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ORIGINAL PAPER

EFFECTS OF DIFFERENT IRRIGATION REGIMES ON SEED YIELD, OIL CONTENT AND FATTY ACID QUALITY OF THE SUNFLOWER IN THRACE REGION, TURKEY*

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Abstract

This research aimed to evaluate different irrigation regimes with the drip irrigation method on the sunflower's oil content and fatty acid quality in the 2018 and 2019 growing seasons, in the Turkish region Thrace. Irrigation water was applied based on the ratio of Class A pan evaporation (k_{cp}:0.00, 0.25, 0.50, 0.75, 1.00 and 1.25) with 7-day intervals. The sunflower's seasonal evapotranspiration varied between 375.2 and 655.0 mm in 2018 and between 278.2 and 801.3 mm in 2019, depending on the amount of irrigation water applied. The highest seed yield was obtained as 5.04 t ha^{-1} in the first year and 5.19 t ha^{-1} in the second year where 125% of the open water surface evaporation value was applied. Water use efficiency (WUE) values ranged between 0.68 and 0.83 kg m^{-3} in the first year of the experiment, and between 0.64 and 0.80 kg m^{-3} in the second year of the experiment. The oil content obtained from the treatments varied between 38.93% and 41.17% in 2018 and between 39.36% and 41.81%. Unsaturated fatty acid (oleic, linoleic, linolenic and the other unsaturated fatty acids (UFA)) and saturated fatty acid (palmitic, stearic, and other saturated fatty acids (SFA)) were evaluated in the research. The oleic acid content was between 48.12% and 49.99% in 2018 and between 40.30% and 41.83% in 2019. The linoleic acid content varied between 41.47% and 43.66% in the first year and between 47.71% and 49.53% in the second year. In the first year, the oleic and linoleic acid results were significant at the 5% level. The second year's results were found to be insignificant. In general, there were no statistical differences between the irrigation regimes in the oil content and fatty acid quality determined for the sunflower. The different irrigation regimes did not affect the oil content and fatty acid quality of the sunflower. In conditions where the water supply is sufficient, I_5 or I_6 treatments can be recommended, providing the highest seed yield.

Keywords: *Helianthus annuus* L., seed yield, evapotranspiration, water use efficiency, oil, fatty acid.

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INTRODUCTION

The sunflower is one of the most important oil plants for vegetable crude oil production in the world and in Turkey as it contains high amounts of oil (22-50%). 11% of the world production and 46% of Turkey's production of crude vegetable oils comes from the sunflower. But the amount of crude oil produced in Turkey does not meet the domestic consumption demand and therefore crude oil is imported every year with thousands of tons of oilseeds (Anonymous 2016). According to 2015 statistics, around 3.5 billion dollars was paid for vegetable oil and oilseed imports (Konyali 2017). Therefore, steps must be taken to cover the crude oil deficit in Turkey.

Sunflower oil consists of unsaturated and saturated fatty acids. It is somewhat superior to other vegetable oils owing to its higher proportion of unsaturated fatty acids (oleic, linoleic and linolenic), and the recently developed medium oleic hybrids have lower saturated fatty acid content (palmitic and stearic). Sunflower oil is free of trans fats, which cause high cholesterol levels and an increased risk of coronary heart disease (Seiler, Gulya 2016). Oil with a high content of polyunsaturated linoleic acid is preferred for margarine and salad oils, while oil with a high content of oleic acid is preferred for frying (Robertson et al. 1979). Sunflower oil, which has high oleic fatty acid composition, is less sensitive to oxidative changes during refining, storage and frying. Therefore, the quality of this oil is maintained for a longer period of time (Miller et al. 1987).

Turkey's major sunflower cultivation area is located in Thrace Region. According to the data of the last decade, Thrace has 55% of the country sunflower cultivation area and provides 53% of its production. The crop is generally grown under rainfed conditions in the region (Yilmaz, Boyraz Erdem, 2020). Therefore, the unit area yields that are obtained remain within certain limits. Among the various types of stress, water deficit has gained prominence in the literature due to its implications for the cultivation of plants, especially in arid and semi-arid regions where the decrease in precipitation is persistent (McKiernan et al. 2014, Albergaria et al. 2020).

