J. Agric. Sci. Mansoura Univ., 25 (2): 675 - 697, 2000.

PERFORMANCE OF SOME SUNFLOWER CULTIVARS AS AFFECTED BY WATER IRRIGATION REGIMES

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ABSTRACT

Two field experiments were carried out at the Experimental Farm, Faculty of Agriculture, Minufiya Univ., at Shebin El-kom to study the effect of three irrigation regimes, i.e. 40, 55 and 70 % available soil moisture depletion (ASMD) on growth, seed yield and its components as well as seed quality of four sunflower cultivars namely Pioneer-6480, Euroflor, Elya and Miak during 1996 and 1997 seasons. The treatments were arranged in split-plot design with four replicates where the irrigation treatments occupied the main plots and the tested sunflower cultivars were assigned in the sub-plots. The most important results are summarized as follows:

1-Sunflower plants grown under water stress (40% ASMD) showed significantly higher in plant height, number of green leaves/plant, stem diameter, leaf area/plant, total dry matter/plant, LAI and SLA at all sampling dates which were 45, 60 and 75 days after sowing, and RGR, NAR and CGR values at the period of 45-60 days. On the contrary, exposed plants to 40% ASMD led to significantly lower in RGR, NAR and CGR values at the period of 60-75 days compared to 55% and 70% ASMD treatments in both seasons. Also, sunflower plants exposed to water stress at 40% ASMD gave the highest mean values for seed yield/plot and its components and seed oil percentage in both seasons. A gradual depression in seed yield/plot and its component mean values, parallel to the decrease in amount of available water in the soil was detected. Iodine value and Lenoleic and Lenolenic acids were increased gradually when plants exposed to water stress at 55% and 70% ASMD meanwhile, saturated fatty acids and Oleic acid decreased with increasing the available soil moisture depletion. Acid value and Refractive index in the analysis of crude sunflower oil were not governed by irrigation regimes in both seasons.

2-Miak cultivar surpassed significantly Elya, Euroflor and Pioneer-6480 cultivars in the vegetative growth and LAI at all sampling dates, and SLA at 60 and 75 days after sowing in both seasons whereas, Elya cultivar exceeded significantly the other three ones in SLA at 45 and 60 days after sowing. Moreover, Elya and Maik cultivars surpassed significantly Euroflor and Pioneer-6480 cultivars in RGR at the period of 60-75, and NAR and CGR at the period of 45-60 days after sowing in both seasons. Miak surpassed significantly the other tested cultivars in seed yield/plot and its components and seed oil percentage in both seasons. Miak and Elya cultivars exceeded significantly Euroflor and Pioneer-6480 in Iodine value whereas, Pioneer-6480 expressed the highest mean values of saturated fatty acids and oleic acid than the other three ones. Miak cultivar surpassed significantly the other tested cultivars in Lenoleic and Lenolenic acids. All tested cultivars did not differ significantly with regard to acid value and refractive index in the analysis of crude sunflower oil in both seasons.

3-Partitioning irrigation sum of squares by means of orthogonal polynomials revealed that linear components caused the majority of varietal response to irrigation regimes in seed yield/plot. Also, the linear slope was positive for all the studied cultivars, indicating that using 40% ASMD increased mean values of seed yield/plot. Appreciable quadratic effect of negative sign was detected in all cultivars except Elya cultivar. Cubic effect, meanwhile, was of negligible in all cases. Therefore, it could be

safely concluded that irrigation sunflower cultivars at 40% ASMD would be fruitful in all cultivars except Elya cultivar where water stress may be tolerated.

4-Studies on the relative depression in mean values of number of seeds/head, 1000-seed weight and seed yield/plot resulted from water stress revealed that Elya and Miak cultivars were more tolerant to drought conditions than both of Euroflor and Pioneer-6480 cultivars.

5-Correlation studies revealed that seed yield/plot in sunflower was significantly and positively associated with number of seeds/head, 1000-seed weight when sunflower cultivars received the normal irrigation regime (40% ASMD). At the higher levels of available soil moisture depletion (70% ASMD), however, insignificant association and negatively was detected between seed yield/plot and each of number of seeds/head and seeds weight/head. On the other hand, 1000-seed weight appeared to be significantly and positively correlated with seed yield/plot at all the studied irrigation regimes.

INTRODUCTION

Sunflower (*Helianthus annus* L.) is grown as a source of vegetable oil and protein. The expanding of cultivated area with sunflower in the world attributed to some aspects; it is tolerant to both moisture and temperature fluctuations than most crop, and can be grown in new reclaimed soils. Moreover, it has a short growing season and wide range of adaptability to different climate conditions. For these reasons, more attention has been paid for cultivated sunflower as an oil crop in Egypt to overcome the decrease in oil production needed for national consumption.

Sunflower, like other crops, needs especial cultural practices to give satisfactory yield of seeds and oil. Soil moisture in the root zone plays an important role in plant growth and its yield. Therefore, it is necessary to determine the optimum water requirement in planning the best irrigation regime for obtaining maximum crop production of sunflower. Sunflower growth and growth analysis criteria were significantly reduced by water stress occurred by prolonging irrigation intervals and increasing available soil moisture depletion at different growth stages (Mekki, 1985; Selim *et al.,* 1994; Teama and Mahmoud, 1994; Esechie, 1995; El-Noemani *et al.,* 1996; Reddy *et al.,* 1996; Sunderman *et al.,* 1997 and Hasan, 1999). Seed yield of sunflower was more sensitive to water stress at flowering stage due to the much more pronounced reduction in both seed yield/plant and per plot (Ferri and Losavio, 1982; Mekki, 1985; Mahey *et al.,* 1989; El-Hity, 1994; Teama and Mahmoud, 1994; Esechie, 1995; and El-Ghareib, *et al.,* 1996). The reducing effect of water stress on seed quality was confirmed by (Ferri and Losavio, 1982; Teama and Mahmoud, 1994 and El-Ghareib, *et al.,* 1996).

Sunflower cultivars differed significantly in their growth and growth analysis parameters. This fact was confirmed by (Woodhams and Koslowski, 1954; Saad *et al.,* 1995; Esechie, 1995; El-Noemani *et al.,* 1996; Sobarad *et al.,* 1996; Ortegon and Diaz, 1997 and Hasan, 1999). Sunflower cultivars differed significantly in yield and its components as well as seed quality (Ferri and Losavio, 1982; Saad *et al.,* 1995; El-Ghareib, *et al.,* 1996; Sobarad *et al.,* 1996; and Hasan, 1999).

Since sunflower is grown for oil, the aim of this study was undertaken to identify a suitable cultivar and optimum water requirement of sunflower crop.

MATERIALS AND METHODS

The field experiments were conducted in the two successive seasos 1996 and 1997 at the Experimental Farm, Fac. of Agric. Minufiya Univ., Shibin El-Kom. Each experiment included twelve treatment combinations resulting from three irrigation regime treatments; i.e. 40, 55 and 70% from the available soil moisture within the root zone (ASMD) and four sunflower cultivars; i.e. Pioneer-6480, Euroflor, Miak and Elya. The soil was clay loam. In both season, Physical and chemical properties of the soil and moisture characteristics were determined according to Bavel *et al.* (1972) which are shown in Table (1).

