatment planting raised-bed method and variety Giza 120 in 2nd season. Regarding the interaction between (I ×PM ×V), the maximum mean value (43.1 %) was obtained from treatment (I_{21} ×PM_1 or PM_2×V_1) while the minimum mean value (35.9 %) was obtained from treatment (I_7 ×PM_1 × V_2) in 2nd season.

3.3.2- Oil yield (kg/ fed):

The presented data in figure (8) showed that oil yield was significantly affected by the tested irrigation intervals in the two growing seasons. The oil yield increased in parallel to the increasing irrigation intervals in the treatments. The maximum mean values of oil yield (652.9 and 653.8 kg/ fed) were obtained from irrigation every 15 days while the lowest means (599.3 and 542.2 kg/fed) were obtained from irrigation every 21 days in two seasons, respectively. In the 1st season, irrigation intervals every

15 days increased oil yield by 0.4 and 8.9 %, and by 1.3 and 20.6 % in the 2nd season, compared to irrigation intervals every 7 and 21 days, respectively. These results agreed with those reported by **Abd El-Lattief (2015); EL-Kotb and Borhan(2013)**. Oil yield (kg/fed $^{-1}$) was calculated by multiplying seed oil percentage by seed yield kg/fed $^{-1}$. The increase in sunflower yield was due to both increases in yield content and oil yield in which sunflower yield was adversely affected by water deficit **(Saeed *et al.*, 2015)**. Scrutiny of data given indicated that planting sunflowers by the raised-bed method gave the greatest increase in seed yield trait. The highest oil yield (647.7 and 640.3 kg fed^{-1}) recorded with raised bed method was 4.4 and 9 % higher than the ridge method in the 2020 and 2021 seasons, respectively. These results agreed with those reported by **Hussain *et al* (2010)**. Oil yield kg /fed = (seed yield kg / fed ×oil percentage %) therefore, the increased seed yield when using planting raised-bed method led to an increase in the oil yield when applying this treatment. Concerning the performance of cultivars during the two seasons, data presented in the same figure, indicate Giza-120 variety exhibited the highest values for oil yield (678.5 and 624.1 kg fed^{-1}), while the lowest values (589.8 and 603.6 kg fed^{-1}) were recorded from variety Sakha-53 in the 1st and 2nd seasons, respectively. The variety Giza 120 produced a higher oil yield of 15.0% in the first season and 3.4 % in the second season compared to the variety Sakha 53. This may be due to higher seed yield production of variety Giza 120 in both seasons, which led to an increase in the oil yield.

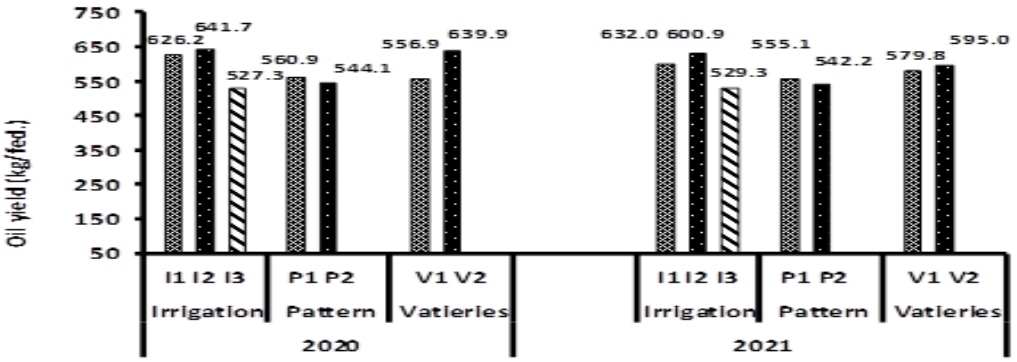

Figure (8): Oil yield (kg /fed) as affected by irrigation periods, sowing methods and varieties in the two studied seasons.

