DOI: 10.29050/harranziraat.756505
Harran Tarım ve Gıda Bilimleri Derg. 2021, 25(1): 30-40

Research Article/Araştırma Makalesi

Determination of seed yield, oil and fatty acid composition of some oil type sunflower (*Helianthus annuus* L.) genotypes in Diyarbakır conditions

Diyarbakır koşullarında bazı ayçiçeği (Helianthus annuus L) genotiplerinin verim, yağ ve yağ asidi kompozisyonunun belirlenmesi

Ferhat ÖZTÜRK[1*]

[1]Sirnak University, Faculty of Agriculture, Department of Field Crop, Sırnak, Turkey

To cite this article:
Öztürk, F. (2021). Determination of seed yield, oil and fatty acid composition of some oil type sunflower (*Helianthus annuus* L.) genotypes in Diyarbakır conditions. Harran Tarım ve Gıda Bilimleri Dergisi, 25(1):30-40.
DOI:10.29050/harranziraat.756505

Address for Correspondence:
Ferhat ÖZTÜRK
e-mail:
fozturk@sirnak.edu.tr

Received Date:
23.06.2020
Accepted Date:
03.11.2020

ABSTRACT

Oil seeds have a significant effect on human and animal nutrition because of their protein, fat, carbohydrate and mineral content. This study was carried out to determination of yield, oil and fatty acid composition of some oil sunflower (*Helianthus annuus* L.) genotypes in Diyarbakır conditions in 2018. The experiment was arranged in a randomized block design with three replications. In the study, thirteen different sunflower genotypes (Nantio, Turkuaz, Sanbro, Sanay MR, Armada CL, Bosfora, Tarsan 1018, LG 5580, Sirena, Transol, LG 5482, Coral and Tunca) were used as plant material. In the study plant height, head diameter, 1000 seed weight, seed yield, protein content, oil content, content of saturated and unsaturated fatty acids in the sunflower genotypes were investigated. The result showed that significant differences were found between genotypes with respect to yield and oil quality components. According to mean values, the highest seed yield obtained from LG-5580 genotype (3813 kg ha^{-1}). The highest values 1000 seed weight were found from LG-5580 (73.7 g) and Tunca (72.5 g) genotypes. The great oil content found as 44.6% from Armada CL genotype. The highest Linoleic acid content values were found by Tunca (55.7%) and LG-5580 (55.3%) genotypes, while the highest oleic values were determined by Bosfora (37.8%) genotype. It was concluded that LG-5580 genotype could reliably be used in sunflower farming under ecological conditions in Diyarbakır, Turkey.

Key Words: Sunflower (*Helianthus annuus* L.), Seed yield, Oil content, Fatty acid

ÖZ

Yağlı tohumlar protein, yağ, karbonhidrat ve mineral içeriği nedeniyle insan ve hayvan beslenmesinde önemli bir yere sahiptir. Bu çalışma, 2018 yılında Diyarbakır koşullarında bazı yağlık ayçiçeği (*Helianthus annuus* L.) genotiplerinin verim, yağ ve yağ asidi kompozisyonunun belirlenmesi için yapılmıştır. Araştırma, tesadüf blokları deneme desenine göre üç tekerrürlü olarak düzenlenmiştir. Çalışmada 13 farklı ayçiçeği genotipi (Nantio, Turkuaz, Sanbro, Sanay MR, Armada CL, Bosfora, Tarsan 1018, LG 5580, Sirena, Transol, LG 5482, Mercan ve Tunca) kullanılmıştır. Çalışmada bitki boyu, tabla çapı, 1000 tohum ağırlığı, tohum verimi, protein içeriği, yağ içeriği, ayçiçeği içindeki doymuş ve doymamış yağ asitlerinin içeriği araştırılmıştır. Sonuç, verim ve yağ kalitesi bileşenleri bakımından genotipler arasında önemli farklılıklar bulunduğunu göstermiştir. Ortalama değerlere göre, en yüksek tohum verimi LG-5580 genotipinden (3813 kg ha^{-1}) elde edilmiştir. En yüksek 1000 tohum ağırlığı değerleri LG-5580 (73.7 g) ve Tunca (72.5 g) genotiplerinden saptanmıştır. En yüksek yağ içeriği Armada CL genotipinden % 44.6 olarak bulunmuştur. En yüksek Linoleik asit içeriği değerleri Tunca (% 55.7) ve LG-5580 (% 55.3) genotiplerinden bulunurken, en yüksek oleik değerleri Bosfora (% 37.8) genotipinde belirlenmiştir. LG-5580 genotipinin, Diyarbakır ili ekolojik koşullarında ayçiçeği tarımında güvenle kullanılabileceği sonucuna varılmıştır.

Anahtar Kelimeler: Ayçiçeği (*Helianthus annuus* L.), Tohum verimi, Yağ içeriği, Yağ asitleri

Introduction

Oilseeds are rich in protein, oil, carbohydrate, and minerals; thus, they have a significant effect on human nutrition and animal feeding. Oil seeds also have an important in terms of in vegetable oil production with high and quality oil content (40-50%). Oil seeds may generate a great source of raw material in the industry. Sunflower is an important oil crop both in the world and in Turkey. Sunflower is grown in 26 million hectares of land worldwide. Considering such a huge cultivated land, the sunflower was considered to have a large adaptation area. According to 2018 data of Turkey, sunflower farming is practiced over 734 thousand ha land area and annual production is around 1.9 million tons (FAO, 2018). In Turkey, majority of vegetable oil production (80%) comes from oil seeds. Approximately 65% of vegetable oil production comes from sunflower and the rest from cottonseed, olive, soybean, and the other oil seeds (Yosmanoğlu, 2002; Çetin and Başalma, 2005). Vegetable oil quality largely depends on ratio of triacylglycerol to three types of fatty acids: saturated, monounsaturated and polin saturated, however, nutritional, and technological characteristics of these fatty acids depend on softened compounds, especially on sterols and tocopherols. Sunflower unsaturated fatty acids are composed of oleic acid (14-43%), linoleic acid (44-75%), and the other fatty acids (0.7%) (Baydar and Turgut, 1999). High linoleic acid contents indicate high quality of vegetable oils (Wagner et al., 2001). Linoleic acid reduces saturation degree of the oil and facilitates digestion and passes into the blood (Kolsarıcı et al., 1995).