Table 1: Mechanical analysis and some physical properties of the soil

Depth (cm)	Season	Sand %	Silt %	Clay %	Textural grade	Field capacity	Wilting %	Available water
0 --20	1996	24.68	28.85	46.52	Clay loam	43.50	22.80	25.96
20-40		26.55	28.29	43.30		38.45	19.45	21.19
40-60		33.84	26.69	39.37		36.55	17.70	18.79
0 --20	1997	24.62	28.75	46.48	Clay Loam	44.10	22.50	25.84
20-40		26.45	28.21	43.28		37.85	19.25	21.11
40-60		33.76	26.62	39.33		36.25	17.50	18.71

The Egyptian clover was the preceding crop in both seasons of the experimentation. A split-plot design with four replications was used. The main plots were devoted to irrigation regime treatments. The sub-plots were occupied by sunflower cultivars. The plot size was 12.96 m^2 combining six rows each of 3.60m length and 60 cm apart. Phosphorus fertilizer was added in the form of calcium superphosphate (15.5% P_2O_5) at the rate of 200 kg/fed during seed-bed preparation. Planting dates were on May 23 and 17 in 1996 and 1997 seasons, respectively. Seeds were sown in hills spaced of 20 cm. apart with two to three seeds/each. Nitrogen fertilizer in the form of ammonium nitrate (33.5% N) at a rate of 60 kg N/fed was applied as top dressing immediately after thinning to one plant/hill before the first irrigation (21 days from sowing). Hoeing was practiced before the first and the second irrigation. Thereafter, soil samples were taken periodically at different intervals just before and after irrigation within 48 hours to predict time of irrigation at three soil depth 0-20, 20-40 and 40-60 cm in both seasons. Irrigation water was applied by raising the soil to its field capacity when it reaches to the desired (ASMD). Water was added when plants consumed approximately 40, 55 and 70% from the available soil moisture within the root zone.

The vegetative samples were taken from the outer two rows in each sub-plot three times during the growth period. 15 days by interval beginning 45 days till 75 days after planting in the two growth seasons. Days to 50%

flowering was recorded on plot mean basis as number of days from sowing until 50% of complete flowers of plants were bloomed. The following growth characters were measured: plant height (cm), stem diameter (cm), number of green leaves/plant, leaf area/plant (cm^2) and total dry matter/plant (g). Moreover, the following growth analysis criteria were calculated according to the formula used and explained in the work of Watson (1958):

1-Leaf area index (LAI) = Leaf area/Ground area = dm^2/dm^2

2-Specific leaf area (SLA) = Leaf area/Leaf dry weight = dm^2/g

3-Net assimilation rate (NAR) = $(W_2-W_1)(A_2-A_1)/(A_2-A_1)(t_2-t_1)$ = $g/cm^2/day$

4-Relative growth rate (RGR) = $(lnW_2-lnW_1)/(t_2-t_1)$ = g/g/day

5-Crop growth rate (CGR) = $(W_2-W_1)/(t_2-t_1)$ = $g/cm^2/day$

Where: W_1 , A_1 and W_2 , A_2 respectively, refer to total plant dry weight and blade leaf area/plant at time t_1 and t_2 .

At the end of flowering stage, the inner four rows of each sub-plot were bagged to avoid birds damage, and devoted for estimating seed yield/plot. At harvest time, heads of ten guarded plants were randomly drawn from the inner four rows in each sub-plot and were separately harvested, bagged and dried under sunshine for two weeks to determine average head diameter, number of seeds/head, 1000-seed weight, seeds weight/head. All seeds obtained from the four inner rows of each plot and the ten guarded plants were bulked together, weighted to calculate seed yield/plot.

Relative depression, in number of seeds/head, 1000-seed weight, seed yield/plot, resulted from water stress was calculated for each cultivar by applying the following formula for the data obtained from each replicate.

$$(T2 - T1) / T2 \times 100$$

Where :

T1 : The mean value of each line and/or cultivar received 70% ASMD.

T2 : The mean value of each line and/or cultivar received 40% ASMD.

All resultant values from this formula were transformed to arcsine values and the data were statistically analyzed.

After harvest and seeds completely dried, 200 g seeds of the randomly sampled from each sub-plot were taken to determine the following traits: Seed oil percentage; was determined by NMR apparatus. The iodine value; was determined by measuring the amount (g) of halogen (Iodine) observed by 100 grams of oil as stated in A.O.A.C. (1985). The iodine value was calculated as grams of iodine observed by 100 grams oil as follows: I.V.= ml. of thiosulphate (blank) - ml. of thiosulphate (sample) x (N thiosulphate x 12.69/wt. of sample), Refractive index; was determined at 25 ^{o}C according to A.O.A.C. (1985), Acid value and Saturated fatty acids were determined by the method described by DeeSnell and Biffen (1972), Fatty acids content i.e., Oleic, Lenoleic and Lenolenic acids; were identified and calculated according to the method described by McNair and Bonelli (1969).

The data obtained were subjected to an ordinary analysis of variance according to the procedure outlined by Gomez and Gomez (1983). Differences among treatment means were compared by using the Revised L.S.D at 5% level of significance adopted by Waller and Duncan (1969). At each irrigation regime, simple correlation coefficients among seed yield and its main components were computed according to the method outlined by Johnson *et al.* (1955).

RESULTS AND DISCUSSION

I- Vegetative growth

1.1: Effect of irrigation regimes

Mean values of plant height, number of green leaves/plant, stem diameter, leaf area/plant and total dry matter/plant as affected by water irrigation regimes are shown in Table (2). Plant height was depressed by increasing (ASMD %) level at all growth periods, i.e. (45, 60 and 75 days from sowing) in the whole seasons. Plants irrigated at 40% ASMD was taller than followed by plants at 55 and 70 % ASMD in both seasons. Such results may be interpreted by the fact that exposing plant to drought causes reduction in cell division, cell elongation and turgidity that might cause the reduction in the plant height as reported by Kramer (1969).

It is obvious from Table (2) that water stress treatments had a significant effect on number of green leaves/plant and stem diameter at all growth periods. The greatest number of green leaves/plant and stem diameter was obtained by irrigation at 40% and 55% ASMD. On the other hand, the lowest number of green leaves/plant and stem diameter was recorded by irrigation at 70% ASMD in both seasons. These findings confirm with those of Selim *et al.* (1994); Teama and Mahmoud (1994); Esechie (1995) and El-Noemani *et al.* (1996).

Leaf area/plant and total dry matter/plant were significantly affected by the water irrigation regime treatments in both seasons. At the three samples of growth, leaf area decreased as water stress increased by extending the irrigation interval. It is clear from the results that there was a progressive increase in leaf area/plant and total dry matter/plant with increasing plant age up to late growth stage (75 days after sowing). It is of great importance to notice that subjecting sunflower plants to water stress at any stage of growth led to a reduction in leaf area/plant and total dry matter/plant in the three samples. Moreover, the most sensitive stage to water stress was the flowering or seed filling stages (60-75 DAS), due to the reduction in most growth criteria. It is worthy to mention that under dry conditions, crops reduced their leaf area. These results are scarcely surprising that net photosynthesis rates per unit leaf area remain relatively constant when sunflower plants are exposed to moderate levels of water stress in the field, while leaf expansion is extremely sensitive even to mild stress (English *et al.*, 1979). In this respect, Selim *et al.* (1994); Teama and Mahmoud (1994); Esechie (1995); El-Noemani *et al.* (1996) and Sunderman *et al.* (1997) found that leaf area/plant and total dry matter/plant were significantly reduced by water stress occurred by prolonging irrigation intervals and increasing available soil moisture depletion with holding irrigation at different growth stages.

1.2. Varietal differences:

Mean values of plant height, number of green leaves/plant, stem diameter, leaf area/plant and total dry matter/plant as affected by sunflower cultivars are shown in Table (2). Plant height was shown to be significantly different among the studied sunflower cultivars at 45, 60 and 75 days from sowing. Miak cultivar was taller than the other cultivars at different growth stages in both seasons. It was observed that plant height in all cultivars increased progressively from 45 to 75 day's stage. The rate of increase was higher during the period from 45 to 60 days from sowing; during the other period it was less than the former ones. It could be concluded that sunflower cultivars under investigation were accelerated in elongation during one specific period, that is, from 45 to 60 days from sowing in comparison with the other period; this period could be considered as the active period for plant elongation of sunflower cultivars. The increase was higher in sunflower cultivar Miak than Elya, Euroflor and Pioneer-6480 in both seasons. This indicates that Miak sunflower cultivar start to elongate with a high rate more than the other cultivars at the different periods. This in turn resulted in the superiority of this cultivar than the others until the last stage of growth studied. This may be due to the genotypic behaviour in combination with the environmental conditions which may be suitable for Miak more than the other cultivars to get more elongation. Several workers reported that sunflower cultivars differed widely in their plant height, Esechie (1995); El-Noemani *et al.* (1996); Sunderman *et al.* (1997). and Hasan (1999).

