MJAVL
Manas Journal of Agriculture Veterinary and Life Sciences
ISSN 1694-7932 | e-ISSN 1694-7932
Volume 13 (Issue I) (2023) Pages 1-8

Morphological and Yield-Related Performance of Some Sesame Populations Originating from Southeastern Anatolia

Ali ÖZKAN[1] * Recep BİNDAK[2] Erdoğan ULUKÜTÜK[3]

[1] Gaziantep University, Faculty of Tourism, Department of Gastronomy, Gaziantep, TÜRKİYE
[2] Gaziantep University, Technical Sciences School, Gaziantep, TÜRKİYE
[3] Gaziantep University, Graduate School of Natural and Applied Sciences, Gaziantep, TÜRKİYE

*Corresponding author: aozkan27@gmail.com

ABSTRACT

In this study, some growth parameters, protein content and fatty acids properties of ten different sesame populations cultivated in Southeastern Anatolia were investigated. Protein and oil contents of the populations varied between 19.60-24.85 % and 30.16-40.36 %, respectively. Oleic acid (43.42-45.05 %), linoleic acid (38.12-39.80 %), palmitic acid (9.33-9.83 %) and stearic acid (5.33 to 5.63 %) were the predominant compounds of the seed oil. Cultivated populations exhibited significant differences in relation to seed yield, seed number per capsule, and 1000-seed weight. Furthermore, seed yield was significantly predicted by oil content and plant height according to the results of multiple linear regression analysis.

ARTICLE INFO

Research article

Received:
17.05.2022

Accepted:
11.05.2023

***Keywords*:**
Fatty acids, Oil and protein contents, Sesame, Sesamum indicum L.

Güneydoğu Anadolu Menşeili Bazı Susam Populasyonlarının Morfolojik Özellikleri ve Verime İlişkin Performansları

ÖZET

Bu çalışmada, Güneydoğu Anadolu'da kültürü yapılan 10 farklı susam popülasyonunun bazı büyüme parametreleri (bitki boyu, kapsül sayısı, yağ oranı, yağ asitleri, ve protein oranı) incelenmiştir. Susam tohumunda yağ içeriği ve protein içeriği sırasıyla % 30.16-40.36 ve % 19.60-24.85 arasında değişmiştir. Tohum yağ asitlerinin ana bileşenleri oleik asit (% 43.42-45.05), linoleik asit (% 38.12-39.80), palmitik asit (% 9.33-9.83) ve stearik asit (% 5.33-5.63) saptanmıştır. Susam popülasyonları, tohum verimi, kapsül başına düşen tohum sayısı ve 1000-tohum ağırlığı bakımından anlamlı farklılıklar göstermiştir. Çoklu doğrusal regresyon analizine göre tohum verimi, yağ içeriği ve bitki boyuyla önemli ölçüde ilişkili bulunmuştur.

MAKALE BİLGİSİ

Araştırma Makalesi

Geliş:
17.05.2022

Kabul:
11.05.2023

Anahtar kelimeler:
Protein ve yağ içeriği, Susam, Sesamum indicum L., Yağ asitleri

To Cite: Özkan, A., Bindak, R., & Ulukütük, E. (2023). Morphological and Yield-Related Performance of Some Sesame Populations Originating from Southeastern Anatolia. *Manas Journal of Agriculture Veterinary and Life Sciences, 13*(1), 1-8. https://doi.org/10.53518/mjavl.1117956

INTRODUCTION

Sesame (*Sesamum indicum* L.; Pedaliaceae) is one of the most important oil seed crops extensively cultivated in the temperate and tropical zones of the world (Biabani and Pakniyat 2008). Each of the planting areas in the sub-tropical temperate regions of the semi-arid tropical area has led to a wide variety of genotypes (Weiss 2000; Söğüt 2008). Sesame seed is rich in oil (44-58 %) and protein (18-25 %) and is often used directly or in processed form (Saydut et al. 2008; Wenliang et al. 2011). In general, it has been reported that the fatty acid components of sesame seeds are linoleic, oleic, palmitic and steric acids, respectively (Özkan, 2018).