As it was in every culture crop, besides plant genetics, physiological, morphological and agronomic characteristics and cultural practices significantly influence yield and quality of sunflower. Therefore, such characteristics and practices should be well-known for high yield and quality. Positive significant correlations were reported in a previous study between linoleic acid content and tocopherol concentration of sunflower genotypes (Kamal-Eldin and Andersson, 1997). Late sowings negatively influence pollination in sunflower because of high temperatures at flowering stage. Especially in the seed development stage, high temperatures affect the fatty acid composition and decrease the oil quality (Kolsarıcı et al., 1987).

Daylight has positive effects on fatty acid composition of sunflowers through different effects on different agronomic traits (Gielen, 1992; Gallina Tosci et al., 1997). Total daylight and day length during the development seed shell significantly influence daily changes in oleic and linoleic acids of sunflower oil, but temperature does not have any effects on these parameters. On the other hand, field and controlled experiments revealed that low temperature increased linoleic acid contents and decreased oleic acid contents of standard cultivars (Harris et al., 1980: Chaampolivier and Merrien, 1996).

As it was in the other cultural crops, sunflower yield and quality could significantly be improved by using appropriate cultivars well adapted to regional conditions. In this study, yield, yield components and fatty acid composition of different sunflower genotypes were determined under ecological conditions of Diyarbakır province of Turkey.

Material and Methods

Location and duration

Experiment to determine the agronomic and quality traits of some sunflower cultivars registered under second-crop in Diyarbakır ecological condition was conducted over an experimental site located at 37°532588´ N and 40°162356´ E coordinates with an altitude of 670 m in 2018 growing season (Figure 1).

Soil properties

The soil samples were taken at 0-30 cm depth before the sowing the crop for determination of chemical and physical properties of the soil. The soil contains 71.6% clay, 1.25% organic matter, 1.63 kg da-1 phosphorus, potassium high level, 13.02% alkaline, 0.01- 0.02% salt and pH 7.73.

Weather information

Monthly average temperature, total rainfall and average humidity during the experimental period were recorded at the Turkish State Meteorological Station Turkey. Climate information is seen in Figure 1 during experiment temperature fluctuated from 18.1 to 31.8 ˚C. The average temperature was around 25.3 ˚C and average rainfall 39.13 mm.

Experimental treatments and design

The experiment was arranged in a randomized block design with three replications.

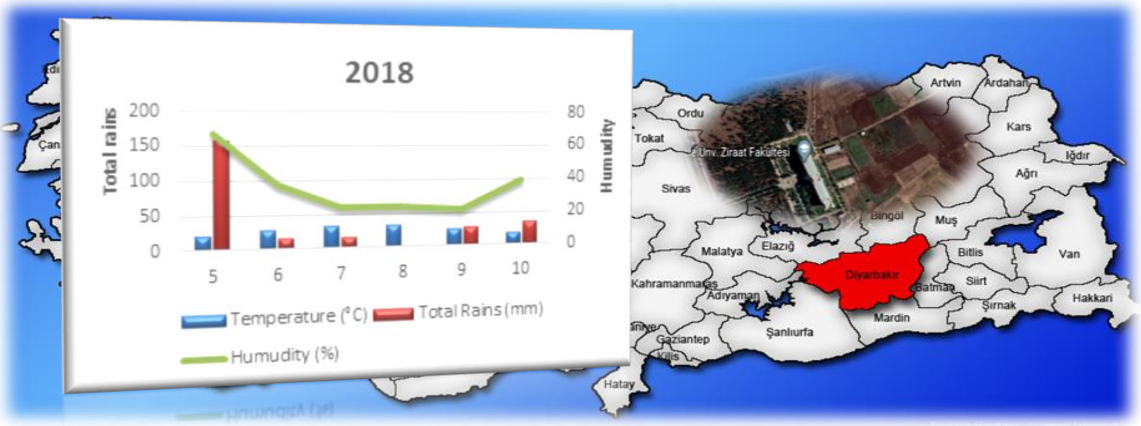

Figure 1. Experimental area and climatic data in 2018

Plant material

A total of 13 sunflower genotypes (1-Nantio (early), 2-Turkuaz (early), 3-Sanbro (early), 4-Sanay MR (early), 5-Armada CL (mid-late), 6-Bosfora (mid-early), 7-Tarsan 1018 (early), 8-LG 5580 (mid-late), 9-Sirena (mid-late), 10-Transol (early), 11-LG5482 (early), 12-Coral (early), 13-Tunca (mid-early)) were used as the plant material of the study.

Experimentation

Soil tillage was practiced over the experimental fields before the experiments. Each four m long plot was divided into four rows consisting of following field spacings: 70 cm between and 30 cm within rows. Sunflower seeds were sown by hand in the 4th week of May as 4 seeds in a hole. 90 kg ha^{-1} N and 70 kg ha^{-1} P_2O_5 fertilizers were applied before sowing. When plants reached a height of 10-12 cm, they were singled out in a way that each hole had one plant. Hoeing was conducted by taking weed density into consideration. Plants were irrigated by five times using furrow irrigation method. Sunflower heads were tied with punched plastic bags allowing air ventilation against bird damage during grain filling stage. When sunflowers were at harvest maturity, plants in rows at each plot's sides and plants within 50 cm at top and bottom of each plot were reaped as border effect and the remaining plants in 4.2 m^2 area were harvested. Heads were dried out for 3 or 4 days in a shade place after the harvest and they were blended separately.

Data collection

In a period when the seeds ripened, the heads of the middle rows were manually harvested. Harvested plants were stacked in bundles, thoroughly and threshed. Counting ad measurements were performed on 15 plants randomly selected from the second and third rows of each plot. Plant height, 1000-seed weight, seed yield, oil and protein ratio, saturated-unsaturated fatty acid components were investigated. Protein ratio (%) was determined with Kjeldahl method (AOAC, 2000). Oil content (%) was measured with the use of a Soxhlet apparatus including n-hexane (60 °C) as an organic solvent Seed fatty acid composition was determined with the use of gas chromatography (GC-MS qp 2010)(Slover and Lanza, 1979). Lon source temp: 200 ^{o}C, Interface temp: 250 ^{o}C and Colon: Rtx®-Wax 30 meter.