Number of green leaves/plant, stem diameter, leaf area/plant and total dry matter/plant for the studied sunflower cultivars were shown to increase significantly during the period from 45 to 75 days from sowing. This was true in all sunflower cultivars investigated. It could be concluded that the growth and weight of sunflower plants extended to increase during the period from 45 to 75 days from sowing with more rate during the first two weeks. This may be due to the increase in plant height; more light interception due to the increase in the canopy cover formed and the resultant could be more dry matter formation which tend to an increase in leaves and stem thickness as well as weight. Miak was shown to surpass the other sunflower cultivars during 45, 60 and 75 days from sowing. Differences among sunflower cultivars in growth characters were found by El-Neomani *et al.* (1996), Sunderman *et al.* (1997). and Hasan (1999).

II. Growth analysis parameters

2.1: Effect of irrigation regimes:

Data presented in Table (3) show the effect of water irrigation regime treatments on growth analysis parameters, i.e. leaf area index (LAI), specific leaf area (SLA), relative growth rate (RGR), net assimilation rate (NAR) and crop growth rate (CGR) at the different stages of growth during 1996 and 1997 seasons, respectively.

Leaf area index (LAI) and specific leaf area (SLA) were shown to be significant different among the studied water irrigation regime treatments at 45, 60 and 75 days after sowing in both seasons. It is noteworthy to mention

that the greatest values of leaf area index (LAI) brought out by irrigation at 40% ASMD. Whereas the minimal values were obtained by irrigation at 70% ASMD at all stages of growth, starting at 45 till 75 days after sowing . It is well known that, Leaf area index is calculated by dividing leaf area on the plant ground area, so the same significant relationships are obtained in the two characters in both seasons. Concerning specific leaf area (SLA), it is clear from the results that plants received 40% ASMD had higher SLA than that water stressed at vegetative and flowering stages, whereas, there no significant differences between the plants received 40% and 55% ASMD. Furthermore, at the period of 75 days after sowing, plants subjected to 70% ASMD water stress during the filling stage exhibited significantly lower SLA values when comparing with those of 40% and 55% ASMD in both seasons. These results are agreement with those of Selim *et al.* (1994), Teama and Mahmoud (1994), El-Noemani *et al.* (1996) Sobarad *et al.* (1996) and Sunderman *et al.* (1997).

Relative growth rate (RGR) and crop growth rates (CGR) were significantly affected by the water supply treatments in both seasons. At the three samples of growth, RGR and CGR decreased by increasing the water stress. It is clear from the results that there was a depression in RGR and CGR with increasing plant age up to late growth stage (75 days after sowing). The decrease in RGR and CGR under water stress may be attributed to the action of water deficit on vegetative growth characters. In this respect, Selim *et al.* (1994), Teama and Mahmoud (1994); El-Noemani *et al.* (1996) and Sobarad *et al.* (1996) found that water deficits inhibited in RGR and CGR of sunflower plants.

Net assimilation rate (NAR) was shown to differ significantly among the various water stress treatments at the growth periods of 45 -60 and 60 - 75 days after sowing in both seasons. It is interesting to notice that plant exposed to 55 or 70% ASMD at 45-60 days after sowing accumulated significantly more assimilates compared to the plants exposed to 40% ASMD. The aforementioned results regarding the increase in NAR of plants stressed at the period from 45-60 days are logic, because if we returned to the results in Table (2), we will find that the increment in leaf area of plants received 40%, 55% and 70% ASMD was 80.88%, 107.89% and 110.80% in the first season, and 74.59%, 86.01% and 130.36% in the second season at the same period from 45-60 days, respectively. Moreover, The increment in total dry matter/plant resultant from 40%, 55% and 70% ASMD treatments was 60.16%, 114.49% and 173.86% in the first season, and 113.13%, 142.96% and 126.95% in the second season, with the advance in plant age from 45 to 60 days, respectively. This conclusion is in line with that previously reached by El-Noemani *et al.* (1996); Sobarad *et al.* (1996) and Sunderman *et al.* (1997).

2.2. Varietal differences:

Data presented in Table (3) show the sunflower growth analysis studied for Miak, Elya, Euroflor and Pioneer-6480 at the different growth stages (45, 60 and 75 DAF) during 1996 and 1997 seasons.

Leaf area index (LAI) for the studied sunflower cultivars was attained to increase significantly during the period from 45 to 75 days after sowing in both seasons. It is important to note that calculating LAI is depending on LA as previously mentioned, so the same trend in LAI could be obtained as in LA, regarding the effect of sunflower cultivars. In both experimental seasons, Miak cultivar exceeded significantly the other three ones in LAI at all the growth periods. Furthermore Miak cultivar ranked significantly first, followed by Elya, Euroflor and Pioneer-6480 in a descending order, during the period of 45 -75 days after sowing in both seasons. In the same connection, El-Noemani *et al.* (1996) reported that Miak sunflower cultivars surpassed significantly the other cultivars i.e., Elya and Hysun in LAI at 41 days in 1993 as well as, at 40 and 81 days in 1994.

Concerning specific leaf area (SLA), significant differences were recorded among the tested sunflower cultivars during the period from 45 to 75 days after sowing in both seasons. It was observed that SLA in all sunflower cultivars decreased progressively from 45 to 75 days after sowing. The rate of depression was higher during the period from 60 to 75 days after sowing than the other period, it was less than the former one. Elya cultivar exceeded significantly the other three ones in SLA at 45-60 days after sowing whereas, Maik cultivars surpassed significantly the other three ones in SLA at 75 days after sowing. Differences among sunflower cultivars in SLA were found by Esechie (1995); El-Noemani *et al.* (1996); Sobarad *et al.* (1996) and Sunderman *et al.* (1997).

Relative growth rate (RGR), net assimilation rate (NAR) and crop growth rate (CGR) were shown to differ significantly among the tested cultivars at the different stages of growth in 1996 and 1997 seasons, respectively. These cultivars can be classified into two groups as follows; the highest cultivars in RGR, NAR and CGR at the period of 45-60 DAF were Miak and Elya, whereas the lowest ones were Euroflor and Pioneer-6480 in both seasons. It was observed that in NAR and CGR in all sunflower cultivars decreased progressively from 60 to 75 days after sowing. Maik and Elya cultivars surpassed significantly the other two ones in NAR and CGR at the period of 60-75 days after sowing. Differences among sunflower cultivars in RGR, NAR and CGR were found by Esechie (1995); El-Noemani *et al.* (1996) and Sunderman *et al.* (1997).

III. Yield and its components

3.1. Effect of irrigation regimes

Water regime had a pronounced effect on sunflower mean values of seed yield and its related variables, and that was true in the two seasons (Table 4). Mean values of number of days to 50% flowering, generally, increased with increasing irrigation numbers in both seasons. The most probable explanation for this result is that, at 40% ASMD treatment, there was a more luxuriant use of water that ultimately resulted in favourable vegetative growth, consequently caused a delay in time of heading. However, the differences were not significant between 55% and 40% ASMD. Selim *et al.* (1994) mentioned that water stress affected inflorescence

Table 4: Mean values for the studied traits as affected by irrigation regimes treatments and sunflower cultivars during 1996 and 1997 seasons.