Sesame seeds have been reported to be used as active metabolites in antiseptics, disinfectants, viricides, antitubercular agents and moth repellants, since they involve sesamin and sesamolin like natural antioxidants. Sesame oil is rich in nutrients and possesses potent antihypertensive activities (Liu et al. 2014). Sesame seeds are not only a good source of oil but also a source of protein when defatted. Sesame oil includes the non-fat portion (1–2 wt %) which contains sesamin, sesamol, sesaminol, sesamolin and episesamin. The incidence of oxidative stress and mammary tumours is diminished through sesamin induced enhanced hepatic detoxification (Sambasiva et al. 2001). In addition to the antioxidant agents, palmitic, stearic, oleic and linoleic acids are known to be the predominant fatty acids in sesame oil (Shahidi et al. 2006).

Sesame seed oil has been used for a long time in the health field, especially in the East (Sambasiva et al. 2001). For example, sesame seed is used as a medicinal plant in Ilam Province, Iran particularly for burn healing (Pirbalouti et al. 2013). In Bangladesh, sesame seed and oil are used for medicinal purposes in the treatment of various ailments, such as diabetes mellitus (Rahmatullah et al. 2012). On the other hand, its oil is used in cosmetics and as topical medicaments in traditional Chinese medicines (Oiso et al. 2008). Sesame seeds contain oleic acid, which is known to be an inhibitor of the development of adrenoleukodystrophy (ALD) which is a fatal disease affecting the brain and adrenal glands and responsive to reduce blood pressure (Teres et al. 2008).

There are numerous studies conducted to examine the agronomic performances of the sesame genotypes in different areas of Turkey (Karaaslan et al. 1999; Baydar 2005; Furat and Uzun 2005; Yılmaz et al. 2005; Uzun et al. 2007; Çağırgan et al. 2009; Söğüt 2009; Hatipoğlu et al. 2017; Bakal 2022; Izgi and Bulut 2023). Although a large number of studies have recently been released, the yield capabilities and fatty acid profiles of the local sesame varieties or populations have not been studied under the ecological conditions of Southeastern Anatolia. Hence, this study was carried out to evaluate some agronomic and morphological properties of the sesame populations originating from Southeastern Anatolia. It is thought that the results obtained will guide those who plan to grow sesame in similar climatic conditions, since the research region is hot and the summers are dry. Therefore, the aim of the study was to determine the oil and protein properties of local populations, it can be predicted that it will guide researchers who consider using sesame plant in industry.

MATERIAL AND METHOD

Plant Growth Conditions

Ten sesame populations grown as local varieties in Kilis province (36.71N, 37.11E) of Southeastern Anatolia in Turkey were used in the present study. The sesame populations were coded as K-1 (Oylum), K-2 (Arpakesmez), K-3 (Yavuzlu), K-4 (Beşiriye), K-5 (Demirışık), K-6 (Polateli), K-7 (Kesmelik), K-8 (Bozcayazı), K-9 (Ekincik), and K-10 (Dölek). The study was performed in the experimental fields of Agricultural Practices and Research Center of Kilis 7 Aralık University in 2010. Certain soil and climate characteristics of the experiment site were given in Tables 1 and 2, respectively.

When the soil properties in Table 1 are examined, it can be said that it is basic with pH=8.48, it is rich in potassium but poor in phosphorus, and the lime rate is much higher than normal.

Table 1. *Physical and chemical properties of the research location's (Kilis) soils*

Analysis	Values	Reference ranges	Evaluation
pH	8.48	6.6-7.3	Alkaline
Lime %	22.35	5.0-10.0	High
Salt %	0.05	0.0-0.015	Salt-free
Organic Matter %	1.60	2.0-3.0	Low
Phosphorus(ppm)	1.00	7-20	very low
Potassium (ppm)	245.00	100-250	adequate
Structure %	57.00	30–50	Loamy
Iron (ppm)	5.26	4.5 <	Adequate
Copper (ppm)	1.77	0.2 <	Adequate
Zinc (ppm)	0.44	1 <	Inadeq.
Manganese (ppm)	4.29	1 <	Adequate

When we look at the climatic characteristics, it is seen that the annual average precipitation is below 400 mm, the summers are quite dry, and water scarcity prevails for optimum efficiency (Table 2).

