Turkish Journal of FIELD CROPS

Turk J Field Crops 2023, 28(2), 130-137
DOI: 10.17557/tjfc.1255415

EVALUATION OF YIELD AND QUALITY CHARACTERISTICS OF OIL SUNFLOWER (*Helianthus annuus* L.) VARIETIES CULTIVATED IN SEMI-ARID IRRIGATED CONDITIONS IN THE NORTHEAST OF TURKEY

Volkan GUL[1], Betul GIDIK[2], Firat SEFAOGLU[3]*

[1]*Bayburt University, Aydıntepe Vocational School, Food Technology Program, Bayburt, TURKEY*
[2]*Bayburt University, School of Applied Sciences, Organic Farming Management, Bayburt, TURKEY*
[3]*Kastamonu University, Faculty of Engineering and Architecture, Department of Genetics and Bioengineering, Kastamonu, TURKEY*
**Corresponding author: volkangul555@gmail.com*

Received: 23.02.2023

ABSTRACT

Sunflower, an oil plant grown in many parts of the world, is capable of growing in many different climatic conditions. It is of great importance to carry out studies on the adaptation of new varieties and to determine the varieties suitable to the ecology of the region in areas where sunflower cultivation is intense. This study was carried out to determine yield and quality characteristics of some sunflower cultivars (SANBROMR, BOSFORA, SYBARBATI, ROSETTA, LG5485, P64LL62, SYGIBRALTAR, P64LC108 P64LE119, P64LP130, P63LE113, 11TR077, ESNIEGARA, ADELYA, and DERAY) under Bayburt providence conditions of Turkey in 2020-2021. It has been determined that there are significant differences between the cultivars for the traits examined. The highest average seed yield (4194.2 kg ha^{-1}) and average linoleic acid content (65.09%) were found for BOSFORA. The highest average oil content ESNIEGARA (48.78%) and average oil yield respectively were obtained from ESNIEGARA (186.02 kg ha^{-1}) and BOSFORA (182.93 kg ha^{-1}) varieties and the highest average oleic acid content was obtained from 11TR077 variety (41.78%). The results of this study emphasized the importance of varieties in sunflower growing. BOSFORA and ESNIEGARA varieties had high yield and quality characteristics in the ecologies of a semi-arid climate.

Keywords: Fatty acids, *Helianthus annuus* L., oil content, seed yield, sunflower, variety

INTRODUCTION

Economic production can be made in a limited number of plants in arid and semi-arid regions due to irregular and insufficient rainfall (Reddy et al., 2003). Sunflower (*Helianthus annuus* L.) is one of the most important crops to be grown under these conditions.

Russia ranks first in world sunflower production with 15.379.287 tons, followed by Ukraine with 15.254.120 tons and Romania with 3.569.150 tons. Turkey ranks 7th among the top 10 countries in cultivation area with 751.693 hectares and 5th in sunflower production with 2.100.000 tons (Anonymous, 2021a). According to the data of 2021, a production of 2.215.000 tons was achieved with an average yield of 273 kg da^{-1} in sunflowers planted on 8.113.116 decares of land in our country (Anonymous, 2021b).

When the adaptation of a cultivated plant is mentioned, the degree of adaptation of that plant to environmental conditions is understood (Ozyavuz, 2011). Depending on the genetic structure of the plant and environmental conditions, there is variability in the yield of the sunflower plant. On the other hand, with research in different ecologies, it has been determined that the components that make up the yield and quality of sunflower (seed yield, oil rate, fatty acid composition, head diameter, seed number/plate ratio, stalk yield, biological yield, etc.) are affected by both variety and agronomic applications (Yilmaz and Kinay, 2015; Aygun and Mert, 2020). The cultivation of varieties with high yield potential under suitable climatic conditions and with appropriate agronomic practices is the basis of obtaining high yields from the unit area. Ali et al. (2013) reported significant differences between the yield and yield elements varieties in the sunflower plant, with a thousand-kernel weight of 48.4-72.5 g and a kernel yield of 1650-2735 kg da^{-1}. In another study, it was determined that there were significant differences among varieties in terms of thousand-kernel weight (59.2-85.7 g), seed yield (467.0-575.0 kg da^{-1}), oil content (39.4-45.7%) and oil yield (197.0-255.0 kg da^{-1}) (Tan, 2014).

The fatty acid composition of oil crops is not constant; fatty acid synthesis is genetic. Studies have determined that it changes depending on ecological, morphological, physiological, and cultural practices. Since most sunflower fatty acids are unsaturated, they are important in human nutrition (Yilmaz and Kinay, 2015). With this feature, sunflower has always assumed the role of a savior product in vegetable oil production in Turkey and the world and has prevented the oil deficit from reaching large dimensions. The fact that suitable varieties and agronomic practices cannot be adequately demonstrated in sunflowers in our country causes annual raw oil imports and oilseed imports to increase daily. The cultivation of varieties with high yield potential under suitable climatic conditions and with appropriate agronomic practices is the basis of obtaining high yields from the unit area. To contribute to production, it is necessary to carry out studies to increase the cultivation area and yield of the sunflower plant, which is seen as an important potential among oil plants. Therefore, to increase the unit area yield in sunflower agriculture, besides the necessary cultural practices (such as cultivation techniques and plant protection measures), determining the most suitable variety is a very important cultivation technique. Therefore, it is necessary to customize this type of research for each region and each variety. This study aimed to determine the balance of adaptation of some sunflower cultivars to Bayburt agricultural and ecological conditions. The study aims to evaluate the interaction of the varieties according to the years, to evaluate the yield and quality parameters, and to determine the high-performance variety or varieties suitable for the agricultural and ecological conditions of the region.