Statistics analysis

Experimental data were subjected to analysis of variance with JMP 13.1 statistical software in accordance with randomized blocks design with 3 replications. Significant means were compared with the use of LSD multiple comparison test at 5% significance level.

Results and Discussion

Variance analysis revealed that differences in protein ratios of the genotypes were found to be significant at p<0.05 level and the differences in the other parameters were found to be significant at p<0.001 level (Table 1).

Table 1. Plant height, head diameter, 1000 Seed weight, Seed yield and protein ration of sunflower genotypes in the experimental

Genotypes	Plant height (cm)	Head diameter (cm)	1000 Seed-weight (g)	Seed yield (kg ha^{-1})	Protein ratio (%)
Nantio	179.0	19.6	51.4	3043.2	18.2
Turkuaz	169.4	18.0	54.3	2946.5	18.9
Sanbro	159.2	18.4	61.4	3052.3	19.3
Sanay MR	166.4	20.0	52.0	2995.6	19.3
Armada CL	160.2	18.8	48.1	2920.3	19.0
Bosfora	137.5	21.8	70.5	3286.8	17.7
Tarsan 1018	146.4	18.1	58.4	3131.1	17.1
Lg 5580	158.3	23.3	73.7	3813.0	17.9
Sirena	157.9	21.3	69.1	3356.3	18.2
Transol	163.7	18	49.8	2434.2	17.6
LG 5485	159.9	18.2	65.3	2705.3	20.0
Coral	163.63	19	71.3	3210.6	19.1
Tunca	158.2	21.6	72.5	3658.6	18.7
Variance analysis					
F value	10.81**	5.35**	12.17**	8.82**	2.13
LSD	7.94	1.4	6.52	357.4	1.57
CV	2.95	4.22	6.32	6.82	5.04

* Significance difference at p ≤ 0.05. ** Significance difference at p ≤ 0.01, LSD:Least significant differences, CV: Coefficient of variation

As the average of genotypes, plant heights varied between 137.5 – 179.0 cm with the greatest value was obtained from Nantio genotype and the lowest value from Bosfora genotype (Table 1). Plant height is a significant indicator of plant growth and development and generally vary based on plant genetics, cultural practices and ecological conditions (climate and soil). Sowing dates may have significant effects on plant height of sunflower since plants benefit more from soil moisture and nutrients and get greater plant heights in early sowings. Sowing dates also largely influence plant vegetative and generative stages (Akther et al., 2013). Tan (2014) reported that sowing date, plant density and environmental factors played a significant role in plant height of long, medium, short and dwarf sunflower plants. Oral and Kara (1989) attributed differences in plant heights to genetic structure of the cultivars, Vega and Hall (2002) indicated that there might be differences in above-ground parts of the plants in early and late sowings. Differences in plant heights may also be resulted from different response of cultivars to cultural practices (Yılmaz and Kınay, 2015; Deviren and Eryiğit, 2017).

There were significant differences in head diameters of the sunflower genotypes (p<0.01), thus different head diameter groups were formed (Table 1). The greatest head diameter was obtained from LG-5580 genotype (23.3 cm) and the lowest head diameters were obtained from Transol (18.0 cm), Turkuaz (18.0 cm), Tarsan 1018 (18.1 cm) and LG-5485 (18.2 cm) genotypes. Head diameter directly influences seed yield. Head diameter of sunflower may vary based on several factors including cultivars, ecological factors, soil conditions, growing techniques, cultural practices, and plant genetics. Besides, head size is also largely influenced by temperature, soil moisture and fertility and sowing dates. It was also reported that differences in head diameter of different sunflower genotypes might be resulted from different genetic potential of the cultivars (Khan 1989). Previous researchers reported head diameters of different sunflower genotypes as between 15.5 – 22.9 cm and indicated that head diameters varied with the sowing dates and late sowings yielded smaller head diameters (Gürbüz et al., 2003). Kaya et al., (2005) indicated that increasing seed yields were obtained with increasing head diameters over 16 cm. Several researchers indicated that head diameters had positive effects on seed yield, thousand seed weight and oil yields (Albayrak, 2014; Ashraf, 2017; Sefaoğlu and Kaya, 2018).

The differences in 1000-seed weights of the sunflower genotypes were found to be significant at $p<0.01$ level. 1000 seed weights varied between 48.1 (Armada Cl) - 73.7 g (LG-5580). Thousand seed weight may vary based on the genotypes and growing conditions. Öztürk and Kızılgeçi (2018) reported that late sowings yielded greater 1000-seed weights than the early sowings and late sowings significantly increased 1000-seed weights because of low temperatures at seed-fill stage. Previous researchers reported 1000-seed weights of different sunflower genotypes as between 38-83 g (Çil et al., 2011; Evci et al., 2011; Sefaoğlu et al., 2009; Yıldız et al., 2009; Kara et al., 2013 and Albayrak, 2014). Present findings on 1000-seed weights comply with those earlier ones. Mrdja et al. (2012) showed that sunflower production in terms of the 1000 seed weight differences between regions was 8.69%, and they stated that all the interactions of regional production areas are essential.