Table 6.Means of 50 % flowering date, plant height, seed weight head, seed yield, 100 seed weight, oil percentage and oil yield by interaction between (irrigation intervals ×planting methods× varieties) seasons 2020-2021.

T			Plant height (cm)		50% Flowering date		Seed weight head (g)		Seed yield (kg/fed)		100 seeds weight (g)		Oil percentage %		Oil yield (kg/fed)	
			2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
I1	PM1	V1	192.8	192.1	51.5	51.5	69.5	72.3	1525.0	1672.3	6.93	6.97	37.0	36.7	563.8	613.1
		V2	222.8	219.5	52.5	52.3	72.8	74.9	1724.3	1640.3	6.19	6.25	36.3	35.9	688.6	588.6
	PM2	V1	174.8	191.1	48.5	47.8	73.5	74.4	1704.7	1706.5	6.21	6.24	39.5	39.2	674.0	668.4
		V2	217.0	226.0	50.5	50.4	90.0	87.3	1737.5	1873.5	6.41	6.46	38.3	38.0	674.8	712.3
I2	PM1	V1	181.8	191.9	50.0	49.6	67.5	71.1	1437.5	1519.2	7.01	7.05	41.5	41.2	597.1	625.4
		V2	228.8	220.5	52.7	51.3	74.9	74.8	1675.0	1570.0	6.53	6.55	41.0	40.7	701.0	638.6
	PM2	V1	180.0	183.3	47.5	47.6	70.0	70.8	1643.4	1688.7	6.83	6.86	39.0	38.7	640.4	653.0
		V2	194.5	194.2	53.2	53.8	77.7	76.9	1705.6	1848.9	6.36	6.37	38.3	37.8	673.0	698.0
I3	PM1	V1	185.0	185.0	44.2	43.9	58.5	61.0	1165.4	1161.9	6.51	6.55	43.8	43.1	509.8	500.9
		V2	203.5	193.8	48.4	47.2	56.5	65.3	1263.6	1307.1	5.66	5.62	43.1	42.7	663.3	557.8
	PM2	V1	182.0	183.2	38.5	39.3	64.2	64.5	1269.6	1299.5	5.58	6.66	43.7	43.1	553.8	560.9
		V2	188.8	190.0	45.5	45.2	68.4	70.6	1426.0	1383.5	5.42	5.47	39.8	39.7	670.3	555.1
Mean			**196.0**	**197.5**	**48.6**	**48.4**	**71.0**	**72.0**	**1581.1**	**1555.9**	**6.39**	**6.42**	**40.1**	**39.7**	**634.1**	**613.9**
LSD0.05			**14.13**	**8.67**	**4.12**	**1.88**	**3.84**	**3.35**	**94.32**	**93.88**	**0.43**	**0.25**	**1.42**	**0.86**	**NS**	**38.67**

Interactions:

Regarding interaction, the interaction was significant between (I × V) and (PM ×V) in 1st season and between (I ×PM ×V) in 2nd season. As for interaction between (I ×V) in the first season. The maximum mean value (673.0 kg /fed $^{-1}$) was obtained from irrigation every 15 days and variety Giza 120 while the lowest mean value (531.8 kg /fed $^{-1}$) was obtained from treatment irrigation every 21 days and variety Sakha 53 in the second season. Concerning interaction between sowing methods and varieties (PM ×V) in the first season, the highest mean value of oil yield (684.3 kg /fed $^{-1}$) was obtained from planting ridge method and variety Giza 120 while the lowest mean values (556.9 kg /fed $^{-1}$) obtained from planting ridge method and variety Sakha 53.As for the interaction between three factors (I×PM ×V) in 2nd season, the maximum mean value (712.3kg /fed $^{-1}$) was obtained from ($I_7 \times PM_2 \times V_2$), while the lowest mean value (500.9 kg /fed $^{-1}$) was obtained from treatment ($I_{21} \times PM_1 \times V_1$).