Irrigation practices are one of the agricultural technologies required to increase the unit yields and therefore oil yields to be obtained from the sunflower. Sunflower yield and oil quality response to irrigation practices has been studied previously (Erdem, Delibas 2003, Swain et al. 2019, Gocmen 2021, Sher et al. 2022). Sezen et al. (2011) concluded that the amount and timing of irrigation are important for efficient use of the applied water and for maximizing the sunflower yield and oil content. Drip irrigation on sunflower plantations has been increasingly common in recent years. In addition to the increase in yield under drip irrigation applications, fresh water is a resource that needs to be carefully managed for global food security, and optimization of irrigation is essential to increase yield per unit of water in these regions (Ozer et al. 2020).

The purpose of the study has been to determine the effects of different irrigation amounts on sunflower (*Helianthus annuus* L.) seed yield, oil content and oil acid quality under the conditions prevalent in Thrace, Turkey. In the research, the sunflower was grown under six different irrigation regimes maintained by drip irrigation in the years 2018 and 2019. It is thought that the results will be beneficial for the sunflower producers of the region and the whole country, and they will be important in alleviating the vegetable oil deficit.

MATERIALS AND METHODS

The experiment was conducted in the 2018 and 2019 sunflower growing seasons, at the Viticultural Research Institute in Tekirdağ (40°59′ N latitude, 27°29′ E longitude and 44 m altitude). The climate of this region is semi-arid. The long-term temperature, relative humidity, wind speed, sunshine duration per day, and total long-term precipitation average values are 14.0°C, 77%, 2.90 m s^{-1}, 6.5 h and 580.8 mm, respectively (Anonymous 2019). Table 1 shows the monthly meteorological data in the experimental area during the growing periods and long-term ones. Evaporation amounts shown in Table 1 were measured from A class Pan placed in the experimental area.

Table 1

The meteorological data in the experimental area during the growing seasons in 2018, 2019 and long-term ones (1960-2019)

Year	Month	Temperature (°C)	Relative humidity (%)	Wind speed (m s^{-1})	Sunshine duration (h)	Class A Pan evaporation (mm)	Precipitation (mm)
2018	April	14.0	76.4	2.2	8.0	20.2 (4 days)	10.6
	May	18.5	79.2	2.8	5.9	118.34	27.4
	June	22.3	72.6	3.0	6.6	149.4	75.4
	July	25.1	69.5	2.6	8.4	157.06	87.7
	August	26.0	63.1	3.8	7.4	118.34	0.0
	September	21.8	67.7	3.1	4.4	25.36 (4 days)	18.7
2019	April	11.6	71.9	2.6	5.4	4 (1 day)	42.9
	May	17.9	70.5	2.3	6.2	124.4	31.2
	June	24.1	64.8	2.8	7.9	189.3	7.5
	July	23.9	65.0	2.7	9.5	202.6	18.8
	August	25.3	62.7	3.5	9.5	220.6	0.0
	September	21.6	65.1	3.3	7.4	32.7 (5 days)	9.6
Long-term (1960-019)	April	11.9	77.1	2.5	5.6	63.6	40.7
	May	16.8	76.0	2.3	7.7	114.8	36.9
	June	21.5	72.0	2.4	9.0	142.1	37.9
	July	24.0	68.8	2.8	9.7	179.8	22.5
	August	24.0	69.4	3.0	8.8	170.9	13.2
	September	20.0	73.4	2.8	7.2	114.9	33.9

The soil type in the experimental area was clay-loam in the first year and loam in the second year. The bulk density ranged from 1.49 g cm^{-3} to 1.61 g cm^{-3}. The available water in the upper 90 cm of soil profile was 152.38 mm (2018) and 128.17 mm (2019). Soil properties of the plot area submitted to irrigation are presented in Table 2. Irrigation water quality is classified as C_2S_1 according to the United States Salinity Lab. with 0.62 sodium absorption ratio (SAR) and 0.72 dS m^{-1} electrical conductivity (EC).