MATERIALS AND METHODS

Experimental Field, Soil, and Climate Characteristics

The research was conducted in the province of Bayburt (1663 m altitude, 41° 39' east longitude, and 40° 15' north latitude), located in the Eastern Black Sea Region, which has a semi-arid climate, between 2020-2021. Continental climatic conditions dominate the region, and autumn and spring transition seasons are short, and winter periods are long. The region has semi-arid climatic conditions, and the short vegetation period is the most important factor limiting the vegetative diversity yield. In this respect, the sunflower plant must be relatively more resistant to drought and low temperatures than other plants.

The meteorological data of the area where the study was carried out are given in Figure 1. The amount of rainfall in the first year (2020) of the experiment was 337.6 mm. The rainfall amount in the first year of the experiment was higher than in the year 2021 (232.8 mm) and the average rainfall of long years (268.8 mm). However, the monthly measured temperature (15.7 ^{0}C) and relative humidity values (48.3%) of 2020 were lower than both 2021 (49.0%) and the long-term average (54.4%). From May to September, when field crops were actively growing, temperatures were close to each other in both years.

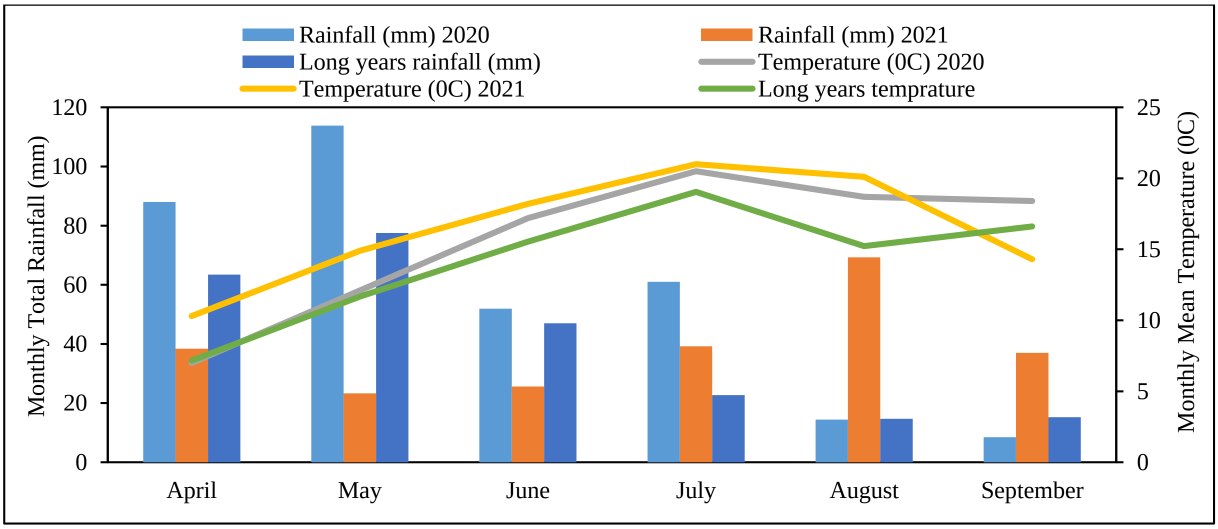

Figure 1. Some important climatic data of the experimental area for the years 2020-2021

Soil samples were taken from the experimental areas where the research was conducted before planting, and some chemical and physical properties of the soils were analyzed in these samples. According to the results obtained from the tests, the texture class of the experimental soils was clayey-loamy. The pH of the soils varied between 7.9 and 7.7. Accordingly, soil reaction was determined as slightly alkaline in both years. The lime content of the experimental soils varied between 17.25% and 17.45%. Phosphorus content ranged between 1.65-1.33 kg da^{-1}, potassium content 45-43 kg da^{-1}, and organic matter content between 0.99-0.85%. According to this situation, the experiment site soils were moderately alkaline, low in phosphorus, medium in organic matter, and sufficient in potassium.

Experimental material, factors and cultivation

The field trial was arranged in the "Randomized Complete Block Design (RCBD)" with 3 replications. In the research, fifteen varieties (SANBROMR, BOSFORA,

SYBARBATI, ROSETA, LG5485, P64LL62, SYGIBRALTAR, P64LC108 P64LE119, P64LP130, P63LE113, 11TR077, ESNIEGARA, ADELYA, and DERAY) were examined. Sowing was done manually on April 18, 2020, and May 08, 2021. Cattle fertilizer was applied to the experimental area at 30 tons per decade. Weeds were controlled both mechanically and by hand using a hoe. In both study years, the plots were irrigated three times (seeding, flowering and seed development period) with the sprinkler irrigation method. Each irrigation brought the soil moisture back to near field capacity. Each plot was 4 m long, 2.8 m wide, and 11.2 m^2. Each plot was sown by hand with 25 cm above the row, 70 cm between the rows, and four rows. A space of 1 m was left between the plots and 3 m between the blocks. The experimental area was 74 m long, 14.4 m wide, and 1065.6 m^2.

The sunflower plants were hand-harvested at the physiological maturation stage when the back of the sunflower head has turned from green to yellow, and the bracts are turning Brown. Harvesting occurred on August 07, 2020, and August 09, 2021. In the harvest, one row from the edges and two plants from the head of each plot were considered edge effects, and the remaining two rows in the middle were harvested. The harvested plants were dried and then threshed, and seeds were extracted. Plant height, table diameter, kernel internodal ratio, thousand-kernel weight, seed yield, and oil yield were measured according to the method described by Day and Kolsarici (2014). Samples taken from each plot were determined by an NMR device in Kastamonu University Central Research Laboratory (MERLAB). The total amount of oil in the samples was determined proportionally according to TS 9059 EN ISO 5511 using the "Continuous Wave Low Separation Power Nuclear Magnetic Resonance Spectrometric Method" (Rodrigues et al., 2005). Fatty acid analyses of the seed samples obtained from each plot were performed at MERLAB, Kastamonu University using gas chromatography-mass spectrometry (GCMS QP 2010 Ultra (Shimadzu)). GC-MS measurements were determined by the fatty acid methyl ester analysis (FAME) method according to IUPAC standard method (Diefenbache and Pocklington, 1992).