Table 2. *Monthly average of rainfall, temperature and humidity for research location in the year 2010*

Month	Rainfall (mm)	Temperature (ºC)	Humudity (%)
January	43.5	8.6	66.6
February	59.1	8.9	61.3
March	34.0	13.3	51.2
April	49.5	16.6	44.8
May	25.4	21.8	43.8
June	13.1	25.5	42.2
July	-	29.1	45.4
August	-	31.6	34.0
September	0.30	26.0	44.1
October	17.5	19.4	48.2
November	-	17.4	35.3
December	93.6	10.1	56.9
Average (Year)	385	18.3	46.8

Field Trials and Growth Parameters

Field trials were performed with three replications and in a randomized complete block design. The seeds were sown by hand at an interval of 0.10 and 0.70 m within and between rows, respectively. Nitrogen (urea) and phosphorus (Triple Super Phosphate (P_2O_5) fertilizers were applied at a rate of 5 kg/da. Ten plants were randomly chosen for each population and subsequently agronomic characteristics such as plant height (cm), branch number per plant, capsule number per plant, seed number per capsule, 1000-seed weight (g) and seed yield (kg/da) were evaluated. Furthermore, collected sesame seeds were dried at 101 ºC for 30 minutes and then powdered and dried. Powdered and dried samples were then used for the analysis of crude protein (%), crude oil (%) and fatty acid composition (%).

Oil, Fatty Acid and Protein Analysis

Seed oil extraction was performed with hexane using the Soxhalet extraction apparatus for four hours. In this context, 10 g of each seed sample was used. After extraction, hexane was evaporated with a rotary evaporator and then 10 ml n-heptane was added to 0.5 g of sesame oil; The mixture was then taken into a screw-capped tube for esterification. After adding 0.5 ml of potassium hydroxide to methanol, the mixture was vortexed for 30 secons, followed by an hour of incubation at ambient conditons. Chromatographic analyses of fatty acid methyl esters were performed with a GC-FID (Shimadzu, GC-2010 series) using the same chromatographic conditions reported in our previous study (Ozkan et al. 2012). The seed protein content was based on the nitrogen content determination by the Kjeldahl method, and then, the content was calculated by multiplying the nitrogen content by 6.25.

Statistical Analysis

Data were subjected to statistical analysis using SPSS 16.0 program (Statistical Package for Social Sciences, USA). Descriptive statistics were summarized and the results were expressed as the mean ± standard error (SE). Comparisons of means were made using one-way variance analysis (ANOVA-F) followed by Duncan's post-hoc test. The statistical significance was accepted when $p < 0.05$. Pearson correlation coefficients and multiple linear regression analysis were used to determine the type of relationship between variables. It was checked whether the assumptions were violated for linear regression. For univariate normality, skewness and kurtosis values (all between -1;+1 interval) were examined together with Kolmogorov-Smirnov ($p>0,05$ for all variables). For multivariate normality, Mardia's multivariate skewness ($s=2.36$, $p=0.292$) and kurtosis ($k=15.17$, $p=0.929$) values were calculated. It was determined from the correlation matrix that there was no multicollinearity problem.

RESULTS AND DISCUSSION

Analysis of variances and the combined results of plant height, branch number, capsule number per plant, 1000-seed weight, seed number per capsule, seed yields of different ten sesame populations cultivated in Kilis ecological conditions are presented in Table 3 and 4, respectively. Accordingly, statistically significant differences were found at the 1 % probability level in terms of 1000-seed weight and seed yield among populations. No statistical differences were revealed among the figures from 10 populations regarding plant height, capsule number per plant, branch number per plant, and seed number per capsule.

The results in relation to growth parameters were found to be higher than the previous studies performed on sesame. The branch number per plant in our study varied between 3.60 and 5.70 per plant (Table 4). The branch number was 2.40-3.52 (El Mahdi et al. 2007) and 4.23-5.48 (Yılmaz et al. 2005) but the capsule number per plant was lower than the study by Yılmaz et al. (2005). Söğüt (2008) reported that the capsule number variability depends on the length of day and flower number per plant, and consequently on climatic variations.

Seed number per capsule changed between 42.76 and 55.90 (Table 4). However, the seed number was 65.3-76.1 (Çağırgan et al. 2009). Seed number per plant and capsule positively depend on capsule number per plant and these characters are controlled by additive gene effects and phenotypic selection (Sumathi & Muralidharan 2009). 1000-seed weight, which can function as the most important selection criterion in order to improve yield (Taş and Çelik 2011), ranged from 2.56 to 3.84 g herein (Table 4). The results are similar to the previous study by Yılmaz et al. (2005).