Table 2

Soil properties of the experimental site

Year	Soil depth	pH	EC	$CaCO_3$	Field capacity	Wilting point	Bulk density
	(cm)		(dS m^{-1})	(%)	(%)	(%)	(g cm^{-3})
2018	0-30	7.64	0.61	1.00	21.73	10.28	1.60
	30-60	7.73	0.65	3.00	22.54	11.88	1.59
	60-90	7.65	0.64	2.50	19.60	9.52	1.54
2019	0-30	7.19	0.62	1.00	23.01	15.91	1.49
	30-60	6.71	0.49	1.00	27.05	17.71	1.58
	60-90	6.95	0.55	1.50	31.76	20.96	1.61

The Sanay MR variety of sunflower was planted on April 27 (2018) and April 30 (2019) and harvested on September 4 (2018) and September 5 (2019). Fertilizer applications were based upon the soil test data and carried out uniformly on each plot during the growing periods. The experiment was laid out in a randomized complete block design with 3 replications for each treatment (Salbas 2020). Each plot covered an area of 25.2 m^2 (4.2 m x 6.0 m) and contained 120 plants with 0.7 m x 0.3 m spacing. There was a 3 m distance between the plots to reduce the edge effect. The plots were irrigated with the drip irrigation method. Irrigation water was taken by a pump from a storage pool. Polyethylene (PE) tube was used for 50 mm main and 32 manifolds of the irrigation system. The diameter of the laterals was 16 mm PE, and each lateral irrigated two plant rows. Pressure compensating drippers were used to supply uniform water distribution. The dripper discharge rate was 4 L h^{-1} above 10 m operating pressure. The spacing between drippers and laterals was chosen as 0.5 m and 1.4 m, respectively, which depended on the soil and crop characteristics. Thus, the percentage of the wetted area (P) that relates the dripper spacing to lateral spacing was 36% according to the methods described by Keller, Bliesner (1990).

The irrigation regime treatments consisted of six levels of cumulative pan evaporation (E_p). The water quantities applied were 0 (I_1), 0.25 (I_2), 0.50 (I_3), 0.75 (I_4), 1.00 (I_5) and 1.25 (I_6) times of pan evaporation measured at 7-day intervals by Class A pan located in the experimental area. The irrigation interval was set at 7 days because it is convenient for farmers and in accordance with some reference on sunflower irrigation (Sezen et al. 2011, Esmaeilian et al. 2012). The amount of irrigation water was calculated by using the equation below:

$$I= E_p \cdot k_{cp} \cdot P \quad (1)$$

where: I – the irrigation amount (mm), Ep – the cumulative pan evaporation for a 7-day interval (mm), k_{cp} – the coefficient of pan evaporation, P – the percentage of wetted area.

The soil water content in the plots was gravimetrically measured every week every 30 cm down to 0.90 m, using a hand sampler. Evapotranspiration was estimated using the soil water balance equation (Allen et al. 1998). The equation can be written as:

$$ET = I + P \pm \Delta SW - DP - RO \quad (2)$$

where: ET – evapotranspiration (mm), I – the irrigation water (mm), P – the precipitation (mm), ΔSW – a change in the soil water storage in the 0.90 m soil profile (mm), DP – deep percolation (mm), RO – the amount of runoff (mm). Since the amount of irrigation water was controlled, the runoff was assumed to be zero.

After the sunflower plants reached physiological maturity, head samples for yield and quality analyses were harvested from three center rows in each plot. Twenty plants were selected randomly from each treatment for the measurement of yield and quality analyses. The oil content and oil acid composition of sunflower seeds were determined by gas chromatography according to Anonymous (1996). Oil was obtained by cold pressing at 24°C without using any chemical/solvent. Agilent 7890 A gas chromatography was used for the measurement of the fatty acid composition. Data on effects of the treatment on the seed yield and oil content were analysed using analysis of variance. The least significant test (LSD) was used to compare and rank treatments (Gomez, Gomez 1984). Differences were declared significant at $p<0.05$ or 0.01.