Statistical analysis

The two-year data obtained from the research were subjected to analysis of variance with the help of JMP 5.0.1 (SAS institute 2002) package according to the Randomized Complete Blocks Desing. Significant differences among treatments were compared and grouped according to Duncan Multiple Range Test at the p<0.05 probability level (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Statistically significant (p<0.01) differences were found between the years for the parameters except for kernel ratio, thousand seed weight, and oil ratio (Table 1). It was determined that the parameter averages obtained in the second year were lower than the first year. The 2021 growing season may negatively affect the development of sunflowers since the amount of rainfall is low and the temperature is high (Figure 1).

Plant Height

In the study conducted for two years under field conditions, year, variety, and year x variety interactions on plant height were found to be statistically significant (p<0.01), (Table 1, Figure 2). The average plant height observed in 2020 (157.06 cm) was higher than the average plant height observed in 2021 (134.46 cm). Adequate rainfall during the growing season increases the initial vegetative growth of the plant (Montemurro et al., 2007). The highest plant height was obtained from ESNIEGARA (164.67 cm) and SYBARBATI (161.87 cm) cultivars. These were followed by the P64LP130(157.07cm), P64LC108 (154.17cm) and 11TR077 (152.67cm) variants. (Table 1). Sefaoglu et al. (2021) found that the plant height of sunflower cultivars varied between 170.7-198.0 cm; Gul and Coban (2020) found that it varied between 103.7-137.9 cm. The study's findings agree with the results reported by the researchers. The differences in plant height may vary according to the genetic characteristics of the varieties, ecological conditions, and care practices.

Head Diameter

Head diameter is one of the important yield parameters in sunflowers. For this reason, it is desirable to have a large diameter. Head diameter values were 20.12 cm in the first year of the research and 13.57 cm in the second year, and this difference between the years was statistically significant (p<0.01). The favorable temperature and rainfall during the flowering period in the first year of the research may have caused the large diameter of the head. Indeed, Uslu et al. (2002) reported that temperature and drought would cause differences in the diameter of the head. Among the varieties, SANBROMR (19.97 cm), BOSFORA (18.68), ADELYA (13.80 cm), and DERAY (13.87 cm) had the largest and the smallest diameter values, respectively, and the difference between the varieties was statistically significant at p<0.01 level (Table 1, Figure 2). The mean values of the diameter of the head measured by the researchers in sunflower varieties grown in different ecologies were found to be between 15.2-22.3 cm (Gul and Coban, 2020), 18.9-22.8 cm (Sefaoglu et al., 2021) and 13.64-16.29 cm (Iqbal et al., 2018). Head diameter may vary depending on the genetic characteristics of the varieties, ecological conditions, climatic factors, cultivation techniques, soil structure, and whether irrigation is applied (Arioglu, 2014).

Thousand Seed Weight

While the effect of year on thousand seed weight, which is a crucial yield factor in our study, was insignificant, cultivar (p<0.05) and year x cultivar interaction (p<0.01) had a statistically significant effect (Table 1, Figure 2). Thousand seed weight was 74.56 g and 71.26 g in 2020 and 2021, respectively. The highest thousand seed weight (85.32 g) was obtained from sunflower variety LG5485, followed by SYBARBATI (80.85 g), P64LL62 (80.02 g) and BOSFORA (79.87). Regarding thousand seed weights, ADELYA (63.63) and DERAY (58.38 g) varieties had the lowest value (Table 1). Thousand seed weight positively affects the yield in sunflowers along with the diameter and number of seeds in the head (Yasin and Singh, 2010). Mrdja et al. (2012) reported 8.69% differences in thousand seed weights among sunflower production regions, and all interactions of regional production areas were significant. It is also known that thousand seed weight in sunflowers varies depending on genetic, environmental, and climatic factors (Beyyavas et al., 2011).