Seed yield is the most significant parameter in sunflower farming. As the average of the genotypes, seed yields varied between 2434.2-3813.0 kg ha^{-1} with the greatest value from LG-5580 (3813 kg ha^{-1}) and Tunca (3658.6 kg ha^{-1}) genotypes while the lowest values from Transol (2434.2 kg ha^{-1}) and LG-5485 (2705.3 kg ha^{-1}) genotypes. Head diameter and 1000 seed weight are factors that directly affect seed yield. The LG-5580 genotype, which creates a high value in terms of seed yield, was also at the top of the table diameter and 1000 seed weight. There are several factors influencing yield in sunflower farming including plant genetics, ecological conditions, morphological, physiological, and agronomic factors. Cultivar used in sunflower farming is the most important factor influencing seed yield (Andrei et al., 1992). Differences in seed yields of the cultivars are mostly attributed to yield potential of the genotypes and growing conditions (Sefaoğlu et al., 2009). Sowing date designate flowering time and has a great impact on dry matter accumulation and seed yield (Sofield, 1977). Therefore, optimum sowing dates should be determined to improve seed yields and stability in sunflower farming (Çoşge and Ulukan, 2005). In addition, cultivar characteristics, cultivarxsowing date interactions should also be known for high yield in sunflower farming. Previous researchers reported significant decreased in seed yields with increasing shifts from normal sowing dates. Alkan (1973) reported about 25 – 35% increases in seed yields with early sowings. Such differences in seed yields were mostly attributed to cultivars, temperatures at different growth stages and environmental factors. The determination of the sunflower genotypes suitable for the region will provide the opportunity to obtain high-yield and high quality products because the soil, environment and climatic factors of the region in which they are grown are very useful in determining seed yield and oil content (Gul and Coban, 2020).

Differences in protein ratios of the genotypes were found to be significant at $p<0.05$ level (Table 1). Protein ratios of the genotypes varied between 17.1 – 20.0% with the greatest value from LG-5485 genotype and the lowest value from Tarsan 1018 genotype. Protein ratios generally vary with the genetic structure of the genotypes. Öztürk and Kızılgeçi (2018) indicated that sowing date also significantly influenced protein ratio and decreasing protein ratios were reported with delayed sowings. Present findings on protein ratios comply with the results of Ergen and Sağlam (2005).

There were significant differences in oil ratios of the genotypes in Table 2. Oil ratios varied between 36.3-44.6% with the greatest value from Armada CL genotype (44.6%). Chemical composition of sunflower seeds may vary based on various factors including growing conditions, temperature, fertilization, irrigation and cultivar characteristics. Alem et al. (2016) found that the oil content of sunflower genotypes grown in different locations were between 28.18-33.50%. High temperatures at seed formation stage generally reduce oil ratios (Gürbüz et al., 2003). Low temperatures at seed formation period and late sowings were also reported to reduce oil ratio of sunflower seeds (Bange et al., 1997; Patanè et al., 2017). Environmental factors, especially temperatures at seed development and ripening stages influence oil ratio of sunflower seeds (Seiler, 1983). However, temperature has varying effects on oil ratio. Harris et al., (1978) reported decreasing oil ratios with increasing temperatures. Öztürk et al. (2017) and Çalışkan et al. (2002) reported that early sowings had greater oil ratios than late sowings. It was also reported in the other relevant studies that oil ratios varied largely based on cultivars and growing conditions (Stanojevic et al., 1998; Özer et al., 2003; Coşge and Ulukan, 2005). Present differences in oil ratios were mostly attributed to differences in cultivars and different ripening groups of the cultivars. Cvejić et al. (2015) reported that there are significant differences between genotypes grown in different locations in terms of oil content and oil yield depending on climatic and environmental factors.

Table 2. Oil ratio and fatty acid contents of sunflower genotypes in the experimental

Genotypes	Oil ratio (%)	Oleic acid ratio (%)	Linoleic acid ratio (%)	Stearic acid ratio (%)	Palmitic acid ratio (%)
Nantio	40.6	29.9	53.1	5.9	7.9
Turkuaz	36.3	32.0	53.1	4.5	7.4
Sanbro	42.5	33.6	51.8	4.4	6.8
Sanay MR	42.7	34.4	51.4	4.2	6.8
Armada CL	44.6	37.2	49.9	3.9	5.7
Bosfora	41.8	37.8	50.7	3.5	5.0
Tarsan 1018	44.0	34.2	51.5	4.3	6.6
Lg 5580	41.4	30.2	55.3	4.9	6.9
Sirena	42.4	36.8	51.6	3.8	5.7
Transol	43.2	35.4	51.5	4.3	6.0
LG 5485	37.8	35.1	51.3	4.3	6.1
Coral	40.3	32.5	53.4	4.3	7.0
Tunca	41.3	31.7	55.7	4.0	6.3
Variance analysis					
F value	4.99**	12.05**	4.23**	5.91**	10.64**
LSD	3.48	2.15	2.28	0.70	0.69
CV	5.00	3.78	2.60	9.5	6.33

* Significance difference at p ≤ 0.05. ** Significance difference at p ≤ 0.01, LSD: Least significant differences, CV: Coefficient of variation

Quality

There were significant differences in oleic acid and linoleic acid contents of the genotypes (Figure 2). Oleic acid contents varied between 29.9 - 37.8% with the lowest values from Nantio (29.9%) genotypes and the greatest value from Bosfora genotype (Table 2). Oil yield and chemical composition, in other words, fatty acid composition, may vary based on triglycerols and bioactive compounds of oil seeds may vary based on cultivars, location and post-harvest technologies (White, 2007). These three factors significantly influence oil characteristics. Besides, oil yield and chemical composition also influenced by unforeseen factors including especially environmental (abiotic and biotic) factors. Abiotic factors include growth season-dependent parameters (humidity, temperature, light intensity, moisture content, CO_2 levels and agronomic factors like soil mineral contents) (Schulze et al., 2005). These factors allow optimum plant growth and development.

