Chemistry of Natural Compounds, Vol. 39, No. 1, 2003

EFFECT OF IRRIGATION ON THE OIL CONTENT AND FATTY ACID COMPOSITION OF SOME SUNFLOWER SEEDS

N. Erdemoglu,[1] S. Kusmenoglu,[1] and N. Yenice[2]

UDC 547.915

The effect of irrigation on the seed yield, oil yield, and oil composition of sunflower in populations of Ekiz1 and VNIIMK 8931, a mixture of N_2, N_3, and N_4 lines, and a synthetic variety obtained from these lines has been studied. The major fatty acid was found to be oleic acid, in addition to linoleic, palmitic, and stearic acids. Irrigation increased seed yield, oil yield, and oil content of all samples. In two of them, the synthetic variety and VNIIMK 8931, the increase was found to be statistically significant. In addition, irrigation of the samples did not increase significantly the amount of oleic and linoleic acids. On the contrary, the amount of linoleic acid in the mixture of N_2, N_3, and N_4 lines and oleic acid in VNIIMK 8931 decreased statistically significantly.

Key words: *Helianthus annuus* L., *Compositae*, sunflower, fatty acids, gas chromatography.

Sunflower (*Helianthus annuus* L.) oil is a worldwide premium oil for consumers. The characteristics of vegetable oils depend on the nature of the fatty acid constituents that determine the suitability for edible and industrial usage. The oil of cultivated sunflower is accepted as high quality edible oil. Sunflower seed oil contains two main unsaturated fatty acids (oleic acid and linoleic acid) and saturated fatty acids (palmitic and stearic acid) [1, 2].

The quality of sunflower oil depends mainly on the relative content of oleic acid. Sunflower oil with a high oleic acid content is less susceptible to oxidative changes during refining, storage, and frying. Therefore, quality is retained longer than sunflower oil high in linoleic acid in both processed oil and the seed [3].

In this study, the effect of irrigation on the seed yield, oil yield, and fatty acid composition of sunflower in Ekiz1, VNIIMK 8931, a mixture of N_2, N_3, and N_4 lines, and a synthetic variety obtained from these lines has been investigated. The seed oil of the sunflower samples were investigated by GC. The oil content, oil yield, and seed yield of the samples obtained from plants growing in nonirrigated and irrigated conditions are given in Table 1.

The oil content of sunflower seeds ranged between 34.26-39.13% in nonirrigated conditions and 38.50-42.73% in irrigated conditions (Table 1). The highest oil content was obtained from sample I4. The oil content of all samples was increased with irrigation, but none of them was statistically significant ($p>0.05$).

The seed yield of the sunflower samples ranged between 84-191 kg/dec in nonirrigated and 138-246 kg/dec in irrigated conditions. For each condition, the highest seed and oil yields were obtained from the synthetic variety. Irrigation of sunflower twice during vegetation increased seed yield and oil yield in all samples, although there was a statistically significant difference in oil yield and seed yield of samples 1 ($p<0.01$) and 4 ($p<0.01$) with irrigation.

1) Department of Pharmacognosy, Faculty of Pharmacy, Gazi University, Etiler 06330 Ankara, Turkey; 2) Education Faculty, Adnan Menderes University, Kepez 09010 Aydin, Turkey. Translated from Khimiya Prirodnykh Soedinenii, No. 1, pp. 3-5, January-February, 2003. Original article submitted December 25, 2002.

0009-3130/03/3901-0001$25.00

TABLE 1. Seed Oil Contens, Seed Oil Yields, and Seed Yields of Sunflower Samples

Nonirrigated conditions				Irrigated conditions			
materials	oil content (%)	oil yield (kg/dec)	seed yield (kg/dec)	materials	oil content (%)	oil yield (kg/dec)	seed yield (kg/dec)
N1: Synthetic variety	36.93	52.4	191	I1: Synthetic variety	40.60	75.7	246
N2: Mixture of the lines	34.26	31.2	124	I2: Mixture of the lines	38.50	39.3	138
N3: Ekiz 1	39.13	50.1	171	I3: Ekiz 1	40.54	51.8	179
N4: V.8931	39.09	24.9	84	I4: V.8931	42.73	50.4	153