Water use efficiency (WUE) and irrigation water use efficiency (IWUE) were determined as seed yield divided by the seasonal ET and seasonal irrigation water applied, respectively (Zhang et al. 1999). The equations can be written as:

$$WUE = Y\ ET^{-1} \quad (3)$$

$$IWUE = Y\ I^{-1} \quad (4)$$

In equations:

WUE – water use efficiency (kg m^{-3}),
IWUE – irrigation water use efficiency (kg m^{-3}),
Y – seed yields (t ha^{-1}),
I – seasonal irrigation water applied (mm),
ET – seasonal evapotranspiration (mm).

RESULTS AND DISCUSSION

The total sunflower growing period lasted in 131 days in the first year and 129 days in the second year. This small difference in the length of the growing seasons can be attributed to climatic factors. Table 3 shows data on applied irrigation water amounts, precipitation, measured soil water depletion and measured seasonal evapotranspiration in 2018 and 2019.

Table 3

Applied irrigation water and measured seasonal evapotranspiration for treatments

Year	Treatment	Soil water depletion (mm)	Precipitation (mm)	Total applied irrigation water (mm)	Measured seasonal evapotranspiration (mm)
2018	I_1	184.7	190.5	-	375.2
	I_2	175.1		67.0	432.6
	I_3	165.1		134.1	489.7
	I_4	160.2		201.0	551.7
	I_5	154.8		267.8	613.1
	I_6	129.7		334.8	655.0
2019	I_1	220.7	57.5	-	278.2
	I_2	176.0		133.7	367.2
	I_3	156.0		267.4	480.9
	I_4	120.9		401.1	579.5
	I_5	90.7		534.4	682.6
	I_6	75.7		668.1	801.3

Irrigation applications were started in the middle of the early vegetative growth period before plant stem elongation. Since approximately 50% of the available water was depleted according to soil moisture measurements, irrigation applications were started. Evaporation amounts also showed an increase in this period.

Although irrigation was planned to be carried out at 7-day intervals, the daily excessive rainfall amounts of 50.5 mm on June 28, 28.2 mm on July 24 and 29.9 mm on July 30 in 2018 affected the irrigation practices. While the total amount of precipitation during the entire growing season was 190.5 mm in 2018, it declined to 57.5 mm in 2019. The difference between the total precipitation amounts of the two treatment years caused the total number of irrigation applications and the amount of irrigation water applied in 2018 to be lower than in 2019. For this reason, irrigation treatments were applied 7 times in the first year and 12 times in the second year. The total amount of irrigation water applied varied between 67.0 and 334.8 mm in 2018, and between 133.7 and 668.1 mm in 2019 for the plots. During the total growing season, seasonal evapotranspiration measured from the objects ranged from 375.2 mm to 655.0 mm in 2018 and 278.2 mm to 801.3 mm in 2019 (Salbas 2020). Seasonal evapotranspiration increased as the amount of water applied during the whole growing season increased. Excessive rainfall in the first year of the experiment and high irrigation water in the second year affected the values of seasonal evapotranspiration. Seasonal evapotranspiration in treatments I_1, I_2 and I_3 was higher than in 2018 due to excessive precipitation. On the other hand, measured seasonal evapotranspiration values in I_4, I_5 and I_6 treatments were higher in 2019 due to the application of more irrigation water. The total seasonal evapotranspiration values of the sunflower obtained from the study are in line with the values obtained from previous studies conducted in Thrace Region, Turkey, and in the world (Erdem, Delibaş 2003, Demir et al. 2006, Sezen et al. 2011).

The seed yield, irrigation water use efficiency (IWUE) and water use efficiency (WUE) for all treatments during the two years are presented in Table 4.