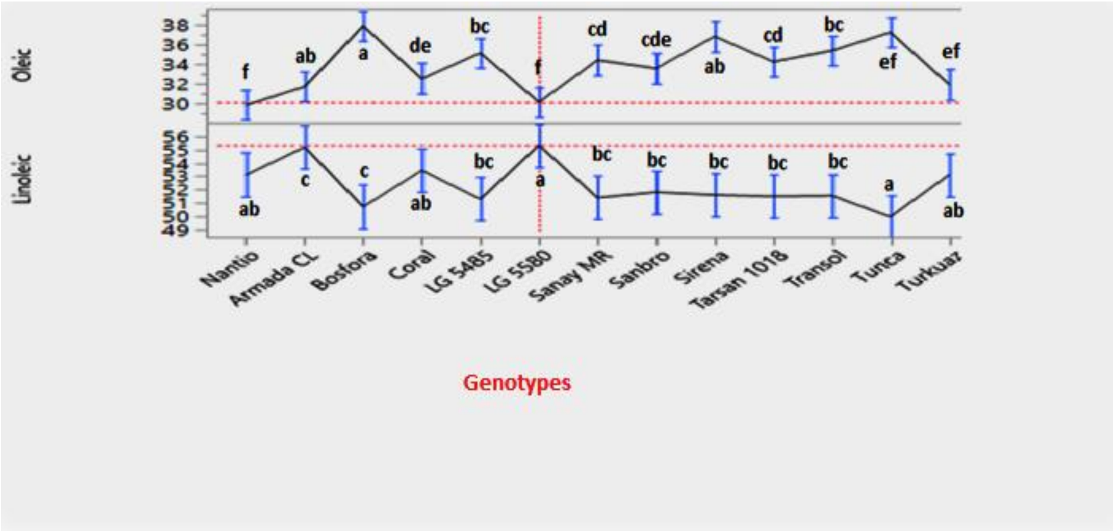

Figure 2. Average oleic acid and linoleic acid content of some genotypes in the examined

Filipescu and Stoenescu (1978) indicated that oleic acid contents of different sunflower seeds may depend on temperatures from flowering to physiological maturity. The other researchers pointed out the effects on solar radiation and day lengths on oleic acid contents and reported increasing oleic acid contents with increasing temperatures in seed formation period (Samancı and Özkaynak, 2003). Increasing temperatures reduce the activity of enzymes catalyzing acid synthesis (Broun and Somerville, 1997). A unit increase in temperatures (1 °C) in seed formation period resulted in about 0.2% increase in oleic acid content (Demurin et al., 2000). Increased oleic acid contents were also reported at high temperatures (Roche et al., 2004). Ambient temperature and soil moisture positively influence seed oil contents (Yücel et al., 1977); but oil yields (Ashley et al., 2001; Leto, 1998) and quality (especially oleic and linoleic acid contents) (Blamey et al., 1997) decrease at late sowings. Differences in above-ground parts of the plants in early and late sowings indicate the effects of sowing date on yields (Vega and Hall, 2002).

The greatest linoleic acid contents were obtained from Tunca (55.7%) and LG5580 (55.3%) genotypes and the lowest linoleic acid contents were obtained from Armada CL (49.9%) and Bosfora (50.7%) genotypes (Table 2). Fatty acid compositions are largely influenced by genetic characteristics of the genotypes, environmental factors, sowing and harvest dates. Latitudes of the growing site also influence fatty acids (Robertsan et al., 1978). Increasing temperatures influence desaturase enzyme activity converting oleic acid into linoleic acid, thus increase linoleic acid content (Harris et al., 1978). It was observed in present study that low temperatures at the end of flowering and in seed formation periods or short photoperiods reduced linoleic acid contents. Popa et al. (2017) reported linoleic acid contents at late sowing as between 59.02 - 64.11% and indicated that linoleic acid contents increased with delayed sowing dates. Contrarily, Flagelle et al. (2002) reported increased linoleic acid contents at early sowings. It was reported that linoleic acid accumulation was observed at low temperatures and oleic acid at high temperatures (Tremolieres and Jacques, 1984).

There were significant differences in stearic acid and palmitic acid contents of the genotypes (Figure 3). Stearic acid contents varied between 3.5-5.9% with the greatest value from Nantio genotype and the lowest value from Bosfora genotype. Of the other important fatty acid components, stearic and palmitic acid contents are largely influenced by locations, genotypes, plant genetics and abiotic factors. Increasing stearic contents at hot regions indicate that temperature was a significant factor controlling stearic acid biosynthesis. Khalil, (2000) reported significant differences in stearic acid content of sunflower genotypes and indicated that low temperatures at plant growth stages increased stearic acid contents. Ahmad and Hassan (2000) indicated that low temperatures and a smaller number of degree-days supported stearic acid accumulation. Popa et al. (2017) reported that sowing date and weather conditions did not influence stearic contents of the cultivars. It was reported in another study that the greatest stearic acid content was obtained from early sowing dates (Ferfuia and Vannozi, 2015).

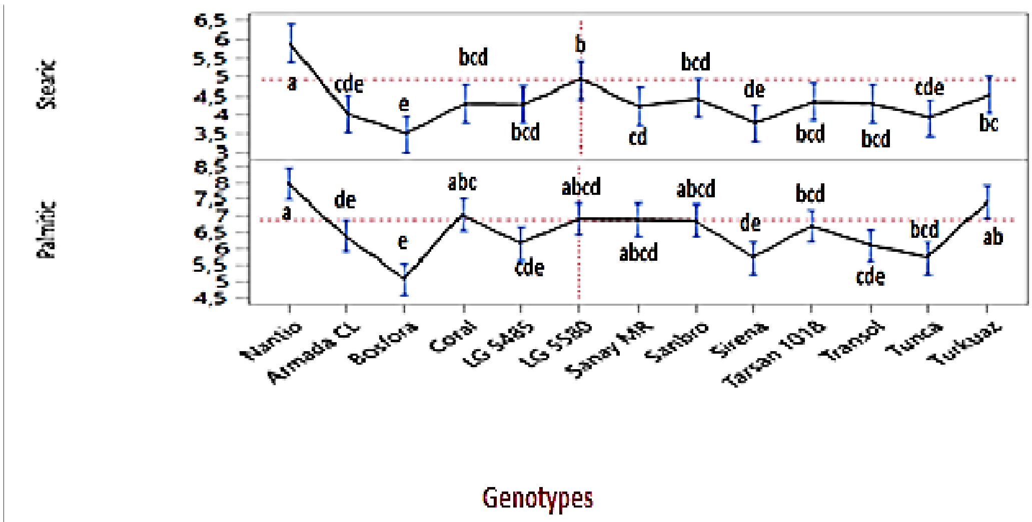

Figure 3. Average stearic acid and palmitic acid content of some genotypes in the examined

The greatest palmitic acid content (7.9%) was obtained from Nantio genotype and the lowest (5.0%) from Bosfora genotype. Oil crops do not have constant fatty acid components and fatty acid composition is influenced by cultivar characteristics, environmental factors and temperature. Low or high palmitic acid contents may be influenced by temperatures at seed formation period. High temperature in this period was reported to increase palmitic acid contents (Ferfuia and Vannozzi, 2015). Correlations between investigated parameters are provided in Table 3. Head diameter had significant and positive correlations with 1000-seed weight and seed yield. Oleic acid rate had significant and positive correlation with plant height and head diameter. Plant height had significant and negative correlations with head diameter, seed yield and 1000-seed weight. There were significant and negative correlations between oil ratio and protein ratio. There were negative correlations also between oleic acid and linoleic acid and between stearic acid and oleic acid ratios. Doğan, (2010) reported that head diameter had positive correlations with 1000-seed weight and seed yield. It was reported in another study that plant height had negative correlations with oil rate and head diameter (Tozlu et al., 2008).