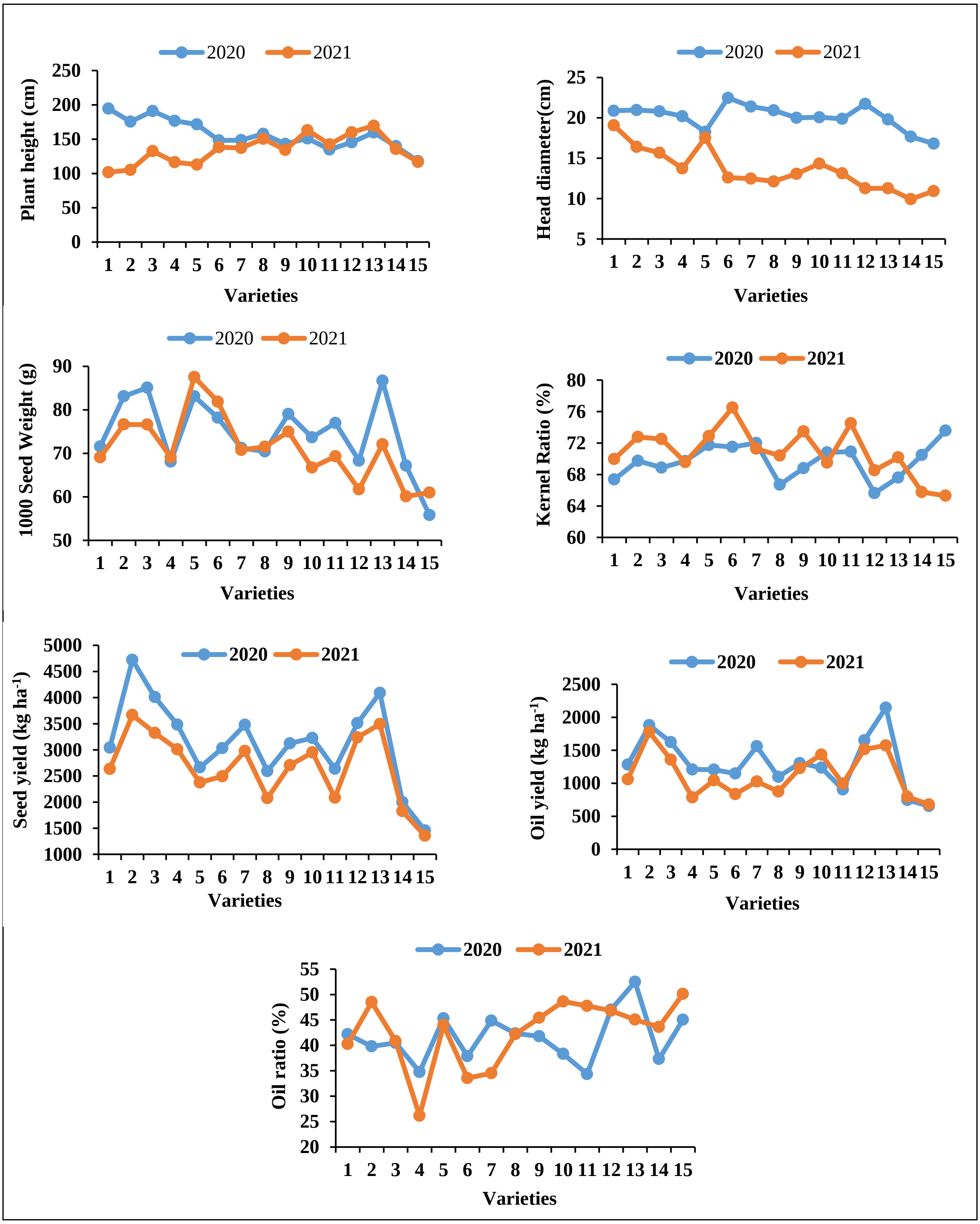

Figure 2. Graphics of physiological and agronomical traits of sunflower varieties combined over 2020 and 2021. * **1:** Sambromr, **2:** Bosfora, **3:** Sybarbati, **4:** Roseta, **5:** LG5485, **6:** P64LL62, **7:** Sygibrattar, **8:** P64lc108, **9:** P64le119, **10:** P64Lp130, **11:** P63Le113, **12:** 11Tr077, **13:** Esniegara, **14:** Adelya, **15:** Deray

Table 1. The means and variance analysis results of physiological and agronomical traits of the sunflower varieties grown at Bayburt, Turkey during the 2020 and 2021 growing seasons.

Varieties			P.H (cm)	H.D (cm)	TSW (g)	K.R (%)	S.Y (kg ha^{-1})	O.R (%)	O.Y (kg ha^{-1})
Year	**2020**		157.06a	20.12a	74.56	69.69	3138.1a	41.60	130.53a
	2021		134.46b	13.57b	71.26	70.87	2680.6b	42.51	113.92b
Varieties	**SANBROMR**		148.18bd	19.97a	70.32de	68.67	2837.9de	41.23fg	117.16de
	BOSFORA		140.32d	18.68ab	79.87ab	71.25	4194.2a	44.15cd	182.93a
	SYBARBATİ		161.87a	18.23bc	80.85ab	70.68	3666.9b	40.67gh	149.20b
	ROSETA		146.57bd	16.97ce	68.58df	69.63	3246.0c	30.44j	98.96fg
	LG5485		142.23cd	17.90bd	85.32a	72.31	2519.3fg	44.65c	112.47ef
	P64LL62		143.20cd	17.53bd	80.02ab	74.00	2763.8ef	35.71ı	99.20g
	SYGIBRALTAR		142.87cd	16.93ce	71.00d	71.63	3227.3c	39.69h	129.46cd
	P64LC108		154.17ac	16.53de	70.97d	68.55	2334.5g	42.27ef	98.86g
	P64LE119		138.70d	16.53de	77.00bc	71.13	914.8de	43.59de	125.19ce
	P64LP130		157.07ab	17.20bd	70.20de	70.15	3089.0cd	43.48ce	133.58c
	P63LE113		138.73d	16.50de	73.14cd	72.72	2360.2g	41.05fg	95.10g
	11TR077		152.67ac	16.50de	65.00ef	67.08	3374.3c	46.92b	158.39b
	ESNİEGARA		164.67a	15.53e	79.38b	68.88	3791.6b	48.78a	186.02a
	ADELYA		137.70d	13.80f	63.63fg	68.12	1914.2h	40.46gh	77.37h
	DERAY		117.50e	13.87f	58.38g	69.43	1406.4ı	47.64ab	66.89h
	Mean		**145.76**	**16.85**	**72.91**	**70.28**	**2909.4**	**42.05**	**122.18**
		df	**Variance Analysis**						
Source of Variation	**Year**	**1**	27.37**	1144.5**	4.95ns	1.38ns	71.3**	3.16ns	27.61**
	Variety	**14**	7.39**	8.22**	14.39**	1.36ns	52.1**	105.9**	57.34**
	Year x Variety	**14**	16.84**	5.87**	2.09*	1.27ns	1.31ns	61.1**	5.79**
	CV		7.1	8.3	6.6	5.7	8.6	2.6	9.4
	LSD (0,05)		12.1	1.6	5.5	-	28.8	1.28	13.2