Traits / Treatments	Flower-ing date (day)	Head Diameter (cm)	No. of seeds/ head	1000-seed weight (gm)	Seed weight /head (gm)	Seed yield /plot (kg)	Seed Oil Perce-Ntage
Irrigation regimes				1996			
40% ASMD	61.19	20.63	1046.08	68.66	71.81	3.295	39.69
55% ASMD	60.16	19.18	993.86	65.33	64.89	3.103	38.38
70% ASMD	57.46	18.30	972.51	61.95	60.25	2.679	36.30
Revised LSD $_{0.05}$	1.06	0.88	26.49	2.81	3.12	0.190	0.38
				1997			
40% ASMD	61.08	21.70	1169.20	68.75	80.37	3.885	40.06
55% ASMD	59.44	19.30	1082.40	67.57	73.14	3.090	38.52
70% ASMD	58.12	18.60	1040.40	64.05	66.63	2.584	36.51
Revised LSD$_{0.05}$	0.76	0.74	45.12	2.35	3.62	0.231	0.41
Cultivars				1996			
Pioneer-6480	58.62	18.45	820.61	59.57	48.89	2.454	39.39
Euroflor	58.15	19.02	994.99	65.56	65.23	2.794	34.69
Miak	62.39	20.48	1175.36	74.67	87.76	3.755	40.20
Elya	59.25	19.38	1029.42	67.32	69.31	3.386	36.15
Revised LSD $_{0.05}$	0.78	1.09	35.19	2.63	2.59	0.262	0.45
				1997			
Pioneer-6480	58.67	18.50	1042.30	60.52	63.08	2.439	39.32
Euroflor	58.24	18.90	1036.60	70.51	66.39	2.945	34.62
Miak	62.12	21.60	1183.30	72.27	85.52	3.949	40.16
Elya	59.16	20.50	1127.10	70.51	79.39	3.378	37.02
Revised LSD $_{0.05}$	0.72	1.13	56.22	3.27	3.11	0.321	0.39

development and fertilization during inflorescence development through reducing the number of primordial and its development within fertile florets. This means that providing soil with sufficient moisture promotes vegetative growth and water deficit induces flowering. There was a progressive and consistent increase in mean values of head diameter, number of seeds per head and 1000-seed weight. The highest mean values were recorded from irrigation at 40% ASMD followed by 55 % and 70 % ASMD. The most probable explanation for the results is that an 40 % ASMD there was a more luxuriant use of water, which ultimately resulted in increasing transpiration and that reflected the increase in all metabolism process in the plant which led to an increase in dry matter accumulation in the different plant organs. On the other hand, the sparsely spaced irrigation in case of 70 % ASMD resulted in poor growth for transpiration. In addition, losses by surface evaporation are great for 40 % ASMD treatment. These results are in quite agreement with the appraisals of Sobarad *et al.* (1996) who found that sunflower was most sensitive to water stress at flowering which reduced head weight, number of seeds/head and 1000-seed weight.

Seeds weight/head as well as seed yield/plot were found herein to be appreciably influenced by the application of water regimes' treatments in both seasons (Table 4). Plants irrigated at 40 % ASMD significantly outyielded those irrigated at 55 % and 70% ASMD. *Seeds weight/head* as well as seed yield/plot in fact, is the out product of its main components. Any increase in one or more of such components without decrease in the others will lead to an increase in seeds weight/head and seed yield per plot. Therefore, the increase in seeds weight/head and seed yield/plot under irrigation conditions found herein was the logical resultant of the increase in both of number of seeds per head and 1000-seed weight at the similar conditions. These results are in harmony with those obtained by El-Gareib *et al.* (1996) and Sobarad *et al.* (1996).

Data detected herein indicated that the significant increases in seed oil percentage mean values were exerted by increasing the amount of available water in the soil. The highest seed oil percentage was obtained when plants irrigated at 40 % ASMD followed by 55 % and 70 % ASMD in both seasons. This result can be explained by fact that accumulation of fat takes place during the developments of storage tissue. Fat increase in quantity and in concentration is probably due to the transformation of sugar to fat in the seed itself, and it is actually sugar rather than fat which is translated into seeds from leaves of plants (Woodhams and Koslowski 1954). In this respect, Mahey *et al.* (1989) found that irrigation sunflower plant with 5 or 10 cm water had significant effect on seed oil content.

3.2. Varietal differences:

Mean performance of the investigated sunflower cultivars overall irrigation regimes, for all the studied traits in both seasons are presented in Table (4). With regard to number of days to 50% flowering for sunflower cultivars, three groups could be identified in both seasons. The early group included Pioneer-6480 and Euroflor cultivars. The late group included Miak cultivar. Whereas, Elya cultivar formed an intermediate group. Sunflower cultivars of early group having in their genetic background genes responsible for earliness, could be utilized for transferring this character by crossing techniques to new released sunflower cultivars. Mean values of head diameter, number of seeds/head, 1000-seed weight and seeds weight/head were remarkably influenced by varietal characteristics. These findings hold fairly true for the two seasons. It is worthnoting that the tested sunflower cultivars could be arranged in descending order to three significant different groups. The first group included sunflower cultivar Miak surpassed all categorizes. The second group comprises sunflower cultivars Elya and Euroflor. The last group comprises sunflower cultivar Pioneer-6480. It could be concluded that sunflower cultivar of Miak was greater in its capability in produce number of seeds per head, and had a higher capacity in transporting metabolites from the vegetative organs to storage centers in the seed (Reddy *et al.,* 1996) and this in turn led to the appreciable increase in weight of 1000 seeds and consequently *seeds weight/head* than the other sunflower cultivars. These results are in line with those obtained by El-Hity (1994); El-Ghareib *et al.* (1996) and Ortegon and Diaz (1997).

Concerning seed yield/plot, the mean values of sunflower cultivar Miak outyielded the other sunflower cultivars, and that was true in both seasons. As it is well known, the seed yield per plot is a product of yield components. Therefore, an increase in seed yield per plot is a logic result for the increase in one or more components and vice versa. From the previous results it can be concluded that the superiority of sunflower cultivar Miak was mainly due to great number of seeds/ head, 1000-seed weight and seeds weight/head. The scope of this finding is generally according to those obtained by El-Hity (1994); El-Ghareib *et al.* (1996) and Ortegon and Diaz (1997).

Seed oil percentage mean values were shown to differ significantly during the two growing seasons. The tested sunflower cultivar of Miak surpassed the other tested sunflower cultivars. This increase in seed oil percentage associated with sunflower cultivar of Miak might be attributed to the superiority of its capability in transformation of sugar to fat in the seed tissue than the other sunflower cultivars. The scope of this finding is generally according to those obtained by Lopez *et al.* (1982), El-Gareib *et al.* (1996) and Sobarad *et al.* (1996).

IV- Interaction between irrigation regimes and cultivars (IxV)

Mean squares associated with interaction between sunflower cultivars and the water irrigation regimes were found herein to lake the level of significance for most studied traits except number of green leaves/plant, leaf area/plant, leaf area index (LAI) and specific leaf area (SLA) in 1996 season, and 1000-seed weight and seed yield/plot in both seasons. These results revealed that, the tested sunflower cultivars differently ranked at various irrigation regime treatments. In other words, the tested cultivars differed in their response to the available soil moisture. The data presented in Table (5) revealed that Elya cultivar showed the highest number of green leaves at 45 DAS whereas, Miak cultivar exceeded the highest number of green leaves/plant at 60 and 75 DAS when plants received 40% ASMD, while the lowest value was exhibited by Pioneer-6480 at all growth periods. Miak cultivar showed the highest leaf area/plant at all growth periods from 45 to 75 DAS when received 40% and 55% ASMD treatments, whereas, the highest value was performed by Elya cultivar when plants received 70% ASMD. Miak and Elya showed the highest values of leaf area index (LAI) and specific leaf area (SLA) at all growth periods when plants received 40% ASMD, while the lowest value was exhibited by Pioneer-6480. Elya cultivar showed the highest SLA at the growth periods when received 55% and 70% ASMD treatments, while the lowest value was exhibited by Pioneer-6480 and Euroflor, respectively. Miak cultivar produced the highest values of 1000-seed weight and seed yield/plot especially when received 40% ASMD. However, the highest values of seed yield/plot were obtained by Miak and Elya cultivars when received 55% and 70% ASMD in both seasons. On the contrary, Pioneer-6480 and Euroflor cultivars produced the lowest values for

both traits when received 40% or 55% or 70% ASMD, respectively. Moreover, clearly high water stress caused a reduction in most traits studied for all tested cultivars. This reduction was more pronounced in early cultivars (Euroflor and Pioneer-6480) than late cultivar (Miak). This means generally that the early cultivars were more sensitive to water stress than late cultivars.