Table 3. Correlation among yield parameters and fatty acid compositions (%) in different sunflower genotypes

	PH	HD	1000 SW	SY	OR	PR	18:1	18:2	18:0	16:0
PH	.									
HD	-0,262*	.								
1000 SW	-0,253*	0,210**	.							
SY	-0,110*	0,459**	0,477**	.						
OR	-0,250	0,175	-0,386	0,125	.					
PR	0,130	-0,083	-0,007	0,112	-0,298*	.				
Oleic	0,001**	0,118*	-0,037*	0,149	-0,198	-0,185	.			
Linoleic	0,013	0,131	-0,035	0,129	-0,131	-0,143	-0,952**	.		
Stearic	0,045	0,193	-0,066	0,038	-0,101	-0,245	-0,724**	-0,696	.	
Palmitic	0,267	-0,203	-0,071	0,318	-0,206	-0,085	-0,720**	-0,633*	-0,230**	.

PH: Plant height, HD: Head diameter, 1000 SW: Seed weight, SY: Seed yield, OR: Oil rate, PR: Protein rate, 18:1: Oleic acid, 18:2: Linoleic acid, 18:0: Stearic acid, 16:0: Palmitic acid

* Significance difference at $p \leq 0.05$. ** Significance difference at $p \leq 0.01$,

Conclusion

Seed yield and fatty acid composition are the most significant parameters in sunflower farming. In this study, the greatest seed yield, 1000-seed weight, head diameter and linoleic acid content were obtained from LG-5580 genotype. It was therefore concluded that the genotype LG-5580 could be reliably used in sunflower farming under ecological conditions in the Diyarbakır province of Turkey.

Conflict of Interest: The authors declare that they have no conflict of interest.

Author Contribution: FÖ conducted, analyzed and wrote that manuscript

References

Ahmad, S., & Hassan, F.U. (2000). Oil yield and fatty acid composition of spring sunflower. *Pak J.Biol.Sci.,3(12)*:2063-2064.

Akther, S., Ahmed, F., Houssen, M.A., Ahmed, B., & Houssain, M.A. (2013). Effect of sowing date on phenology, growth and yield of lentil genotypes. *J. Expt Biosc.* 4(1):99-104.

Albayrak, Ş.N. (2014). Effects of sowing dates and different forms of nitrogen fertilizer on yield and yield components of oilseed sunflower. *Ataturk University Graduate School of Natural and Applied SciencesD epartment of Field Crops*. MscThesis

Alem, C., A. Worku, M. Mekonnen, T. Asres, D. Fentie, E. Mihiretu and J. Esmael. (2016). GGE stability analysis of seed yiakteld in sunflower genotypes (*Helianthus annuus* L.) in western Amhara Region, Ethiopia. *International J. Pl. Breed. and Genet.* 10: 104-109. DOI: 10.3923/ijpbg.2016.104.109

Alkan, B. (1973). Sunflower cultivation and fertilization. Soil and Fertilizer Research Institute Directorate, Publication Number: 15, 4-5,

Andrei, E., Ivancia, V., Barnaveta, E., ve Tarnauceanu, D. (1992). Aspects and directions on seed production of sunflower in lasi County. Cercetari Agronomice in Moldova, 25 (1): 248-252.

AOAC. (2000). Association of Official Agri- cultural Chemists, Official and Tentative Meth-ods of Analysis. 2nd Ed. Washington, D.C., USA

Ashley R.O., Eriksmoen E.D., & Whitney M.B. (2001). Sunflower date of planting study in Western North Dakota. In 2001 *Annual Report, Dickinson Research Extension Centres*, Dickinson,ND,187-198

Ashraf, A. (2017). Effects of nitrogen doses on yield and yield components of oilseed sunflowers (Helianthus annuus L.) having different growing stages. *Ataturk University Graduate School of Natural and Applied Sciences Department of Field Crops.* Phd Thesis

Bange M.P., Hammer G.L., & Rickert K.G. (1997). Enviromental control of potentional yield of sunflower in subtropics. Aust. J. Agric. Res. 48:231-240

Baydar, H., & Turgut, İ. (1999). The change of fatty acid composition according to some morphological and physiological characteristics and ecological regions in oilseed plants. *Tr. J. Of Agriculture and Forestry*, 23(1), 81-86.

Blamey F.P.C., Zollinger R.K., & Schneiter A.A. (1997). Sunflower production and culture, agronomy monographs. *Sunflower technology and production*. Chapter 12.

Broun, P., & Somerville, C. (1997). Accumulation of ricinoleic, lesquerolic and densipolic acid an seeds to transgenic arabidopsis plants that Express a fatty acyl hdroxlasec DNA from castor bean. *Plant Phsiology* 113: 933-942.

Cvejić, S., S. Jocić, I. Radeka, M. Jocković, V. Miklič, V. Mladenov & V. Lončarević. (2015). Evaluation of stability in new early-maturing sunflower hybrids. *Journal on Processing and Energy in Agriculture*. 19(5): 255-258.

Çalışkan ME, Günel E, Çağar A, & Mert M. (2002). Effect of sowing dates on phenological development, yield and oil content of sunflower in a Mediterranean type environment. *Indian Journal of Agronomy*. 47(3): 427-432

Çetin, Ö.E., & Başalma, D. (2005). The effects of foliar fertilizer applied to sunflower (Helianthus annuus L.) on yield and yield components at different developmental stages. *Turkey VI. Field Crops Congress*, 5-9 September 2005, Antalya

Chaampolivier, L., & Merrien, A. (1996). Evolation de lateneur en huile et de sa composition en acides gras chezdeux varietes de tournesol(oleique ou non) sous l'effetde temperatures differentes pendant la maturation des grines, *OCL*, III,2, 140- 144.