*. ** significant at the 0.05 and 0.01 levels, respectively. For each main effect, values within columns followed by the same letter are not significant, ns: nonsignificant. **PH:** Plant height; **HD:** Head Diameter; **TSW:** Thousand Seed Weight; **KR:** Kernel Ratio; **SD:** Seed Yield; **OR:** Oil Ratio; **OY:** Oil Yield, **CV:** Coefficient of variation, **LSD:** Least Significant Difference

Kernel Ratio

The kernel ratio is the most crucial feature affecting oil yield. The amount of oil in the kernel shell is relatively low, and a high kernel ratio is a desirable quality characteristic. According to the results of variance analysis, year, variety, and year x variety interactions on kernel ratio were found to be insignificant (Table 1, Figure 2). According to Table 1, while the average kernel ratio of sunflower varieties was 69.69% in 2020, this value increased slightly to 70.87% in the second year. The average kernel ratio of sunflower varieties varied between 67.08% and 74.0%. The lowest kernel ratio was obtained from 11TR077 (67.08%), and the highest kernel ratio was obtained from P64LL62 (74.0%) (Table 1). Although the kernel ratio was insignificant in the study, the kernel ratio in sunflowers varies depending on genetic, environmental, cultural, and climatic factors (Sefaoglu et al., 2019).

Seed Yield

Regarding seed yield, year and variety factors were statistically significant at $p<0.01$ level, while year x variety interaction was found insignificant. Seed yield means and variance analysis results are given in Table 1 and Figure 2. The average grain yield was 3138.1 kg ha^{-1} and 2680.6 kg ha^{-1} in 2020 and 2021, respectively. An average of 17.1% more seed yield was obtained in the first experimental year compared to the second experimental year. This difference may be due to climatic factors between years. It is reported by Vicianová et al. (2020), Gul and Coban (2020), and Sefaoglu et al. (2021) that climatic conditions (temperature), especially during flowering, are a critical period in seed production. Among the varieties, the highest seed yield was obtained from the BOSFORA variety with 4194.2 kg ha^{-1}, while the lowest seed yield was obtained from the DERAY variety (1406.4 kg ha^{-1}). Similar to our results, many other studies have reported significant differences in seed yield among sunflower varieties (Sutradhar et al., 2014; Gul and Kara, 2015; Alem et al., 2016; Gul and Coban, 2020; Sefaoglu et al., 2021). Seed yield can be expressed as a result of the cumulative effects of various yield components formed under the influence of many factors, such as the genetic structure of varieties, agricultural practices, climate, and environmental factors (Cil et al., 2011; Vicianová et al., 2020).

Oil Ratio

Although the oil ratio in sunflowers varied between years (41.6% in 2020 and 42.51% in 2021), this difference was insignificant (Table 1). The difference between varieties on oil ratio was statistically significant at $p<0.01$ level, and the oil ratio varied between 30.44-48.78% among varieties. The highest oil ratio was obtained from ESNIEGARA (48.78%), while the lowest oil ratio was obtained from ROSETA (30.44%) (Table 1, Figure 2). Our results were similar to those of Kaya et al. (2007), 40.0-45.0%, and Siddiqi et al. (2012), 35-42% higher than Khan et al. (2018), 32.60-37.68%. The oil ratio difference between varieties is affected by many factors, such as genetic, environmental, and climatic factors (Cvejić et al., 2015; Sefaoglu, 2019). In addition, the researcher has stated that the high temperature and drought occurring during the grain-filling period cause decreases in the oil ratio (Gul and Coban, 2020).

Oil Yield

The effect of year, variety, and year x variety interaction on oil yield obtained based on seed yield and oil ratio was statistically significant (p<0.01), (Table 1, Figure 2). Sunflower varieties' average oil yield values were 130.53 kg ha^{-1} and 113.92 kg ha^{-1} in 2020 and 2021, respectively.

Oil yield varied between 66.89-186.02 kg ha^{-1} among the varieties used in the study (Table 1). The highest oil yield was obtained from ESNIGARA (186.02 kg ha^{-1}) and BOSFORA (182.93 kg ha^{-1}), the lowest oil yield was obtained from ADELYA (77.37 kg ha^{-1}) and DERAY (66.89 kg ha^{-1}) (Table 1). Some researchers reported significant differences in oil yield among sunflower varieties (Cvejić et al., 2015; Raghavendra et al., 2020). It can be said that the oil yield difference is caused by the differences in the variety, ecology, climate, and soil conditions (Sefaoglu et al., 2021). Previous studies reported that seed yield was the main reason for the high oil yield (Vagdar et al., 2014).