4-Conclusion:-

The study recommended that, for maximum seed yield, treatments (irrigation every 15 days, sowing raised-bed method and variety Giza 120) could be applied to the yield of Sunflower in upper Egypt.

5-References.

Abass, H.A. and M.K. Alag (2016): Role of proline acid in improving sunflower yield and yield components under deficit conditions water. The Iraqi Journal of Agricultural Sciences 47(2): 451-438 Dol: 10.36103. /ijas v47i2.586.

Abd El-Lattief, E.A. (2015): Impact of irrigation intervals on productivity of sesame under southern Egypt condition. International Journal of Advanced Research in Engineering and Applied Sciences 4 (10):1-9.

Abdou, S. M. M.; K.M. Abd El- Latif; R.M.F. Farrag and K.M.R. Yousef (2011): Response of sunflower yield and water relations to sowing dates and irrigation scheduling under middle Egypt condition. Advances in Applied Science Research. 2 (3): 141-150.

Abdul Rauf; M. Maqsood; A. Ahmad and A.S. Gondal (2012): Yield and oil content of sunflower (*Helianthus annuus* L.) as influenced by spacing and reduced irrigation condition. Crop Prod. 01, 41-45.

Amer, M. H.; S.A. Abdel Hafiz and M.B. Abdel Ghany (2017): Water saving in irrigated agriculture in Egypt (Case Studies and Lessons Learned). LAP LAMBERT Academic Publishing. ISBN-10: 620202402X.

Bakheet, B. R.; E.A. Ali; A.A. Omar and H. A.A. Hamed (2022): Effect of planting methods and foliar spraying with zinc dioxide nanoparticles on the seed and oil yields of sunflower. Assuit Journal of Agriculture Sciences 53 (3):1- 13.

Bapir, S.H. and S. W. Hamad (2022): Interactive effect of irrigation skipping and salicylic acid on yield of sunflower (*Helianthus annuus* L.). Zjpas, 34 (4): 53-66.

Brar, J. S.; S.S. Mahal; K.S. Saini and N.S. Brar (2016): Response of sunflower yield to planting methods and irrigation schedules. Indian J. Agric. Res., 50 (1): 71-75.

Buriro,M.; A.S. Sanjrani; S. Chachar; Q. Chachar; J. Ahmed; B. Buriro; A.W. Gandahiand and T. Mangan (2015): Effect of water stress on growth and yield of sunflower. Journal of Agricultural Technology Vol. 11(7): 1547-1563.

Debaeke, P.; L. Bedoussac; C. Bonnet; E. Bret-Mestries; C. Seassau; A. Gavaland, A.; D. Raffaillac; H. Tribouillois; G. Véricel and E. Justes (2017):Sunflower crop: Environmental-friendly and agroecological. OCL - Oilseeds and fats, Crops and Lipids 24(3):12, D304.

Ebtessam, A. Y.; M.A. Ahmed; N. Bader; A.F. Magda and K.M. Shalaby (2015): Alleviation of drought effect on sunflower (*Helianthus annuus* L) C.V.sakha-53 cultivar by foliar spraying with antioxidant . Middle East Journal of Agriculture, 4(4):794-801.

EL- Kotb, H. M. A. and T.I. Borhan (2013): Combination impact of irrigation regimes and N&K-humate rates on sunflower productivity and water use efficiency in sandy soil. Egypt J. soil Sci.vol.53 (1):119-133.

El-Hamidi, M.; F.A. Zaher and A. Shaaban (2020): Edible oil production in Egypt: An Overview. Curr. Sci. Int., 9(4): 649-655.

Elmahdy, A. M. (2020): Water productivity evaluation for irrigated wheat in Luxor, Upper Egypt using the DSSAT CERES – Wheat Model. Ph.D. Thesis, Soils and Water Sciences Dept., Fac. of Agriculture. Assiut Univ., Egypt.

Elsheikh, Eman R. A. (2015): Water productivity of sunflower under different irrigation regimes on Gezira clay soil, Sudan. Ph.D. Thesis, Water Education. UNESCO-IHE Institute, Wageningen Univ., Holland.