Çil, A,N., Çil, A., Evci, G., & Kaya, Y. (2011). Sunflower breeding and adaptation studies ın Cukurova region. International Symposium on Sunflower Genetic Resources, October 16 – 20, 2011, S,53, Kuşadası, İzmir, Turkey.

Coşge, B., & Ulukan, H. (2005). Variety and planting time in our sunflower (Helianthus annuus L.) cultivation. *Süleyman Demirel University Journal of the Institute of Science,* 2005, 9(3).

Demurin, Y., Skoric D, Veresbaranji., & Jocic, S. (2000). Inheritance of İncreased Oleic Acid Content in Sunflower Seed Oil. *Helia,* 23, 87.

Deviren, R., & Eryiğit, T. (2017). The Determination of Yield Performance of Some Sunflower (*Helianthus annuus* L.) Cultivars Under Iğdır Plain Irrigable Condition. *KSU J. Nat. Sci.,* 20 (special), 166-171, 2017

Doğan, M. (2010). A research about defining technologic and agricultural properties of sun seed species under non irrigable conditions. *Çukurova university institute of natural and applied sciences department of field crops. (*Msc.Thesis). Erişim adresi: https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp

Ergen, Y., & Sağlam, C. (2005). Yield and yield characters of differrent confectionery sunflower varieties in conditions of Tekirdag. *Journal of Tekirdag Agricultural Faculty* , 2005, 2(3): 221- 227.

Evci, G., Pekcan, V., Yılmaz, İ,M., Kaya, Y., Şahin, İ., Çıtak, N., Tuna, N., Ay, O., & Pilaslı, A. (2011). Determination of the relationship between oil quality and yield components in sunflower (Helianthus annuus L,). *Turkey IX Field Crops Congress*, S,279, Bursa.

FAO, (2018). The Food and Agriculture Organization of the UnitedNations.http://www.fao.org/faostat/en/#data/QC [Data access: 07.05.2020]

Ferfuia, C., & Vannozzi, G.P. (2015). Maternal effects on seed fatty acid composition in a reciprocal cros of high oleic sunflower (Helianthus annuus L.). *Euphytica* 205:325-336
DOI: 10.1007/s10681-015-1378-3

Filipescue, H., & Stoenescu,F.M. (1978). Variability of linoleic acid content in sunflower oil, depending on genotype and environment. *Helia.* 1978:42-7.

Flagella Z, Rotunno T, Tarantino E, Caterina R Di, & caro A.De, (2002). Changes in seed yield and oil fatty acid composition of high oleic Sunflower (Helianthus annus L.) hybrids in relation to the sowing date and the water regime. *European Journal of Agronomy,* Volume 17, Issue 3, Pages 221-230

Gallina, Tosci T., De Panfilis, F., & Lercker, G. (1997). Valutazione della qualita di ol idi semi spremıti a freddo presenti sul mercato. *Ind. Alim, XXXVI*, 983-989.

Gielen, H., (1992). Oil for oleochemical industry. *Procee in 13th International Sunflower Conference,* Pisa, Italy.7-11 September, Vol. II, 1533-1543.

Gul, V. & Çoban, F. (2020). Determination of yield and quality parameters of oil sunflower genotypes grown in Turkey. *Turk J. Field Crops*, 25(1), 9-17. https://doi.org/10.17557/tjfc.609749

Gürbü,z B., Kaya, M.D., & Demirtola, A. (2003). Sunflower Farming. Hasat Publishing Ltd. Sti. ISBN- 975-8377-23-X.

Harris, H.C, McWilliam, J.R., & Mason, W.K. (1978). Influence of temperature on oil content and composition of sunflower seed. *Austr J Exp Agric Anim Husb* 29: 1203–1212.

Harris, H.C., McWilliam, J.R., & Bofinger, V.J. (1980). Prediction of oil quality of sunflower from temperature probabilities in Eastern AUSTRALİA,*Aust. J. agric. Res,* 31, 477-488.

Kamal-Eldin, A., & Andersson, R. (1997). A multivariate study of the correlation between tocopherol content and fatty acid composition in vegetable oils. J*. Am. Oil Chem. Soc*,74,4, 375-380.

Kara, K., Öztürk, E., & Polat, T. (2013). A research on the cultivation of oilseed sunflower varieties with different growing periods in dry and juicy conditions for winter (ice cream) and summer. *Turkey 10. Field Crops Congress*, 10-13 September 78-85, Konya.

Kaya, Y., Evci, G., Pekcan, V., Gücer, T., Durak, S., & Üstün, A. (2005). Yield relationships in oil sunflower. *6. Field Crops Congress of Turkey* (2), 619-622, Antalya

Khalil, L.A. (2000). Seed yield and fatty acid profile of sunflower hybrids. *Sarhad J Agric*. 2000;16:601-4.

Khan, M.I. (1989). Correlation study in sunflower (*Helianthus annuus* L.). *J Agric Res.* 1989;27:275-9.

Kolsarıcı, Ö., Bayraktar, N., İşler, N., Mert, M., & Arslan, B. (1995). Production projections and production targets of oilseed plants. *IV. Technical Agriculture Congress Proceedings Book,* Vol. I. Ankara, 467- 483.

Kolsarıcı, Ö., Geçit, H.H., & Elçi, Ş. (1987). Field Crop. Ankara Univ. *Faculty of Agriculture. Publication* No: 1008, 103-118

Leto, C. (1998). Sunflowers in south central Italy. *Informatore Agrario*, 54: 47-56

Mrdja, J., J. Crnobarac, V. Radić & V. Miklič. 2012. Sunflower seed quality and yield in relation to environmental conditions of production region. *Helia*. 35(57): 123-134.

Oral, E., & Kara, K. (1989). A research on some sunflower varieties in Erzurum ecological conditions. *Doğa Turkish Journal of Agriculture and Forestry,* 13 (2): 343-355.