Partitioning irrigation regime sum of squares associated with each cultivar to linear, quadratic and cubic effects, for seed yield/plot are presented in Table (6). On average, linear components caused the majority of varietal response to irrigation regimes in this trait. Also, the linear slope was positive for all the studied cultivars, indicating that using 40% ASMD increased mean values of seed yield/plot. Appreciable quadratic effect of negative sign was detected in all cultivars except Elya cultivar. Cubic effect, meanwhile, was of negligible in all cases. Therefore, it could be safely concluded that irrigation sunflower cultivars at 40% ASMD would be fruitful in all cultivars except Elya cultivar where water stress may be needed.

Table 6: Linear, quadratic and cubic sum of squares for each variety in relation to water irrigation regimes overall the two seasons of the experimentation.

Cultivar	d.f	Sum of square for seed yield/plot		
		Linear	Quadratic	Cubic
Pioneer-6480	1	68.42**	- 0.37	-0.24
Euroflor	1	79.48**	- 9.33	- 0.37
Miak	1	83.76**	- 16.67*	- 0.28
Elya	1	98.77**	27.34**	-3.17
Error	27			
Coefficient of regression (b)		- 0.148** kg seeds/plot		

***, ** denote significance at 0.05 & 0.01, respectively.**

As mentioned above, plants received 40% ASMD after sowing expressed in all cases the highest mean values. A gradual depression in such mean values parallel to the decrease in amount of available water in the soil was detected. Moreover, the relationships among irrigation treatments were only of linear fashion. This means that the tested sunflower cultivars differed in the rate of depression in its mean performances resultant from water stress, and that was the cause of the detected difference in sunflower cultivars ranking from irrigation treatment to another. Therefore, for better representation of interaction between the tested cultivars and irrigation regime treatments, the depression in mean values resultant from water stress was calculated for each cultivar.

V- Relative depression resulted from water stress:

The obtained depression in mean values at 70% ASMD treatment was proportioned to the mean values at 40% ASMD treatment, and the product was defined as relative depression resulted from water stress. The relative depression data was transformed to arcsine values and thereafter subjected to statistical analysis. This type of analysis, however, was only carried out for number of seeds/head, 1000-seed weight and seed yield/plot in both seasons (Table 7).

Relative depressions mean value for each sunflower cultivar in number of seeds/head, 1000-seed weight and seed yield/plot due to water stress are presented in Table (7). The relative depression mean values for seed yield/plot were lesser in Elya and Miak sunflower cultivars than either in Euroflor or Pioneer-6480, and that was true in both seasons. This means that Elya and Miak tested sunflower cultivars appeared to be more tolerant to drought conditions than the other ones. The tested sunflower cultivars, moreover, could be identified in this respect to couple significantly different groups. The first group comprises Elya and Miak sunflower cultivars exhibited lesser depression in seed yield under drought conditions than the second one, and that was true in both seasons. These results are in harmony with those obtained by El-Ghareib *et al.* (1996) who reported that Elya and Miak cultivars were more tolerant to drought than other ones. It is worthy to mention that Miak and Elya sunflower cultivars were recorded above to be outyielded the other ones. Therefore, the two sunflower cultivars would be of interest in North Coast farming for their high seed yielding ability and their high drought tolerance.

Table 7: Relative depression mean values, resulted from water stress for each sunflower cultivar in 1996 and 1997 seasons.

Traits / Cultivars	number of seeds /head		1000-seed weight (g)		seed yield /plot (kg)	
	1996	**1997**	**1996**	**1997**	**1996**	**1997**
Pioneer-6480	19.03	20.52	9.78	6.84	16.58	22.13
Euroflor	12.24	14.59	7.82	6.77	14.08	17.86
Miak	10.45	11.48	4.79	5.52	10.89	10.96
Elya	8.97	8.38	3.21	4.51	8.34	10.14
Revised $LSD_{0.05}$	2.78	3.49	1.84	1.67	2.19	2.27

Number of seeds/head mean values attached to the relative depression, resultant from water stress, were found herein to be highly significantly different in both seasons. This result again clarified that Miak and Elya sunflower cultivars were less affected by drought conditions than Euroflor and Pioneer-6480 sunflower cultivars. In this respect, sunflower cultivars were ,moreover, categorizes into three contrasting groups based on their relative depression resultant from water stress. The first group showing most drought resistant values were Miak and Elya sunflower cultivars. The third group comprises Pioneer-6480 that was the most susceptible to water stress showing high relative depression in number of seeds/head. The second group comprises Euroflor sunflower cultivar was intermediate. It is worthy to mention that the depression in mean values of number of seeds/head due to water stress was relatively lower than its correspondence of seed yield/plot .This phenomenon was more pronounced in all sunflower cultivars under study. This finding may reflect the great superiority of growing sunflower cultivars. Also sunflower has a wide range of adaptability to different climate conditions which allow its to grow under water stress conditions.

Regarding relative depression in mean values of 1000-seed weight resultant from water stress, significant differences were recorded among the tested sunflower cultivars. The results indicated that Miak and Elya sunflower cultivars exceeded significantly Euroflor and Pioneer-6480 cultivars in drought tolerance, and that was true in both seasons. Great similarity in the relative depression mean value of 1000-seed weight was observed in Elya sunflower cultivar and had a higher relative depression than the other cultivars.

VI-Correlation studies:

The estimates of phenotypic correlation coefficients between different pairs of seed yield/plot and its main components, i.e. number of seeds/head, seeds weight/head and 1000-seed weight for sunflower cultivars grown under different irrigation regimes, i.e., 40%, 55% and 70% ASMD after sowing, in both seasons of experimentation are presented in Table (8). Seed yield/plot was found herein to be significantly and positively associated with its main components when sunflower cultivars received the normal irrigation regime i.e. 40% ASMD. The computed correlation coefficients between seed yield/plot and each of number of seeds/head and 1000-seed weight were nearly similar in magnitude. This similarity may reflect the identity of both traits in contributing seed yield. Seeds weight/head, however, appeared to be of lower participation in this respect. Similar results were obtained by several investigators in sunflower crop as El-Ahmer *et al.*(1989) and Khan *et al.* (1989).

Table 8: Simple correlation coefficients among seed yield and its main components of the tested sunflower cultivars at each level of irrigation regimes.

Traits	Water irrigation regimes		
	40% ASMD	55% ASMD	70% ASMD
Seed yield/plot			
No. of seeds/head			
1996	0.519**	0.426**	0.486**
1997	0.625**	0.392*	0.411*
Seeds weight/head			
1996	0.256	0.066	- 0.216
1997	0.285	0.063	- 0.265
1000-seed weight			
1996	0.568**	0.425**	0.469**
1997	0.539**	0.438**	0.528**
Number of seeds/head			
Seeds weight/head			
1996	0.613**	- 0.434**	- 0.284
1997	0.409*	- 0.229	- 0.223
1000-seed weight			
1996	0.467**	- 0.414*	- 0.201
1997	0.674**	- 0.283	- 0.235
Seeds weight/head			
1000-seed weight			
1996	0.290	- 0.246	- 0.429**
1997	0.278	- 0.233	- 0.534**

r = 0.325 & 0.418 at 0.05 & 0.01 level of probability, respectively.
***, ** denote significant different at 0.05 & 0.01 level of probability.**

Insignificant and negative association, at the lower level of available soil moisture depletion was detected between seed yield/plot and seeds weight/head. Number of seeds/head and 1000-seed weight, on the other hand, appeared to be significantly and positively correlated with seed yield/plot at all the studied irrigation regimes. This finding coincided with the results reached above where seeds weight/head was less affected by lowering number of irrigation after sowing than number of seeds/head and 1000-seed weight, and hence seed yield/plot. Therefore, it could be safely concluded that variability in seed yield of sunflower under water stress conditions was mostly due to variability in number of seeds/head and 1000-seed weight. Khan *et al.* (1989) came to the same conclusion.