Table 4

Seed yield, IWUE nad WUE values for treatments

Year	Treatment	Seed yield	IWUE	WUE
		(t ha^{-1})	(kg m^{-3})	(kg mg^{-3})
2018	I_1	2.73 *c***	–	0.73 ns
	I_2	2.94 *c*	4.39 *a***	0.68
	I_3	4.08 *b*	3.04 *b*	0.83
	I_4	3.91 *b*	1.95 *c*	0.71
	I_5	4.75 *ab*	1.77 *c*	0.77
	I_6	5.04 *a*	1.50 *c*	0.77
		$LSD_{00.1}$= 0.88	$LSD_{00.1}$= 0.70	
2019	I_1	2.22 *c***	–	0.80 ns
	I_2	2.75 *bc*	2.06 *a***	0.75
	I_3	3.35 *b*	1.25 *b*	0.70
	I_4	3.73 *b*	0.93 *c*	0.64
	I_5	5.05 *a*	0.95 *c*	0.74
	I_6	5.19 *a*	0.78 *c*	0.65
		$LSD_{00.1}$= 0.99	$LSD_{00.1}$=0.23	

a, *b*, *c*, …. – LSD groups, ns – not significant, ** significant at p<0.01

The sunflower seed yield varied between 2.73 t ha^{-1} and 5.04 t ha^{-1} in the first year, and between 2.22 t ha^{-1} and 5.19 t ha^{-1} in the second year of the treatment. Seed yields in both years changed depending on the amount of water entering the soil (precipitation + irrigation). Especially the high amount of precipitation in the first year of the experiment caused higher seed yields than in the second year from the treatments I_2, I_3 and I_4, where irrigation water application was lower. On the other hand, in I_5 and I_6 treatments, where the amount of irrigation water applied is higher in the second year, higher seed yields were obtained compared to the first year since the amount of water entering the soil was higher. Grain yields obtained in I_5, where 100% of the open water surface evaporation value measured from Class A pan evaporation was applied, was 4.75 t ha^{-1} in the first year of the experiment and 5.05 t ha^{-1} in the second year. In I_6, where 125% of the open water surface evaporation value was applied, these values were 5.04 t ha^{-1} and 5.19 t ha^{-1} (Salbas 2020). In previous studies conducted in the region and elsewhere, similar yield values were obtained in conditions where there was the maximum plant water requirement ($ET_c = ET_m$) – Erdem, Delibas (2003), Swain et al. (2019). The IWUE values ranged from 1.50 to 4.39 kg m^{-3} in the first year and between 0.78 and 2.06 kg m^{-3} in the second year of the treatment (Salbas 2020). The reason for the high IWUE values obtained in the first year is that less irrigation water is applied to the treatments due to high precipitation compared to the second year. According to the results of variance analysis, statistically significant differences were found between the IWUE values at both levels of $p<0.01$. According to LSD tests made according to these values, I_2 treatment with the least irrigation water among the test subjects constituted the top group. The highest values were obtained from I_2 treatment in both years. The WUE values ranged between 0.68 and 0.83 kg m^{-3} in the first year of the trial, and 0.64 and 0.80 kg m^{-3} in the second year of the trial. The highest WUE value was obtained in I_3 treatment in the first year and in I_1 treatment in the second year. The WUE values obtained in both years were similar between the treatments. According to the results of variance analysis, no statistically significant differences were found between the WUE values in both years of the treatment.

The harvest moisture content, oil content and oil acids from each treatment and summary statistics are presented in Table 5 for two cultivation periods. The moisture content of sunflower seeds is important in terms of storage and processing of crude oil. It is recommended that the moisture content for sunflower seeds should be below 10% for proper storage (Kaya 2013). The moisture content of the treatments varied between 5.71 and 5.99% in 2018, and between 6.20 and 6.30% in 2019. The moisture content was not significantly affected by different irrigation amounts in the two years. The main parameter in the vegetable oil industry is the production of seeds with a high oil content. The high oil content of sunflower seeds raises the income of producers. The oil content obtained from treatments varied between 38.93% and 41.17% in 2018, and between 39.36% and 41.81% in 2019.

As a result of the analysis of variance made according to these values, no statistically significant differences were found between the two years.