Özer, H., Öztürk, E., & Polat, T. (2003). Determination of the agronomic performances of some oilseed sunflower (Helianthus annuusL,) hybrids grown under Erzurum ecological conditions. *Turk J Agric For*, 27 (2003) 199-205.

Öztürk, E., Polat, T., & Sezek, M. (2017). The effect of sowing and nitrogen fertilizer form on growth, yield and yield components in sunflower. Turk J. Field Crops. 22 (1), 143-151.
DOI: 10.17557/tjfc.312373

Öztürk, F. & Kızılgeçi, F. (2018). Effects of different sowing dates on the yield and yield components of some

sunflower (*Helianthus Annuus* L.) genotypes. *El-Cezerî Journal of Science and Engineering* Vol: 5, No: 3, 2018 (749-755)
DOI: 10.31202/ecjse.418282

Patanè, C, Cosentino, C.L., & Anastasia, U. (2017). Sowing time and irrigation scheduling effects on seed yield and fatty acids profile of sunflower in semi-arid climate. *İnternational Journal of Plant Production* 11 (1), 17-32

Popa, M., Anton, G.F., Rişnoveanu, L., Petcu, E., & Babeanu, N. (2017). The effect of planting date and climatic condition on oil content and fatty acid composition in some Romanian sunflower hybrids. *AgroLife Scientific Journal*-Volume 6, Number 1.

Robertson, J. A., Chapman, G.., & J. R. Wilson. (1978). Relation of day after flowering to chemical composition and yield in Florida. *Journal of the American Oil Chem- ists Society*, 58: 698-701

Roche, J., Essahat, A., Bouniols, M., El-Asri Z., Mouloungui, M., & Mondies, A.M. (2004). Diversified Composition of Sunflower *(Helianthus annuus* L.). *Journal of Eco-Physiology.* 3. 59-71

Samancı, B., & Özkaynak, E. (2003). Effect of planting date on seed yield, oil content and fatty acid composition of safflower (*Carthamus tinctorius* L.) cultivars grown in the Mediterranen region of Turkey. *J. Agronomy& Crop Science*, (189): 359-360.

Sefaoğlu, F., & Kaya C. (2018). Determınation of adaptation capabilities of some oil sunflower (Helianthus annuus L,) genotypes in Erzurum ecological conditions. *Alınteri Journal of Agriculture Sciences*. 2018, 33(1): 37-41
DOI: 10.30910/turkjans.448311

Sefaoğlu, F., Özer, H., Öztürk, E., & Polat, T. (2009). Adaptation of some oilseed sunflower varieties in Erzurum ecological conditions and determination of their important agricultural characteristics. *Turkey VIII, Field Crop Congress*, 19-22 October

Seiler, G.J, (1983). Effect of genotype, flowering date and environment on oil content and oil quality of wild sunflower seed. *Crop Science*, 1063-1068.

Sofield, L.T., Evans, M.G. Cook & Wardlaw, I.F. (1977). Factors Influencing the Rate and Duration of Grain Filling in Wheat. *Australian Journal of Plant Physiology* 4(5) 785 – 797

Schulze, E.D., Beck, E., & Müller-Hohenstein, K. (2005). Plant Ecology. S*pringer Verlag, Berlin*, pp. 7–9.

Slover, H.T. & Lanza, E. (1979) Quantitative analysis of food fatty acids by capillary gas chromatography. *J. Am. Oil Chem. Soc*. 56, 933- 943.

Stanojevic, D., Petrovic, R., Dijanovic, D., & Stankovic, V. (1998). Variability of oil and protein contents in sunflower seed as affected by the hybrid and location*, 2 Balkan Symposium on Field Crops. Vol. 1, Genetics and Breeding*, pp 379-381, Novi-sad, Yugoslavia,

Tan, A.Ş. (2014). Yield Potential of Some Oilseed Sunflower Hybrid Cultivars in Menemen Ecological Conditions. *Journal of Aegean Agricultural Research Institute* 24 (1), 1-24.

Tozlu, E., Dizikısa, T., Kumlay, A.M., Okçu, M., Pehluvan, M., & Kaya, C. (2008). Determination of agronomic performances of some oil seed sunflower (*Helianthus annuus* L.) hybrids grown under Erzurum ecological·conditions. *Journal of Agricultural Sciences.* 14(4), 359-364.

Tremolieres, A. & R. Jacques. (1984). Effect of light and temperature on fatty acid composition of rape and sunflower seeds. Comptes-rendus-des-Seances-de-1, Academie-d, Agric.de-France., 70: 510-516.

Vega, A.J. & Hall, A.J. (2002). Effects of Planting Date, Genotype and Their Interactions on Sunflower Yield: I. Determinants of Oil- Corrected Grain Yield. *Crop Sci*., 42: 1191-1201

Wagner, K., Tomasch, R.H., & Elmadfa, I. (2001). Impact of diets containing corn oil or olive / sunflower oil mixture on the human plasma and lipoprotein lipid metabolism. *Eur J Nutr*, 40:161-167.

White, P.J. (2007). Fatty acids in oil seed (vegetable oils). In: Chow CK (ed.), fatty acids in foods and their health implications, *Third edition. CRC Press, Boca Raton, FL,* pp. 227–262.

Yıldız, G., Özer, H., Polat, T., Öztürk, E., & Sefaoğlu, F. (2009). The effect of different sowing times on yield and agricultural characteristics of oily sunflower. *Turkey VIII, Field Crops Congress*,19-22 October 2009, Hatay/Türkiye.

Yılmaz, G., & Kınay, A. (2015). Determination of yield and yield components some sunflower (Helianthus annuus L.) varieties in Tokat-Kazova conditions. *Anadolu Journal of Agricultural Sciences*. 30 (3). 281-286
DOI: 10.7161/anajas.2015.30.3.281-286

Yosmanoğlu, M. (2002). Sunflower Report. Ministry of Agriculture and Rural Affairs, *Research Planning Coordination Board*. December.

Yücel, E., Yazıcı Y., Özsaraç M., Ünal E., Yücer M., Eğilmez Ö., Çuhadar İ., & Şanlı Ö. (1977). Sunflower project handbook. *Ministry of Agriculture and Rural Affairs*, publish no: 170, 14-35.