FAO (2013): FAO- Water Development and Management Unit- Crop Water Information-Sunflower.

FAOSTAT (2018): Food and Agricultural Organization of the United Nations, Rome, Italy.

Hussain, M.; M. Farooq; K. Jabran and A. Wahid (2010): Foliar application of glycinebetaine and salicylic acid improves growth, yield and water productivity of hybrid sunflower planted by different sowing methods. Journal of Agronomy and Crop Science, 196(2): 136-145.

Katanga, Y. N.; O. Danmaigoro and Y. Buba (2017): Effect of sowing methods, seed rate and variety on yield and seed quality of sesame (*Sesamum indicum* L.) and its implication on returns in Sudan Savanna of Nigeria. Asian Research Journal of Agriculture,6(4):1-7.

Kaya, M.D. and O. Kolsarici (2011): Water use features of sunflower (*Helianthus annuus* L) hybrids irrigated at different growth stage. African Journal of Biotechnology 10 (22), 4591-4595.

Kaya, Y.; V. Pekcan and N. Cicek (2016): Effects of drought on morphological traits of some sunflower lines. Ekin J Crop Breed Genetic. 2:54–68.

Langeroodi, A.R. S.; B. Kamkar; J.A.T. Silva and M. Ataei (2014): Response of sunflower cultivars to deficit irrigation. HELIA 37(60): 37-58.

Mukhesh, G. and G. Raja (2015): performance of sunflower (*Helianthus annuus L*) under variable date of sowing and irrigation. Rajend Anager, Hyderabad-50003.

Nissen, O. (1983): MSTAT- C. A Microcomputer Program for the Design Management and Analysis of Agronomic Research Experiments. MSTAT Distribution Packages Contains: Program Disketers (not bootable) and users Guide. 153 p.

Paul, P. L. C. (2020): Agronomic practices increase sunflower yield in the rabi (dry) season in clay-textured, salt-affected soils of the coastal region of Bangladesh. Ph. D. Thesis, Irrigation and Water Management Dept., Murdoch University, Perth, Western Australia, Australia.

Saeed, A. A. Q.; G. Abdel-Nasser and M.A. Gomaa (2015): Growth, productivity and water use of sunflower crop under drip irrigation system. J. Adv. Agric. Res. (Fac. Agric. Saba Basha).20(3)

Saeed, M. (2015): Prospects and hydraulics of film-hole irrigation in irrigated environment. Ph.D. Thesis, Centre of Excellence in Water Resources Engineering., Assiut Univ. of Engineering and Technology, Lahore, 54890, Pakistan.

Sher, A.; M. Suleman; A. Qayyum; A. Sattar; A. Wasaya; M. Ljaz and A. Nawaz (2018): Ridge sowing of sunflower (*Helianthus annuus* L.) in a minimum till system improves the productivity, oil quality, and profitability on a sandy loam soil under an arid climate. Environ Sci. Pollut Res Int 25 (1) Dol:10.1007/s11356-018-1336-4.

Sher, A.; M.Y. Arfat; Sami Ul-Allah; Abdu Sattar; M. Ijaz; Abdul Manaf; Abdul Qayyum; A.T. K. Zuan; , Omaima Nasif and Kristina Gasparovic (2021): Conservation tillage improves productivity of sunflower (*Helianthus annuus L)* under reduced irrigation on sandy loam soil. PLOSONE 16(12):1- 9.

Soriano, M.A., Orgaz, F., Villalobos, F.J., Fereres, E.,(2004): Efficiency of water use of early plantings of sunflower. European Journal of Agronomy 21: 465–476.

Yagoub, S. O.; A.A.M. Osman and A.K. Abdesalam (2010): Effect of Watering Intervals and Weeding on Growth and Yield of Sunflower (*Helianthus annuus l*). Journal of Science and Technology 11 (2): 52 – 56.