Number of seeds/head was found herein to be significantly and positively associated with both of *seeds weight/head* and 1000-seed weight when sunflower cultivars received 40% ASMD. At the lower number of irrigation (70% ASMD), however, loose and negatively associations were detected between number of seeds/head and each of the two traits.

Seeds weight/head was positively and insignificantly associated with 1000-seed weight when sunflower cultivars received 40% ASMD. Paradoxically, both traits were found to be negatively and significantly correlated when 70% ASMD was applied. The contradiction in sign between the correlation coefficients at both irrigation regimes may explain the loose association detected herein between both traits when plants received 55% ASMD. In this connection Khan *et al.* (1989) in sunflower came to the same results.

Again, seed yield as it is well known, is a complex trait which is greatly affected by environmental factors. Therefore, direct selection for seed yield is usually misleading. Indirect selection for seed yield through one or more of its components, however, would be fruitful if this or these components are strongly correlated with seed yield per se. From the results reported herein, it could be concluded that developing new sunflower cultivars characterized by its high yielding potentiality would be realized if selection is achieved for greater number of seeds/head and heavier seed weight, when normal irrigation regime is in consideration. Under water stress conditions, selection for heavier seed weight only would be enough to produce high yielding capacity of sunflower cultivars.

VII. Seed quality:

7.1. Effect of irrigation regimes

The effects of irrigation regimes on oil composition of sunflower are shown in Table (9), such data indicated that the iodine value was increased gradually when plants exposed to water stress at 55% or 70% ASMD. The increment in iodine value of 70% ASMD treatment over 40% and 55% ASMD amounted to 1.80% and 0.88 % in the first season and 0.94% to 0.91% in the second season, respectively. The increase in iodine value due to increasing the available soil moisture depletion (70% ASMD) was essentially due to the increase in available unsaturated fatty acids during the period of stress at different ripening seed stages. These results are in

harmony with those obtained by Ferri and Losavio (1982). Significant differences among the tested irrigation regimes in saturated fatty acids were obtained in both seasons. 40% ASMD treatment produced the highest saturated fatty acids compared to 70% ASMD treatment. Acid value and refractive index in the analysis of crude sunflower oil were not governed by irrigation regimes. These results hold fairly true in both seasons of experiments. These results are in agreement with those obtained by Balamurugan *et al.* (1989). Oleic acid decreased with increasing the available soil moisture depletion (70% ASMD). These results are in agreement with those obtained by Lopez *et al.* (1982) where they found that the oleic acid concentration of the oil decreased with increasing the available soil moisture depletion (70% ASMD). Plants exposed to water stress at 40% ASMD gave the lowest Lenoleic and Lenolenic acids, while Plants exposed to water stress at 70% ASMD produced the highest Lenoleic and Lenolenic acids. Balamurugan *et al.* (1989), however, found that Lenoleic and Lenolenic acids decreased by increasing water stress.

7.2. Varietal differences:

The results represented in Table (9) indicated that the tested cultivars significantly differed about the oil composition. The tested cultivars differed significantly in iodine value. They could be classified in this concern into two groups. The first group comprised Elya and Miak cultivars which surpassed the second categorizes which include the cultivars Euroflor and Pioneer-6480, respectively. Parallel behaviour was observed in both seasons. These results are in harmony with those obtained by Lopez *et al.* (1982) and Hasan (1999) who showed that large differences in iodine value were found among cultivars. The differences among the four tested cultivars in saturated fatty acids were statistically confirmed in both seasons. Pioneer-6480 expressed the highest value of saturated fatty acids which exceeded that of Elya, Miak and Euroflor. The differences in saturated fatty acids among cultivars were previously reported by Lopez *et al.* (1982) and Hasan,(1999). The tested cultivars did not differ significantly with regard to acid value and refractive index in the analysis of crude sunflower oil . Oleic acid mean values showed that the differences among the four tested sunflower cultivars were significant in the two seasons. Oleic acid could be arranged in descending order regarding the cultivar as follows; Pioneer-6480, Euroflor, Miak and Elya. The differences in oleic acid among cultivars were previously reported by Balamurugan *et al.* (1989) and Hasan,(1999). Miak and Elya cultivars surpassed Pioneer-6480 and Euroflor in Lenoleic acid and Lenolenic acids. It is worthy to mention that Pioneer-6480 and Euroflor cultivars were the earliest matured among the tested cultivars. From this result, it can be concluded that the earliest sunflower cultivars had low Lenoleic and Lenolenic acids and vice versa. The differences in Lenoleic and Lenolenic acids among cultivars were previously reported by Lopez *et al.* (1982) and Hasan,(1999).

The data of both seasons about the interaction effect of the available soil moisture depletion treatments and sunflower cultivars did not reach the level of significance for all oil composition traits.

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J. Agric. Sci. Mansoura Univ., 25 (2), February, 2000.

سلوك بعض أصناف عباد الشمس المتأثرة بنظم الإجهاد المائى

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أجريت تجربتان حقليتان بمزرعة كلية الزراعة جامعة المنوفية بشبين الكوم خلال موسمى الزراعة 1996 و 1997 بهدف دراسة تأثير الرى عند ثلاث مستويات من الماء الميسر (الرى بعد نفاذ 40، 55، 70% من الماء الميسر) على نمو ومحصول وصفات جودة بذور أربعة أصناف من عباد الشمس (بيونير6480 ، إيروفلور، إليا، مياك). ولقد نفذت التجربة فى تصميم القطع المنشقة حيث وزعت معاملات الرى على القطع الرئيسية بينما وزعت أصناف عباد الشمس على القطع الشقية وتتلخص أهم النتائج فيما يلى:-

1-أدى رى نباتات عباد الشمس بعد نفاذ 40% من الماء الميسر إلى إرتفاع معنوى واضح فى طول النبات، عدد الأوراق الخضراء للنبات، قطر الساق، مساحة الأوراق وانتاج المادة الجافة الكلية للنبات عند أعمار 45، 60 و 75 يوم من الزراعة. كما أدت هذه المعاملة إلى إرتفاع معنوى واضح فى صفة دليل مساحة الأوراق (LAI) والمساحة النوعية للأوراق (SLA) عند مختلف أعمار النباتات وفى معدل الكفاءة التمثيلية (NAR) ومعدل نمو المحصول (CGR) ومعدل النمو النسبى (RGR) خلال الفترة 45-60 يوم من الزراعة بينما أدت إلى انخفاض معنوي واضح لصفات (NAR) و(CGR) و (RGR) خلال الفترة 60-75 يوم من الزراعة بالمقارنة بمعاملة الرى بعد نفاذ 70% من الماء الميسر. كما أدت هذه المعاملة إلى ارتفاع معنوى واضح فى صفة محصول البذور بالقطعة والصفات المرتبطة به ونسبة الزيت فى البذور، ولقد لوحظ أن هناك انخفاض تدريجى فى متوسط القيم للصفات المحصولية متمشياً مع النقص فى كمية المياه المتاحة فى التربة الزراعية. بينما أدت معاملة رى نباتات عباد الشمس بعد نفاذ 55% و 70% من الماء الميسر إلى زيادة تدريجية فى الرقم اليودي للزيت وحمض الينوليك والينولينك وإلى انخفاض تدريجى فى الأحماض الدهنية المشبعة وحمض الأوليك، بينما لم يكن هناك أثر معنوى واضح على رقم الحموضة ومعامل إنكسار الزيت خلال موسمى الزراعة.