Simple correlations between each variable are presented in Table 5. Seed yield contributing characters, which also depend on high-yielding varieties and management practices, are important in phenotypic selection. Corresponding to the agronomic properties of populations cultivated, seed yield per da varied between 13.51 (for K-5) and 23.32 (for K-1) demonstrated significant positive correlations between plant height ($r=0.45^{*}$) and oil content ($r=0.44^{*}$). In general, it is found that the varieties that are tall, branched, and carry a higher number of capsules, are significant for phenotypic selection. The highest and positive genotypic correlation coefficient of seed yield was observed with capsule number, branches per plant, and plant height (Sarwar et al. 2005).

Table 3. *Variance analysis regarding plant growth, development and yield parameters*

Source of Variation	df	Sum of squares					
		Plant height	Branch number per plant	Capsule number per plant	Seed number per caps.	1000-seed weight	Seed yield
Total	29	471.37	35.97	3489.94	1392.87	4.74	317.04
Population	9	164.92	11.30	1442.79	474.58	2.98^{**}	296.09^{**}
Error	20	306.45	24.67	2047.15	918.29	1.76	20.95
CV (%)		6.36	23.22	26.80	14.16	11.86	25.18

$^{*}p< 0.05$, $^{**}p< 0.01$

Table 4. *Mean values for plant height, branch number per plant, capsule number per plant, seed number per capsule, 1000-seed weight, seed yield of populations*

Population	Plant height (cm)	Branch number per plant	Capsule number per plant	Seed number per capsule	1000-Seed weight (g)	Seed yield (kg/da)
K-1	67.36[a]	5.46[ab]	48.06[ab]	51.80[ab]	3.54[ab]	23.32[a]
K-2	62.03[bc]	4.30[abc]	38.53[ab]	48.26[ab]	3.58[ab]	18.37[abc]
K-3	63.83a[abc]	4.03[bc]	39.26[ab]	51.46[ab]	2.56[c]	14.25[c]
K-4	63.70[abc]	5.03[abc]	46.06[ab]	48.70[ab]	3.35[b]	14.00[c]
K-5	62.43[abc]	5.00[abc]	38.46[ab]	43.63[b]	3.41[ab]	13.51[c]
K-6	64.56[abc]	4.60[abc]	33.70[b]	44.60[a]	3.37[ab]	18.36[abc]
K-7	59.56[c]	3.66[c]	28.30[b]	42.76[b]	3.57[ab]	13.67[c]
K-8	62.70[abc]	5.30[ab]	41.50[ab]	51.33[ab]	3.42[ab]	14.24[c]
K-9	60.60[c]	4.86[abc]	41.03[ab]	50.90[ab]	3.84[a]	15.42[bc]
K-10	66.83[ab]	5.70[a]	54.26[a]	55.90[a]	3.39[ab]	19.77[ab]
Mean	63.36	4.80	40.93	48.94	3.41	16.49
LSD	6.65	1.90	17.22	11.54	0.51	5.44
CV%	6.36	23.22	26.80	14.16	11.86	25.18

Means in the same column by the same letter are not significantly different to the test of Duncan (α=0.05) ns: Non significant

Table 5. *Correlation coefficients among plant variables*

	Plant height	Branch number	Capsule number	Seed per capsule	1000-seed weight	Oil content
Branch number	0.65^{**}					
Capsule number	0.70^{**}	0.71^{**}				
Seed per capsule	0.33	0.14	0.38^{*}			
100-seed weight	–0.18	–0.15	–0.16	–0.02		
Oil content	0.08	–0.25	–0.07	0.27	0.45^{*}	
Seed yield	0.45^{*}	0.24	0.31	0.25	0.16	0.44^{*}

**: $p< 0.01$, *: $p< 0.05$

Table 6. *Linear regression model for Yield by plant height and oil content*

	B	SE	Beta	t	P	Tolerance	VIF
Constant	-11.81	8.06		–1.47	0.15		
Plant Height	0.33	0.12	0.42	2.71^{*}	0.01	0.99	1.01
Oil content	2.02	0.77	0.40	2.63^{*}	0.01	0.99	1.01

Dependent variable = Yield, R^2=0.365, Adj-R^2 = 0.318, SEE = 2.66549, $F_{(2;27)}$ = 7.772, p = 0.002

Total number of capsules per plant was strong positively associated with the plant height (r=0.70**) and branch number (r=0.71**). The capsule number showed variation between 28.3 and 54.26 per plant among different populations cultivated in Kilis ecological conditions. There is a weak positive correlation (r= 0.38*) between the number of capsules and number of seeds per capsule. Oil content and 1000-seed weight had a positive and significant (r=0.45*) correlation (Table 5). Similar studies conducted in different locations (Hatipoğlu et al. 2017 in Şanlıurfa conditions; Bakal, 2019 in Çukurova conditions) are in agreement with the findings of this study. Multiple linear regression results showed that seed oil content (B=2.02; p <0.05) and plant height (B=0.33; p<0.05) were significant predictors of yield (Table 6). Izgi and Bulut (2023), in their study in Mardin conditions, stated that plant height had no effect on yield, whereas oil content had a significant positive effect on yield.