Table 5

Mean values and (±) SD for oil quality parameters of sunflower in 2018 and 2019

Year	Treatment	Moisture content (%)	Oil content (%)	Oleic acid (C18:1) (%)	Linoleic acid (C18:2) (%)	Palmitic acid (C16:0) (%)	Stearic acid (C18:0) (%)	Linoleic acid (C18:3) (%)	UFA (%)	SFA (%)
2018	I_1	5.87±0.11	41.17±0.68	49.36±0.42*a**	42.37±0.24*ab**	4.46±0.03	2.45±0.09	0.04±0.020	0.25±0.035	1.08±0.203
	I_2	5.71±0.35	40.86±1.68	48.12±0.35*b*	43.66±0.38*a*	4.52±0.08	2.49±0.14	0.03±0.010	0.24±0.047	0.95±0.148
	I_3	5.95±0.05	39.23±0.83	48.92±1.01*ab*	42.74±1.11*ab*	4.54±0.10	2.59±0.16	0.03±0.010	0.20±0.066	0.97±0.153
	I_4	5.97±0.08	40.01±0.36	49.99±0.97*a*	41.47±1.19*b*	4.34±0.28	2.81±0.46	0.03±0.017	0.22±0.017	1.14±0.089
	I_5	5.96±0.07	39.26±1.00	49.90±0.17*a*	41.55±0.42*b*	4.45±0.12	2.67±0.43	0.03±0.006	0.20±0.040	1.20±0.305
	I_6	5.99±0.08	38.93±3.28	49.58±0.25*a*	41.97±0.19*b*	4.44±0.08	2.58±0.13	0.03±0.012	0.25±0.029	1.14±0.059
		ns	ns	$LSD_{0.05}$:1.20	$LSD_{0.05}$:1.36	ns	ns	ns	ns	ns
2019	I_1	6.22±0.03	39.36±1.89	41.83±2.13	47.71±2.08	5.04±0.23	3.78±0.20	0.05±0.006	0.27±0.021	1.32±0.023
	I_2	6.30±0.04	41.81±0.53	40.30±0.33	49.45±0.46	5.22±0.09	3.48±0.10	0.05±0.012	0.25±0.031	1.25±0.056
	I_3	6.26±0.05	40.45±3.51	41.19±2.35	48.46±2.50	5.20±0.25	3.57±0.34	0.05±0.021	0.26±0.006	1.27±0.066
	I_4	6.29±0.07	40.35±2.25	41.14±2.39	48.48±2.47	5.18±0.20	3.66±0.29	0.07±0.006	0.27±0.049	1.21±0.044
	I_5	6.22±0.04	40.91±2.52	40.99±1.81	48.91±1.80	5.19±0.21	3.34±0.20	0.06±0.000	0.28±0.012	1.24±0.010
	I_6	6.20±0.06	41.65±1.84	40.37±1.84	49.53±1.90	5.13±0.20	3.45±0.14	0.06±0.025	0.24±0.038	1.22±0.055
		ns	ns	ns	ns	ns	ns	ns	ns	ns

a, *b*, *c*, … – LSD groups, ns – not significant, * significant at p<0.05, SD – Standard Deviations

Thus, it can be said that different irrigation water applications did not affect the sunflower oil content. The oil content obtained from the experimental objects were found to be in parallel with the values obtained from previous studies (Erdem, Delibaş 2003, Sezen et al. 2011).

The fatty acid composition is important for the evaluation of oil quality. Mature sunflower seeds approximately contain 90% unsaturated fatty acid (oleic, linoleic, linolenic, UFA) and 10% saturated fatty acid (palmitic, stearic, SFA) – Steer, Seiler (1990). Sunflower oil quality is usually determined by oleic and linoleic acid concentrations. There is a negative correlation between the linoleic acid concentration and oleic acid concentration in sunflower oil (Unger, Thompson 1982).