2-تفوق الصنف مياك معنوياً على أصناف إليا، إيروفلور، بيونير6480 فى طول النبات، عدد الأوراق الخضراء للنبات، قطر الساق، مساحة الأوراق وانتاج المادة الجافة الكلية للنبات وفى صفة دليل مساحة الأوراق (LAI) خلال مراحل النمو الثلاث وفى المساحة النوعية للأوراق (SLA) عند العمرين 60 و75 يوم من الزراعة لكلا الموسمين. بينما تفوق الصنف إليا معنوياً على باقى الأصناف الأخرى فى المساحة النوعية للأوراق (SLA) عند العمرين 45 و 60 يوم من الزراعة لكلا الموسمين بالإضافة إلى ذلك فقد تفوق الصنف إليا ومياك معنوياً على صنفى إيروفلور و بيونير6480 فى معدل النمو النسبى (RGR) خلال الفترة 60-75 يوم من الزراعة وفى معدل الكفاءة التمثيلية (NAR) ومعدل نمو المحصول (CGR) خلال الفترة 45-60 يوم من الزراعة فى كلا الموسمين. تفوق الصنف مياك معنوياً على باقى الأصناف الأخرى فى صفة محصول البذور والصفات المرتبطة به ونسبة الزيت فى البذور. وتفوق صنفى إليا وإيروفلور معنوياً على صنفى مياك و بيونير6480 فى الرقم اليودى للزيت، بينما تفوق الصنف بيونير6480 على باقى الأصناف الأخرى فى الأحماض الدهنية المشبعة وحمض الأوليك، بينما تفوق الصنف إيروفلور معنوياً على باقى الأصناف الأخرى فى أحماض الينوليك والينولينك. لم يكن هناك فروق معنوية بين الأصناف المختبرة فى رقم حموضة الزيت ومعامل إنكساره خلال موسمى الزراعة.

3-تجزئ مجموع مربعات المعاملات الخاصة باستجابة الأصناف لنظم الرى المدروسة باستخدام طريقة المقارنات المستقلة المتعددة الحدود أسفر عن أن مجموع المربعات الراجع إلى الارتداد الخطى (linear) معنوي وأن منحنى الاستجابة ذات قيمة موجبة لكل الأصناف المدروسة. كما كان تأثير مكون معادلة الدرجة الثانية (Quadratic) ذات قيمة سالبة ماعدا صنف إليا، كما وكان تأثير مكون معادلة الدرجة الثالثة (Cubic) ضئيل للغاية. لذلك يمكن استنتاج أن نظام الرى المناسب لأصناف عباد الشمس المدروسة هو بعد نفاذ 40% من الماء الميسر باستثناء صنف عباد الشمس إليا الذي يتحمل الإجهاد المائى بدرجة أعلى من باقى الأصناف المدروسة.

4-أوضحت دراسة معدل الإنخفاض النسبى(Relative depression) في قيم متوسطات عدد البذور فى القرص ووزن الألف بذرة ومحصول البذور للقطعة الناتج عن الإجهاد المائى أن صنفى إليا ومياك أكثر مقاومة لظروف الجفاف عن صنفى إيروفلور وبيونير6480.

5-أوضحت الدراسة أن هناك إرتباط معنوى موجب بين محصول البذور وصفات عدد البذور فى القرص ووزن الألف بذرة لأصناف عباد الشمس عند رى النباتات بعد نفاذ 40% من الماء الميسر خلال موسمى الزراعة. كما لوحظ أن هناك إرتباط غير معنوى سالب بين محصول البذوروعدد البذور فى القرص ووزن بذور القرص عند رى النباتات بالمستوى المرتفع من الإجهاد المائى (بعد نفاذ 70% من الماء الميسر). وعلى عكس ذلك لوحظ أن هناك إرتباط معنوى موجب بين صفة وزن الف بذرة ومحصول البذور عند جميع نظم الرى المتبعة في الدراسة.

Table 2: Effect of irrigation regime treatments and sunflower cultivars on growth parameters at 45, 60 and 75 days after sowing during 1996 and 1997 seasons.

Irrigation regimes / Characters	Days after sowing	40% ASMD	55% ASMD	70% ASMD	Revised $LSD_{0.05}$	Pioneer -6480	Euroflor	Elya	Miak	Revised $LSD_{0.05}$
	(DAS)					1996				
Plant height (cm)	45	105.84	97.67	93.12	3.11	99.96	94.52	94.87	106.12	2.24
	60	237.85	209.44	176.39	6.01	219.87	185.76	186.47	239.47	3.24
	75	259.89	243.44	219.58	9.27	247.29	219.67	222.89	279.34	4.21
No. of green leaves/plant	45	22.46	21.61	19.88	0.71	20.98	19.98	20.84	23.46	0.64
	60	24.63	23.98	21.86	0.58	23.13	22.06	22.94	25.78	0.76
	75	24.98	23.49	22.36	0.63	23.42	22.27	22.89	25.91	0.89
Stem diameter (cm)	45	2.48	2.29	1.89	0.17	1.89	2.23	2.36	2.39	0.11
	60	2.84	2.85	2.45	0.24	2.45	2.67	2.84	2.89	0.14
	75	2.91	2.89	2.63	0.18	2.43	2.78	2.90	3.13	0.18
Leaf area/plant (cm^2)	45	2984.67	2474.97	2286.31	95.48	2425.31	2531.64	2633.47	2737.52	123.48
	60	5398.68	5145.44	4819.57	113.83	4464.28	4973.51	5368.65	5678.48	175.34
	75	7594.82	7136.49	6198.89	218.37	5659.83	6979.15	7478.34	7789.53	286.33
Total dry matter/plant (g)	45	86.47	60.53	43.15	2.48	59.86	62.54	64.52	66.61	3.21
	60	138.49	129.83	118.17	3.75	95.34	129.83	142.49	147.64	7.08
	75	273.19	250.42	227.63	5.27	197.63	254.32	273.19	276.51	6.72
						1997				
Plant height (cm)	45	110.88	96.21	87.19	4.15	98.49	94.39	94.27	105.21	3.78
	60	235.14	208.19	189.97	13.27	222.49	187.76	189.19	244.97	4.22
	75	268.72	241.89	221.26	14.55	248.42	219.67	223.81	282.29	8.37
No. of green leaves/plant	45	22.13	21.21	19.51	0.49	20.23	19.96	20.79	22.82	0.43
	60	23.98	23.06	21.37	0.63	22.39	21.41	22.61	24.80	0.72
	75	24.95	23.88	22.62	0.79	23.27	22.64	23.90	25.45	0.81
Stem diameter (cm)	45	2.42	2.34	1.96	0.14	1.86	2.27	2.41	2.42	0.17
	60	3.03	2.79	2.41	0.22	2.41	2.69	2.92	2.93	0.15
	75	3.17	2.91	2.61	0.21	2.61	2.79	3.02	3.17	0.16
Leaf area/plant (cm^2)	45	3084.63	2694.91	2055.32	102.45	2447.23	2539.61	2674.97	2784.67	144.29
	60	5385.37	5012.68	4734.64	179.28	4473.28	4519.57	5498.68	5685.37	168.61
	75	7696.82	7152.39	6721.99	233.46	5889.27	7198.82	7694.82	7978.69	193.29
Total dry matter/plant (g)	45	70.29	56.54	46.64	2.56	53.11	56.36	59.14	62.68	2.78
	60	149.81	137.37	105.85	3.87	95.34	127.37	149.68	151.64	6.27
	75	282.26	257.39	225.14	5.46	197.63	254.99	277.26	289.83	9.17

DAS = Days after sowing

Table 3: Effect of irrigation regime treatments and sunflower cultivars on growth analysis of sunflower cultivars at 45, 60 and 75 days after sowing during 1996 and 1997 seasons.