TABLE 2. The Percentages of Major Fatty Acids of Sunflower Oils

Materials	Palmitic acid 16:0	Stearic acid 18:0	Oleic acid 18:1	Linoleic acid 18:2
N1	10.37±0.43	8.86±0.30	36.12±1.32	5.60±0.22
I1	11.31±1.12*	7.97±0.58*	45.34±3.59*	10.78±0.91*
N2	8.37±0.44	7.42±0.18	41.05±1.03	33.00±0.90
I2	12.15±0.82*	8.57±0.46*	43.15±2.76*	10.87±1.34 (p: 0.001)
N3	11.42±0.81	8.78±0.29	33.98±1.39	16.08±0.41
I3	10.66±0.74*	7.77±0.92*	33.20±3.13*	20.07±1.37*
N4	11.85±1.73	9.56±1.17	29.06±3.76	7.78±0.17
I4	13.04±0.06*	8.13±0.02*	24.89±0.11 (p: 0.03)	6.07±0.03*

Data are expressed as a mean ± SD. *p>0.05.

TABLE 3. The Percentages of the Minor Fatty Acids of Sunflower Oils

Fatty Acids	N1	I1	N2	I2	N3	I3	N4	I4
Caproic acid (6:0)	4.19±0.80	1.43±0.43	Tr.	1.90±0.04	3.07±0.45	4.93±0.60	7.48±0.01	6.57±0.60
Caprilic acid (8:0)	1.42±0.11	2.17±0.39	1.23±0.17	1.96±0.05	2.43±0.59	1.88±0.05	1.22±0.66	1.74±0.12
Nonanoic acid (9:0)	0.97±0.08	0.61±0.14	0.49±0.02	0.81±0.26	1.07±0.34	1.61±0.22	1.78±0.45	1.34±0.16
Capric acid (10:0)	3.26±0.08	1.42±0.22	0.89±0.20	1.73±0.34	3.04±0.55	6.19±0.53	5.44±1.30	5.00±0.76
Undecanoic acid (11:0)	7.61±0.16	5.84±0.02	1.48±0.12	6.76±0.08	8.04±0.60	6.75±0.83	9.07±1.79	10.43±0.78
Myristoleic acid (14:1)	0.79±0.06	0.45±0.02	Tr.	0.51±0.01	0.60±0.11	0.49±0.10	0.93±0.01	1.30±0.04
Elaidic acid (18:1, z)	Tr.	0.72±0.15	0.56±0.03	0.77±0.11	Tr.	Tr.	0.37±0.16	Tr.
Behenic acid (22:0)	0.96±0.08	0.80±0.06	0.82±0.07	0.84±0.08	1.02±0.08	0.67±0.06	0.81±0.22	1.00±0.10

Data are expressed as a mean ± SD. Tr.: Trace, lower than 0.30.

The amounts of the four main fatty acids are given in Table 2. Linoleic, oleic, palmitic, and stearic acids were found to be the major fatty acids. As shown in Table 2, the oleic acid content ranged between 29.06-41.05% in nonirrigated and 24.89-45.34% in irrigated conditions. The highest average oleic acid concentration was found in sample I1 (45.34%). The linoleic acid content varied between 5.6-33.0% in nonirrigated conditions and 6.07-20.07% in irrigated conditions. The highest average linolenic acid was found to be 33.0% in sample N2. There was a statistically significant decrease in linoleic acid of sample 2 (p: 0.001) and oleic acid of sample 4 (p: 0.03) with irrigation but not in other samples (p>0.05). There was an increase in oleic acid and linoleic acid content in sample 1. However, the difference was not statistically significant between irrigation and nonirrigation conditions for linoleic (p>0.05) and oleic (p>0.05) acids. The amounts of palmitic and stearic acids were not found to be different.

TABLE 4. GC Analysis Conditions

Equipment	Hewlett-Packard II Series Gas Chromatograph 5890 Apparatus
Column	Ultra-1 (50 m times 33 mm film thickness times 0.2 mm i.d.) Cross-linked methyl silicone column
Carrier gas and flow rate	Helium, 0.9 ml/min
Injection temperature	250°C
Column temperature	180°C for 2 min, 250 °C at a rate of 2°C/min and kept constant at 250°C for 10 min
Split ratio	50:1
Detector	FID (250°C)
Integrator	HP 3396 Series II

The composition of minor fatty acids of the oil of sunflower samples in nonirrigated and irrigated conditions is shown in Table 3. Undecanoic acid was found to be present in the highest amount among the minor fatty acids. The highest average undecanoic acid was observed in sample I4.