With respect to the different populations, crude oil contents were found to be between 30.16 (for K-4) and 40.36 % (for K-2), and crude protein contents were found to be between 19.60 (for K-7) and 24.85 % (for K-10) (Table 7). In general, populations with low oil contents were found to have higher protein contents.

Table 7. *Oil and protein contens (%) of different populations*

Population	Oil content Mean±SE	Protein content Mean±SE
K-1	40.26±4.67[a]	22.70±3.26[a]
K-2	40.36±2.66[a]	21.70±2.40[a]
K-3	30.50±4.42[a]	24.15±2.31[a]
K-4	30.16±5.51[a]	23.45±2.96[a]
K-5	36.43±4.05[a]	24.15±1.91[a]
K-6	38.40±2.90[a]	24.15±2.47[a]
K-7	34.70±4.43[a]	19.60±2.55[a]
K-8	32.90±1.91[a]	24.15±2.69[a]
K-9	33.33±2.65[a]	24.15±2.78[a]
K-10	37.26±2.40[a]	24.85±2.42[a]
Mean	35.44	23.31
CV%	18.22	17.34
LSD	11.02	7.67

Means sharing different letters in columns are significantly different (Duncan test, α=0.05) for each populations

Protein content of the sesame seeds exhibited different ranges for different studies. The content was 18.3 - 25.18 % (Bahkali et al. 1998), 19.60-24.85 % (Dhawan et al. 1972), 22.3-32.9 % (El Naim et al. (2012), 21.3 to 25.31 % (Baydar et al., 1999). In this work, the populations cultivated showed a relatively similar protein content (24.85 %) to the previous reports.

Karaaslan et al. (1999) researched sesame oil content and found out that it varied between 36 to 50 %, in native varieties (52-61 %) and imported varieties, 43.42-49.67 % by Yılmaz et al. (2005) and (45.48%) by Sağır et al. (2009). Consequently, the crude oil content found in the current study was lower than the previous reported studies. These values may change with different ecological conditions, management practices and cultural factors. In addition, genetic structure and developmental stages may result in these variations.

The proximate fatty acid composition of sesame seeds is presented in Table 8. Different percentages were found for both fatty acids, the average values being 44.02 for oleic acid and 39.17 % for linoleic acid. Concerning the differences among populations cultivated, oleic acid (43.42-45.05 %), linoleic acid (38.12-39.80 %), palmitic acid (9.33-9.83 %) and stearic acid (5.33-5.63 %) are the major unsaturated fatty acids (Table 8).

Table 8. *Fatty acid composition (%) in the sesame populations*

Population	Palmitic acid (16:0)	Stearic acid (18:0)	Oleic acid (18:1)	Linoleic acid (18:2)
K-1	9.83	5.33	43.51	39.57
K-2	9.49	5.55	44.14	39.17
K-3	9.56	5.51	43.49	39.69
K-4	9.60	5.45	44.43	38.74
K-5	9.66	5.36	43.79	39.32
K-6	9.45	5.63	45.05	38.12
K-7	9.63	5.55	43.70	39.33
K-8	9.45	5.56	43.42	39.80
K-9	9.33	5.62	44.93	38.37
K-10	9.44	5.33	43.74	39.63
Average	9.55	5.49	44.02	39.07
CV %	1.46	2.09	1.48	2.87

Oleic acid and linoleic acid were the main constituents, accounting for more than 80.0 % of total fatty acids (Ünal and Yalçın 2008). In a study conducted in India, Mondal et al. (2010) reported that the percentage content of oleic, linoleic, palmitic and erucic acids ranged between 36.7-52.4, 30.4-51.6, 9.1-14.8 and 0.0-8.0, respectively. Some sesame cultivars in the south-eastern part of Turkey were reported to contain palmitic acid (9.7 %), stearic acid (4.8 %), oleic acid (45.3 %) and linoleic acid (39.5 %) whereas the ranges for sesame cultivars in the Mediterranean Region reported by Baydar et al. (1999) was stated to involve palmitic acid (9.3 %), stearic acid (4.7 %), oleic acid (43.4 %) and linoleic acid (41.7 %). Palmitic acid (8.32-9.44 %), stearic acid (4.93-5.76 %), oleic acid (41.06-42.42 %), linoleic acid (41.67-44.36 %) ranges were reported to be in some Turkish sesame seeds by (Ünal and Yalçın 2008).