The oleic acid content ranged from 48.12 to 49.99% in 2018, and from 40.30 to 41.83% in 2019. The oleic acid content was significantly affected by irrigation regimes in the first year, while it was not significantly affected in the second year. The oleic acid content obtained from the experimental objects is within the limits (14.00-71.80%) given in the Anonymous (2012). The oleic fatty acid values were higher in the first year than in the second year of the experiment. Linoleic acid, which is the other important unsaturated fatty acid, is one of omega-6 fatty acids. The linoleic acid content obtained from treatments varied between 41.47% and 43.66% in 2018, and between 47.71% and 49.53% in 2019. The linoleic acid values were higher in the second year tan in the first year. The oleic acid content obtained in the experiment is within the limits (18.70-74.00%) given in the Anonymous (2012). The influence of irrigation regimes on the linoleic acid content showed significant differences in the second year. While the oleic acid content was higher in the first year of the experiment, the linoleic acid content was higher in the second year of the experiment. The linolenic acid and other unsaturated fatty acid (UFA) values ranged from 0.03 to 0.07% and from to 0.20 to 0.28% in the two years, respectively. In many oil plants, the fatty acid composition can vary depending on various climatic conditions, especially temperature. Generally, the different irrigation regimes did not significantly affect the sunflower's unsaturated fatty acid content.

Palmitic acid, a saturated fatty acid, is the first fatty acid synthesized by living organisms, and it ranged from 4.34 to 4.54% in 2018, and 5.04 to 5.22% in 2019 among the experimental treatments. The palmitic acid values were not significantly affected by different irrigation amounts in the two years. The oleic acid content obtained from the experimental objects is within the limits (4.00-7.60%) given in the Anonymous (2012). Stearic acid together with palmitic acid are the most important saturated fatty acids of sunflower oils. The stearic acid content obtained from the treatments varied between 2.45% and 2.81% in 2018, and between 3.34% and 3.78% in 2019. As a result of the analysis of variance for stearic acid, no statistically significant differences were found in either year. Thus, it can be said that different irrigation water applications do not affect the sunflower's stearic acid content. The oleic acid content obtained from the experimental plots is within the limits (2.10-6.50%) given in the Anonymous (2012). The other saturated fatty acid (SFA) values ranged from 0.95 to 1.20% in 2018, and from 1.21 to 1.32% in 2019 among the experimental plots, and no statistical differences were observed between the irrigation treatments. In the research, the saturated fatty acid values were within the limits given in Anonymous (2012).

CONCLUSIONS

In the study carried out in Thrace, Turkey, in the 2018 and 2019 plant growing seasons, sunflower plants were grown under six different irrigation regimes. Seasonal evapotranspiration measured from the experimental plots varied from 375.2 to 655.0 mm in 2018, and from 278.2 to 801.3 mm in 2019, depending on the amount of irrigation water applied. The highest seasonal evapotranspiration values were obtained from the trial object where 125% of the open water surface evaporation amount measured from Class A pan evaporation was applied in both years. Seed yields obtained from the trials ranged between 2.73 t ha^{-1} and 5.04 t ha^{-1} in the first year, and between 2.22 t ha^{-1} and 5.19 t ha^{-1} in the second year. Seed yields obtained from treatments in both years changed depending on the amount of water entering the soil (precipitation + irrigation). The highest grain yields were obtained from the treatment where 125% of the open water surface evaporation value was applied. As a result of statistical processing of data concerning the effects of different irrigation water treatments on sunflower seed yield, the difference between the experimental objects was found to be significant at 1% level. As a result of the LSD grouping prepared according to these values, the top group was composed of the experimental objects where 100% and 125% of the open water surface evaporation value was applied. I_5 and I_6 treatments can be recommended as they provide the highest grain yield in conditions where the water supply is sufficient. The oil content and oil acid composition of sunflower seeds were also evaluated. The oil content obtained from treatments varied between 38.93% and 41.17% in 2018, and between 39.36% and 41.81% in 2019, and no statistically significant differences were found in both years. In the research, unsaturated fatty acid (oleic, linoleic, linolenic, UFA) and saturated fatty acid (palmitic, stearic, SFA) of sunflower oil acids were determined. The different irrigation regimes did not significantly affect the sunflower's unsaturated fatty acid and saturated fatty acid content.

The sunflower is an oilseed plant with the largest cultivation area and production output in Thrace region, and in whole Turkey. The high amount of oil in sunflower seeds enables a high amount of oil obtained from a unit area and a low oil cost. It is obvious that high yields to be obtained from sunflower plants grown under irrigated agricultural conditions will reduce the oil deficit. It is thought that the results obtained in this study will be helpful for the regional and national sunflower producers.

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