Fatty Acids

In sunflower, which is rich in monounsaturated (oleic acid) and polyunsaturated (linoleic acid) fatty acids, oleic acid showed statistically significant (p<0.01) differences in terms of variety, year, and year x variety interaction, while linoleic acid showed statistically significant (p<0.01) differences in terms of variety and year x variety interaction (Table 2). According to the years, oleic and linoleic acid ratios were determined as 21.07% and 54.24% in 2020 and 22.13% and 54.35% in 2021, respectively. It was determined that the oleic acid ratios, which are especially important according to the years, were higher in the second year compared to the first year. This difference was reported by Baydar and Erbas (2005), that fatty acid compositions are significantly affected by environmental conditions such as temperature, humidity, etc. Oleic (C18:1) and linoleic (C18:2) acids, unsaturated fatty acids commonly found in sunflower varieties, varied in the range of 16.37-41.78% and 29.46-65.09%, respectively. The highest oleic and linoleic acid contents were obtained from cultivars A12 (11TR077) and A2 (BOSFORA), while the lowest oleic and linoleic acid contents were obtained from cultivars A15 (DERAY) and A12 (11TR077), respectively (Table 2). The fact that the varieties with the highest oleic acid content had the lowest linoleic acid content indicates a negative interaction between oleic acid and linoleic acid ratio (Sahin et al., 2022). Fatty acid content varies depending on genetic, climatic, ecological, morphological, physiological, and cultural practices (Baydar and Erbas, 2005). Especially in periods of low temperature, the conversion of linoleic acid to oleic acid in oilseeds may slow down (Schlegel et al., 2016).

Table 2. The means and variance analysis results of fatty acids of the sunflower varieties grown at Bayburt, Turkey during the 2020 and 2021 growing seasons.

	Varieties	df	Oleic Acid (C18:1)	Linoleic Acid (C18:2)	Stearic Acid (C18:0)	Palmitic Acid (C16:0)	Behenic Acid (C22:0)
Years	2020		21.07±0.89b	54.24±1.13	9.44±0.34a	11.70±0.38a	1.29±0.06b
	2021		22.13±0.97a	54.35±1.67	9.09±0.48b	10.63±0.44b	1.47±0.07a
Varieties	SANBROMR		23.60±0.98b	51.75±0.35ef	10.40±0.28ac	12.35±0.46a	1.11±0.01cd
	BOSFORA		16.49±0.69g	65.09±0.20a	6.78±0.25ef	7.56±0.33c	1.27±0.09cd
	SYBARBATİ		20.57±0.59cd	54.86±2.65bf	9.34±1.20be	11.06±1.32ab	1.39±0.04bc
	ROSETA		22.52±0.31bc	52.67±2.72df	8.67±1.24ce	12.26±1.53a	1.43±0.14bc
	LG5485		19.25±1.04df	57.68±3.34be	7.66±0.91df	11.90±1.60a	1.37±0.14bc
	P64LL62		23.35±0.77b	54.96±1.95bf	7.49±0.51df	10.81±0.94ab	1.36±0.11bc
	SYGIBRALTAR		20.09±0.49de	61.52±0.60ab	5.50±0.13f	8.63±0.33bc	1.27±0.05cd
	P64LC108		19.13±0.79df	58.47±0.87ae	8.42±0.27ce	11.00±0.18ab	1.27±0.02cd
	P64LE119		17.53±0.15fg	60.51±0.38ac	9.02±0.38be	8.57±0.30bc	1.40±0.08bc
	P64LP130		18.01±1.69eg	53.83±4.25cf	10.73±1.76ac	12.35±1.60a	1.68±0.05b
	P63LE113		20.16±0.30ce	53.02±0.28df	11.54±0.17ab	12.56±0.15a	0.94±0.11d
	11TR077		41.78±0.78a	29.46±3.44g	12.29±1.34a	12.45±1.09a	2.25±0.25a
	ESNİEGARA		24.19±0.73b	49.22±0.34f	10.65±0.40ac	12.89±0.24a	1.44±0.04bc
	ADELYA		20.94±1.06cd	52.69±3.98df	10.39±1.54c	12.07±1.46a	1.15±0.38cd
	DERAY		16.37±1.08g	58.72±3.13ad	10.12±1.20ad	11.03±1.19ab	1.36±0.05bc
	Mean		**21.60**	**54.30**	**9.30**	**11.20**	**1,40**
		df	**Variance Analysis**				
Source of Variation	**Year (Y)**	1	10.59**	0.074ns	14.57**	10.77*	14.16**
	Varieties (V)	14	4471.6**	3180.35**	266.74**	83.59**	16.91**
	YxV	14	410.1**	1496.57**	344.72**	151.92**	15.33**
	CV		1.03	0.64	3.02	4.0	5.7
	LSD (0.05)		0,26	0.41	0.32	0.51	0.20

*. ** significant at the 0.05 and 0.01 level, respectively. For each main effective values within columns followed by the same letter are not significantl. **ns:** nonsignificant. **CV:** Coefficient of variation, **LSD:** Least Significant Difference

Saturated fatty acids were significantly ($p<0.01$) affected by year, cultivar, year, and cultivar interactions. The most common saturated fatty acids found in vegetable oils are palmitic acid (C16:0), stearic acid (C18:0), and behenic acid (C22:0) (Karaca and Aytac, 2007). The ratios of palmitic acid, stearic acid, and behenic acid in 2020-2021 varied between 9.44-9.09%, 11.70-10.63%, and 1.29-1.47%, respectively. Except for behenic acid, the ratios of other saturated fatty acids were higher in the first year than in the second year. It is stated that various physiological, ecological, climatic, and cultural factors are effective in this difference between years (Baydar and Erbas, 2005). It was reported that low temperatures during the growing period increased the stearic acid content and decreased the palmitic acid content. Depending on the temperature, stearic acid and palmitic acid content was an inverse relationship (Ferfuia and Vannozzi, 2015; Popa et al., 2017). The highest palmitic, stearic, and behenic acid contents, which are the most important saturated fatty acids, were obtained from A12:11TR077 (12.29%), A13: ESNIGARA (12.89%) and A12:11TR077 (2. 25%), while the lowest palmitic, stearic and behenic acid content was obtained from A7: SYGIBRALTAR (5.50%), A2: BOSFORA (7.56%) and A11: P63LE113 (0.94%) cultivars, respectively. Our results differed from those obtained by Ismail and Arafat (2014) and Merrill et al. (2008). It has been reported that the fatty acid composition of the cultivars is significantly affected by the growing conditions, and in particular, the fatty acid content of the seeds at seed filling and ripening periods differ significantly (Zamani et al., 2020).