Irrigation regimes / Characters	Days after sowing	40% ASMD	55% ASMD	70% ASMD	Revised $LSD_{0.05}$	Pioneer-6480	Euroflor	Elya	Miak	Revised $LSD_{0.05}$
1996										
Leaf area index (LAI) dm^2/dm^2	45	4.991	4.372	3.867	0.561	3.864	4.210	4.608	4.958	0.341
	60	6.892	5.976	4.401	0.812	4.989	5.682	5.969	6.382	0.257
	75	7.428	6.612	4.556	0.761	5.252	6.147	6.413	6.983	0.329
Specific leaf area (SLA) dm^2/g	45	2.281	1.979	1.686	0.082	1.862	1.929	2.148	1.988	0.052
	60	1.997	1.868	1.761	0.101	1.834	1.862	1.995	1.895	0.031
	75	1.716	1.529	1.453	0.072	1.497	1.522	1.592	1.652	0.034
Relative growth rate (RGR) g/g/day	45-60	0.086	0.062	0.059	0.013	0.064	0.066	0.072	0.073	0.003
	60-75	0.099	0.074	0.043	0.005	0.067	0.070	0.074	0.076	0.004
Net assimilation rate (NAR) $g/m^2/day$	45-60	0.101	0.118	0.131	0.022	0.101	0.105	0.128	0.131	0.008
	60-75	0.073	0.097	0.121	0.013	0.079	0.089	0.108	0.111	0.011
Crop growth rate (CGR) $g/cm^2/day$	45 - 60	0.498	0.451	0.416	0.019	0.416	0.443	0.479	0.482	0.012
	61 - 75	0.456	0.403	0.391	0.023	0.387	0.393	0.441	0.446	0.021
1997										
Leaf area index (LAI) dm^2/dm^2	45	5.231	3.993	3.736	0.012	3.993	4.076	4.606	4.606	0.352
	60	6.992	5.754	4.585	0.026	5.252	5.608	6.123	6.123	0.331
	75	7.128	6.098	4.987	0.057	5.144	5.943	6.598	6.598	0.542
Specific leaf area (SLA) dm^2/g	45	1.996	1.878	1.844	0.022	1.862	1.889	1.937	1.937	0.0421
	60	2.142	1.974	1.818	0.011	1.884	1.984	2.021	2.021	0.024
	75	1.898	1.785	1.654	0.024	1.739	1.768	1.799	1.799	0.016
Relative growth rate (RGR) g/g/day	45-60	0.079	0.063	0.059	0.012	0.059	0.062	0.071	0.074	0.006
	60-75	0.077	0.062	0.053	0.011	0.063	0.067	0.074	0.078	0.005
Net assimilation rate (NAR) $g/m^2/day$	45-60	0.097	0.114	0.129	0.012	0.099	0.102	0.123	0.129	0.022
	60-75	0.066	0.085	0.098	0.009	0.069	0.073	0.089	0.099	0.011
Crop growth rate (CGR) $g/cm^2/day$	45-60	0.516	0.443	0.403	0.023	0.433	0.441	0.467	0.474	0.013
	60-75	0.442	0.335	0.321	0.014	0.339	0.345	0.382	0.396	0.023

DAS = Days after sowing

Table 5: Mean values of the interaction between irrrigation regimes and sunflower cultivars for some the studied traits during 1996 and 1997 seasons.

Irrigation regimes	Sunflower cultivars	Days after sowing (DAS)	No. of green leaves /plant	Leaf area /plant (cm^2)	Leaf area index (LAI) dm^2/dm^2	Specific leaf area (SLA) dm^2/g	1000-seed weight (gm)		Seed yield /plot (Kg)	
			1996	1996	1996	1996	1996	1997	1996	1997
	Pioneer-6480	45	20.2	2685.27	4.267	2.042	57.21	65.65	3.250	3.587
		60	21.4	4832.39	5.377	2.439				
		75	22.7	5979.55	5.992	1.737				
40% (ASMD)	Euroflor	45	21.9	2751.48	4.850	2.136	68.95	70.86	3.702	5.042
		60	22.4	5229.47	6.372	1.992				
		75	23.8	6988.76	6.927	1.782				
	Miak	45	23.9	3164.49	5.431	2.539	76.54	77.64	4.415	5.884
		60	26.2	6169.51	6.982	2.279				
		75	26.8	8097.83	7.533	1.842				
	Elya	45	24.1	2896.73	4.935	2.595	71.92	73.17	3.824	5.424
		60	25.4	5828.58	6.238	2.368				
		75	26.2	7822.61	6.988	1.882				
	Pioneer-6480	45	19.4	2425.31	3.673	1.662	54.83	61.62	3.208	3.462
		60	19.9	4464.28	4.559	1.782				
		75	20.3	5659.83	4.661	1.378				
55% (ASMD)	Euroflor	45	20.9	2502.87	3.725	1.819	65.06	65.02	3.324	3.979
		60	20.9	4345.21	4.889	1.711				
		75	21.2	5873.64	5.627	1.246				
	Miak	45	22.6	2698.83	4.658	1.913	72.38	70.21	4.037	4.816
		60	23.1	5428.77	5.692	1.735				
		75	23.3	7528.19	6.413	1.511				
	Elya	45	22.8	2498.69	4.608	2.038	69.03	65.99	3.852	4.504
		60	23.7	4897.25	5.969	1.812				
		75	23.7	6589.78	6.553	1.518				
	Pioneer-6480	45	17.1	2055.39	3.128	1.489	51.20	55.89	2.308	3.033
		60	18.9	4192. 78	3.937	1.582				
		75	19.1	5122.61	4.241	1.311				
70% (ASMD)	Euroflor	45	18.6	2082.12	3.425	1.429	58.36	65.54	2.849	3.405
		60	18.9	3986.23	4.619	1.599				
		75	19.8	5873.64	5.332	1.288				
	Miak	45	21.3	2298.39	4.522	1.636	68.38	71.45	4.035	4.305
		60	22.1	4897.61	5.439	1.702				
		75	22.8	6589.22	6.199	1.352				
	Elya	45	22.4	2398.49	4.439	1.889	65.70	67.24	3.542	3.991
		60	22.7	5128.19	5.394	1.772				
		75	23.1	6804.28	6.259	1.484				
Revised $LSD_{0.05}$			0.58	105.64	0.851	0.068	2.76	2.98	0.45	0.49

Table 9: Effect of available soil moisture depletion and sunflower cultivars on oil composition during 1996 and 1997 seasons.

Irrigation regimes	Available soil moisture depletion				Sunflower cultivars				
Characters	40% (ASMD)	55% (ASMD)	70% (ASMD)	Revised $LSD_{0.05}$	Pioneer-6480	Euroflor	Miak	Elya	Revised $LSD_{0.05}$
	1996				1996				
Iodine value	125.482	126.941	129.421	1.08	125.481	126.941	128.780	127.932	1.06
Saturated fatty acids	14.850	14.330	13.765	0.09	14.751	14.231	14.191	14.090	0.12
Oleic acid	28.411	27.590	24.624	1.19	28.231	27.640	25.871	25.761	1.28
Linoleic acid	51.589	52.079	53.487	0.74	51.681	51.341	53.880	52.641	1.31
Linolenic acid	4.509	4.651	4.672	0.07	4.511	4.541	4.701	4.691	0.02
Acid value	0.42	0.422	0.421	--	0.421	0.421	0.421	0.421	--
Refractive index	1.473	1.473	1.4731	--	1.473	1.473	1.473	1.473	--
	1997				1997				
Iodine value	125.818	127.435	129.281	1.15	125.611	127.031	128.951	128.411	1.08
Saturated fatty acids	14.689	14.364	13.817	0.11	14.721	14.291	14.131	14.021	0.14
Oleic acid	28.112	26.859	24.769	0.88	28.110	27.611	25.681	24.920	1.23
Linoleic acid	52.112	51.879	53.209	0.83	52.082	51.831	52.980	52.711	1.22
Linolenic acid	4.498	4.682	4.718	0.03	4.510	4.661	4.682	4.681	0.02
Acid value	0.422	0.422	0.423	--	0.423	0.423	0.423	0.423	--
Refractive index	1.473	1.473	1.473	--	1.473	1.473	1.473	1.473	--