CONCLUSIONS

Sesame is an important oilseed crop, and its oil is valuable for human health due to its richness in unsaturated fatty acids. In this study, among the local sesame populations, K-1 and K-10 showed the best performance and seemed promising for further investigations. Furthermore, the seed yield is significantly associated with plant height and oil content, which are also significant predictors according to the multiple linear regression results. As a conclusion, it would be useful to sow and compare the populations showing good performance with commercially registered varieties in terms of yield and yield parameters in subsequent years.

CONFLICT OF INTERESTS

There is no conflict of interest between the authors

AUTHORS CONTRIBUTION

AÖ; Conceptualization, writing, review, editing, supervision. RB; Editing, statistical analysis, evaluation. EU; Planning, field studies, original draft.

REFERENCES

Bahkali, AH., Hussain, MA., and Basahy, A., (1998). Protein and oil composition of sesame seeds (*Sesamum indicum* L.) grown in the Gizan area of Saudi Arabia. *Int. J. Food Sci. Nutr. 49*: 409-414.

Bakal, H. (2022). The comparison of some important agronomic and quality characteristics of sesame (*Sesamum indicum* L.) varieties grown as a main and double crop. *Harran J. Agric. Food Sci. 26*(3): 358-370.

Baydar, H. (2005). Agronomic and technological characteristics of the lines with yield, oil, oleic and linoleic types in sesame (*Sesamum indicum* L). *Akdeniz Univ. J. Faculty of Agric. 18*(2): 267-272.

Baydar H., Turgut, I., and Turgut, K. (1999). Variation of certain characters and line selection for yield, oil, oleic and linoleic acids in the Turkish sesame (*Sesamum indicum* L.) populations. *Turk. J. Agric. Forest. 23*: 431-441.

Biabani, AR., and Pakniyat, H. (2008). Evaluation of seed yield-related characters in sesame (*Sesamum indicum* L.) using factor and path analysis. *Pakistan J. Biol. Sci. 11*: 1157-1160.

Çağırgan İ., Özerden, S., and Özbaş, O. (2009). Agronomic trait assessment and selection for number of capsules in determinate × indeterminate crosses of sesame. *Turk. J. Agric. Forest. 33*: 231-241.

Dhawan S., Singhvi, SC., and Simlot, MM. (1972). Studies on the quality of sesame seed and oil. I. Varietal differences in the quantity and quality of oil. *J. Food Sci. Technol. 9*: 23-25.

El Mahdi, ARA., El Amin, SEM., and Ahmed, FG. (2007). Effect of sowing dateon the performance of sesame (*Sesamum indicum* L.) genotypesunder irrigation conditions in northern Sudan. African Crop Science Conference Proceedings, African Crop Science Society, *Printed in El-Minia, Egypt*, 8: 1943-1946.

El Naim, AM., El Dey, EM., Jabereldar, AA., Ahmed SE., and Ahmed, AA. (2012). Determination of suitable variety and seed rate of sesame (*Sesamum indicum* L.) in Sandy Dunes of Kordofan Sudan. *Int. J. Agric. Forest. 2*(4): 175-179.

Furat, Ş., and Uzun, B. (2005). Agricultural and morphological properties of Turkish sesame collection (In TR). *6th National Field Crops Congress*. Proceedings Book I: 431-436.

Hatipoğlu, H., Arslan, H., Karakuş, M., & Abrak, S. (2017). Determination of some suitable sesame (*Sesamum indicum* L.) Genotypes as Second Crop under Harran plain conditions, *J. Agric. Faculty of Uludag Univ. 31*: 61-67.

Izgi, M.N., & Bulut, B. (2023). Agronomic characteristics and yield values of sesame (*Sesamum indicum* L.) cultivars at various sowing dates, *Turk. J. Agric. Res. 10*(1): 109-120.