CONCLUSION

Differences in climate and environmental factors in the years of the experiment significantly affected the measured parameters. It was determined that there were significant differences among the varieties in terms of yield and quality parameters. The highest average seed yield (4194.2 kg ha^{-1}) and average linoleic acid content (65.09%) were obtained from the BOSFORA variety. The highest average oil content ESNIEGARA (48.78%) and average oil yield respectively were obtained from ESNIEGARA (186.02 kg ha^{-1}) and BOSFORA (182.93 kg ha^{-1}) varieties and the highest average oleic acid content was obtained from 11TR077 (41.78%) variety. It can be said that the differences in seed yield and oil content between years are due to soil characteristics, climate, and environmental factors. In terms of fatty acids, although unsaturated fatty acids differed between the varieties over the years, we can say that the high values of linoleic acid compared to oleic acid are due to the genetic structure of the varieties. The study using different varieties to find the most suitable varieties for the region determined that BOSFORA and ESNİEGARA varieties were more dominant than the other varieties according to the climate and environmental factors changing over the years. When evaluated in terms of fatty acids, it was determined that the average unsaturated fatty acid ratio was higher in the BOSFORA variety (81.58%) than the others. These results indicate the importance of such studies for determining suitable oil sunflower varieties for cultivating high-yield and quality products in these regions, which are directly affected by altitude, climate, environment, and soil characteristics.

LITERATURE CITED

Alem Gesesse, C., A. Worku, M.M. Kassie, T. Asres, D. Fentie, E. Mihiretu and J. Esmael. 2016. GGE stability analysis of seed yield in sunflower genotypes (*Helianthus annuus* L.) in the western Amhara Region in Ethiopia. International Journal of Plant Breeding and Genetics 10(2): 104-109.

Ali, A., M. Aziz, W.S. Hassani, M. Asif, S. Ahmadi, M. Mubeen and M. Yasin. 2013. Growth and yield performance of various spring planted sunflower (*Helianthus annuus* L.) hybrids under semi-arid conditions of Sargodha. Science International (Lahore) 25(2): 341-344.

Anonymous. 2021a. FAO Production Year Book. www.fao.org (Accessed November 20, 2021).

Anonymous 2021b. Crop production statistics of cereals and other plant products (TUIK). https://dergipark.org.tr/tr/download/article-file/2268618 (Accessed November 20, 2021).

Arioglu, H.H. 2014. Oil Crops Cultivation and Breeding Textbook. Adana: Cukurova University Faculty of Agriculture Textbooks Publication (in Turkish).

Aygun, Y.Z. and M. Mert. 2020. Effects of soil conditioners and nitrogen applications on cotton (*Gossypium hirsutum* L.) yield and fiber technological properties. Biological Diversity and Conservation 13(3): 290-299.

Baydar, H. and S. Erbas. 2005. Influence of seed development and seed position on oil, fatty acids, and total tocopherol contents in sunflower (*Helianthus annuus* L.). Turkish Journal of Agriculture and Forestry 29(3): 179-186.

Beyyavas, V., H. Haliloglu, O. Copur and A. Yilmaz. 2011. Determination of seed yield and yield components of some safflower (*Carthamus tinctorius* L.) cultivars lines and populations under semi-arid conditions. African Journal of Biotechnology 10(4): 527-534.

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

Cil, A., A.N. Cil, G. Evci and F. Hairy. 2011. Determination of vegetative and agricultural characteristics of some oil sunflower (*Helianthus annuus* L.) hybrids in Cukurova conditions. IX. Field Crops Congress, p. 996-999 (in Turkish).

Day, S. and O. Kolsarıcı. 2014. The effects of different row spacing and nitrogen doses on yield and yield components of hybrid confectionery sunflower (*Helianthus annuus* L.) genotype in Ankara conditions. Soil Water Journal 3(2): 81-89.

Diefenbache, A. and W.D. Pocklington. 1992. Standard Methods for the Analysis of Oils, Fats, and Derivatives. Oxford (UK): 1st Suplementtothe 7th Revised and Enlarged Edition, International Union of Pure and Applied Chemistry, Pergamon Press.

Ferfuia, C. and G.P. Vannozzi. 2015. Maternal effects on seed fatty acid composition in a reciprocal cross of high oleic sunflower (*Helianthus annuus* L.). Euphytica 205:325-336.

Gul, V. and K. Kara. 2015. Effects of different nitrogen doses on yield and quality traits of common sunflower (*Helianthus annuus* L.). Turkish Journal of Field Crops 20(2): 159-165.

Gul, V. and F. Coban. 2020. Determination of yield and quality parameters of oil sunflower genotypes grown in Turkey. Turkish Journal of Field Crops 25(1): 9-17.

Ismail, A.I. and S.M. Arafat. 2014. Quality characteristics of high-oleic sunflower oil extracted from some hybrids cultivated under Egyptian conditions. Journal of Food Technology Research 1(2): 73-83.

Iqbal, Q., A. Safdar. M.N. Tahir, O. Shafique, B.A. Khan, A. Ijaz and I. Khan. 2018. Assessment of different exotic sunflower hybrids for their agroecological adaptability. Pakistan Journal of Agricultural Research 31(2): 122-132.

Karaca, A. and S. Aytac. 2007. The factors affecting the fatty acid composition of oil crops. Journal of Faculty of Agriculture 22(1):123-131.