There is a strong inverse relationship between oleic and linoleic acids. This strong inverse relationship is greatly influenced by environment, particularly temperature during maturation. High temperature increases the content of oleic acid and decreases that of linoleic acid, while low temperatures increase linoleic acid content [4-6]. The genetic control of fatty acid composition has been proved in cultivated varieties and in wild sunflower species [3, 7-9] In our study, the amount of oleic acid was found to be higher than linoleic acid in both nonirrigated and irrigated conditions. These results might be attributed to the high temperature and genetic control of the samples.

In conclusion, irrigation increased seed yield, oil yield, and oil content of sunflower samples and in two of them, samples 1 and 4, the increase was found to be statistically significant. Irrigation did not increase significantly the amount of oleic and linoleic acids.

EXPERIMENTAL

Field experiments were conducted at the Faculty of Agriculture of the University of Ankara, Turkey in 1995 and 1996 where they were cultivated. All specimens were kept at the Department of Pharmacognosy, Faculty of Pharmacy, Gazi University. Each irrigated and nonirrigated plot's area was 480 m^2, for a total area of 960 m^2. Fertilizer was not use in both of the plots.

In the first year (1995), seeds of the mixture of three inbred lines (N_2, N_3, N_4) were sown to obtain the synthetic variety. At the same time, sibling was performed between these inbred lines to obtain their seeds. When blooming had begun, artificial pollination was made using cotton. The pollination procedure was continued until all the heads located in the parcel completed blooming. At the end of the year, the synthetic variety and inbred lines were separately harvested.

In the second year (1996), the mixture of the lines, a synthetic variety, and the Ekiz 1 and VNIIMK 8931 (V.8931) varieties were replicated four times under irrigated and nonirrigated experimental conditions, according to a randomized block design. During vegetation (April-September), the temperature in Ankara was 18.4°C and 20.3°C in 1995 and 1996, respectively. Total rain was 24.13 and 14.78 mm and relative humidity was 52.17% and 48.67%.

When blooming had begun, irrigation was made in June 18 and July 29 twice. VNIMK 8931 has been sown to obtain its oil until 1985 in Turkey. The Ekiz 1 variety was obtained at the Faculty of Agriculture of the University of Ankara. The codes of the materials are given in Table 1.

Harvested sunflower heads were threshed separately and cleaned for analysis. The fruits were dried and peeled. Seeds were weighed accurately and ground with anhydrous Na_2SO_4. They were extracted with petroleum ether (bp 40-60°C) in a Soxhlet apparatus, and fatty acids were later converted to methyl esters with a boron trifluoride-methanol complex (20%) reagent [10]. The methyl esters of fatty acids were dissolved in CH_2Cl_2 and injected into the gas chromatograph.

The fatty acid compositions of the sunflower seed oils were determined by GC and its conditions are given in Table 4. The peaks of fatty acids were identified by comparing with their authentic samples. Statistical evaluation revealed the mean and standard deviations at different values for three injections. Statistical analysis was done by SPSS for the windows packet program. The $p<0.05$ level was accepted as statistically significant.

REFERENCES

1. B. W. Simpson, C. M. Mcleod, and D. L. George, *Aust. J. Exp. Agric.*, **29**, 233 (1989).
2. A. De Haro and J. Fernandez-Martinez, *J. Agric. Sci.*, **116**, 359 (1991).
3. J. F. Miller, D. C. Zimmerman, and B. A. Vick, *Crop Sci.*, **27**, 923 (1987).
4. H. C. Harris, J. R. McWilliam, and W. K. Mason, *Aust. J. Agric. Res.*, **29**, 1203 (1978).
5. P. J. Goyne, B. W. Simpson, D. R. Woodruff, and J. D. Churchett, *Aust. J. Exp. Agric.*, **19**, 82 (1979).
6. T. Lagravere, D. Kleiber, and J. Dayde, *Oleagineux Corps Gras Lipides*, **5**, 477 (1998).
7. J. Fernandez-Martinez, A. Jimenez, J. Dominguez, J. M. Garcia, R. Garces, and M. Mancha, *Euphytica*, **41**, 39 (1989).
8. A. G. Rather and G. S. Sandha, *Indian J. Agric. Sci.*, **68**, 209 (1998).
9. S. Lacombe and A. Berville, *Mol. Breeding*, **8**, 129 (2001).
10. W. R. Morrison and L. M. Smith, *J. Lipid Res.*, **5**, 600 (1964).