Kaya, Y., G. Evci, S. Durak, V. Pekcan and T. Gucer. 2007. Determining the relationships between yield and yield attributes in sunflowers. Turkish Journal of Agriculture and Forestry 31(4): 237-244.

Khan, H., A. Safdar, A. Ijaz, I. Khan, S. Hussain, B.A. Khan and M. Suhaib. 2018. Agronomic and qualitative evaluation of different local sunflower hybrids. Pakistan Journal of Agricultural Research 31(1): 1-10.

Merrill, L.I., O.A. Pike, L.V. Ogden and M.L. Dunn. 2008. Oxidative stability of conventional and high-oleic vegetable oils with added antioxidants. Journal of the American Oil Chemists' Society 85(7): 771-776.

Montemurro, F., D. De Giorgio, F. Fornaro, E. Scalcione and C. Vitti. 2007. Influence of climatic conditions on yields an uptake and efficiency in sunflower. Italian Journal of Agrometeorology 2: 28-34

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

Ozyavuz, M. 2011. Analysis of ecological conditions of vegetation with geographic information systems and remote sensing techniques, Ganos (Isiklar) Mountain, Tekirdag. Tekirdag Faculty of Agriculture Journal 8(2): 37-47 (in Turkish).

Popa, M., G.F. Anton, L. Risnoveanu, E. Petcu and N. Babeanu. 2017. The effect of planting date and climatic condition on oil content and fatty acid composition in some Romanian sunflower hybrids. AgroLife Scientific Journal 6(1): 212-217.

Raghavendra, M.A., B.V.S Bellakki and R. Satyanarayana. 2020. Effect of soil and foliar applications of zinc and iron on yield and economics of sunflower (*Helianthus annus* L.) under irrigation. International Journal of Current Microbiology and Applied Sciences 9(1): 928-937.

Reddy, G.K.M., K.S. Dangi, S.S. Kumar and A.V. Reddy. 2003. Effect of moisture stress on seed yield and quality in sunflower (*Helianthus annuus* L.). Journal of Oilseed Research 20(2): 282-283.

Rodrigues, J.C., A.C. Nascimento, A. Alves, N.M. Osório, A.S. Pires, J.H. Gusmão and S. Ferreira-Dias. 2005. Calibration of near infrared spectroscopy for the solid fat content of fat blends analysis using nuclear magnetic resonance data. Analytica Chimica Acta 544(1-2): 213-218.

Sahin, C.B., M. Yilmaz and N. Isler. 2022. Determination of oil quality and fatty acid compositions of some peanut (*Arachis hypogaea* L.) genotypes grown in the Mediterranean region. Turkish Journal of Field Crops 27(1): 142-148.

Schlegel, A.J., Y. Assefa, D. O'Brien, F.R. Lamm and L.A. Haag. 2016. Comparison of corn, grain sorghum, soybean, and sunflower under limited ırrigation. Agronomy Journal 108: 670–679.

Sefaoglu, F. 2019. Determination of adaptation capabilities of some oil sunflower genotypes in Igdır wet conditions. Journal of Igdır University Institute of Science 9(3): 1747-1753 (in Turkish).

Sefaoglu, F., H. Ozturk, E. Ozturk, M. Sezek, Z. Toktay and T. Polat. 2021. Effect of organic and inorganic fertilizers or their combinations on yield and quality components of oil seed sunflower in a semi-arid environment. Turkish Journal of Field Crops 26(1): 88-95.

Siddiqi, M.H., S. Ali, J. Bakht, A. Khan, S. Khan and N. Khan. 2012. Evaluation of sunflower lines and their crossing combinations for morphological characters, yield and oil contents. Pakistan Journal Botany 44(2): 687-690.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics. A Biometrical Approach. 2nd edition. McGraw-Hill, New York, USA, pp. 20-90.

Sutradhar, A.P., R.P. Lollato, K. Butchee and D.B. Arnall. 2014. Determining critical soil pH for sunflower production. International Journal of Agronomy 13: 894196.

Tan, A.S. 2014. Performances of some oil sunflower cultivars under Menemen ecological conditions. Journal of Aegean Agricultural Research Institute 24(1): 1-24 (in Turkish).

Uslu, N., I. Tutluer, Y. Taner, B. Kunter. Z. Sagel and H. Peskircioglu. 2002. Effects of temperature andmoisture stress during elongation and branchingon development and yield of safflower, sesameand and safflower. Newsletter. P.101-106.

Vagdar, M.S., L. Sdamsi, S. Kobraee and R. Behrooz. 2014. The effect of planting row interval and plant density on the phonological traits of safflower (*Cartdamus tinctorius* L.) dryland conditions. International Journal of Biosciences 4(12): 202-208.

Vicianová, M., L. Ducsay, P. Ryant, M. Provazník, A. Zapletalová and M. Slepčan. 2020. Oilseed rape (*Brassica napus* L.) nutrition by nitrogen and phosphorus and its effect on yield of seed oil and higher fatty acids content. Acta Universitatis Agriculturae ET Silviculturae Mendelianae Brunensis 68(1): 129-136.

Yasin, A.B. and S. Singh. 2010. Correlation and path coefficient analyses in sunflower. Journal Plant Breeding and Crop Science 2(5):129-133.

Yilmaz, G. and A. Kinay. 2015. Determination of yield and yield components some sunflower (*Helianthus annuus* L.) varieties in Tokat-Kazova conditions. Anadolu Journal of Agricultural Sciences 30: 281-286 (in Turkish).

Zamani, S., M.R. Naderi, A. Soleymani and B.M. Nasiri. 2020. Sunflower (*Helianthus annuus* L.) biochemical properties and seed components affected by potassium fertilization under drought conditions. Ecotoxicology and Environmental Safety 190: 110017.