Karaaslan D., Söğüt, T., and Sakar, D. (1999). Determination of some sesame (*Sesamum indicum* L.) cultivars grown as double crop under Diyarbakir (south-east of Turkey) irrigated conditions. *3th National Field Crops Congress, Adana-Turkey*, Proceeding Book: 15-18.

Lee, JH., Song, NK., Joo, WS., and Song, KB. (2014). Effects of nano-clay type and content on the physical properties of sesame seed meal protein composite films. *International J. Food Sci. Technol. 49*: 1869-1875.

Leon, L., Uceda, M., Jimenez, A., Martin, LM., and Rallo, L. (2004). Variability of fatty acid composition in olive (*Olea europaea* L.) progenies. *Span. J. Agric. Res. 2*(3): 353-359.

Liu, CT., Periasamy, S., Chang, CC., Mo, FE., and Liu, MY. (2014). Sesame oil therapeutically ameliorates cardiac hypertrophy by regulating hypokalemia in hypertensive rats. JPen-Parenter. *Enter. 38*(6): 750-757.

Mondal, N., Bhat, KV., and Srivastava, PS. (2010). Variation in fatty acid composition in Indian germplasm of sesame. *J. Am. Oil Chem. Soc. 87*(11): 1263-1269.

Oiso, N., Yamadori, Y., Noriko-Higashimori, N., Kawara, S., and Kawada, A. (2008). Allergic contact dermatitis caused by sesame oil in a topical Chinese medicine, shi-un-ko. *Contact Dermatitis. 58*(2): 109.

Özkan, A. (2018). Effect of water deficit on biochemical and growth of sesame in the Middle East Euphrates Valley. *KSU J. Agric Nat. 21*(1), 91-99.

Ozkan, A., Curat, D., & Kulak, M. 2012. Morphological properties and chemical compositions of some sesame (*Sesamum indicum* L.) populations cultivated in Kilis, Turkey. *Afr. J. Agric. Res. 7*(19): 3029-3033.

Rahmatullah, M., Hasan, A., Parvin, W., Moniruzzaman, MD., Khatun, A., Khatun, Z., Jahan, FI., and Jahan, R. (2012). Medicinal plants and formulations used by the soren clan of the santal Tribe in Rajshahi district, Bangladesh for treatment of various ailments. *Afr. J. Tradit. Complem. 9*(3): 350-355.

Pirbalouti, AG., Momeni, M., and Bahmani, M. (2013). Ethnobotanical study of medicınal plants used by Kurd tribe in Dehloran and Abdanan districts, Ilam province, Iran. *Afr. J. Tradit. Complem. 10*(2): 368-385.

Sağır, P., Sağır, A., and Söğüt T. (2009). The effect of Charcoal rot disease (*Macrophomina phaseolina*), irrigation and sowing date on oil and protein content of some sesame lines. *J. Turk. Pathol. 38*(1-3): 33-42.

Sambasiva, R., Chavali, SR., Utsunomiya, T., and Forse, RA. (2001). Increased survival after cecal ligation and puncture in mice consuming diets enriched with sesame seed oil. *Crit. Care Med. 29*(1): 140-143.

Sarwar, G., Haq, MA., and Saleem-Mughal, M. (2005). Genetic parameters and correlation study in diverse types of sesame germplasm. *Sesame and Safflower Newsletter, 20*: 34-39.

Saydut, A., Duz, Z., Kaya, C., Kafadar, AB., and Hamamci, C. (2008). Transesterified sesame (*Sesamum indicum* L.) seed oil as a biodiesel fuel. *Bioresource Technol. 99*: 6656–6666.

Shahidi, F., Liyana-Pathirana, CM., and Wall, DS. (2006). Antioxidant activity of white and black sesame seeds and their hull fractions. *Food Chem. 99*: 478-483.

Söğüt, T. (2009). Effect of main and second cropping on seed yield, oil and protein content of sesame (*Sesamum indicum* L.) genotypes. *Turk. J. Field Crops. 14*: 64-71.

Sumathi, P., and Muralidharan, V. (2009). Genetic analysis of the hybrids, involving monostem / shy branching genotypes in sesame (*Sesamum indicum* L.). *E. J. Plant Breed. 1*: 65-69 .

Taş, B., and Çelik, N. (2011). Determinatıon of seed yield and some yield components through path and correlation analyses in many six-rowed barley (*Hordeum vulgare conv. hexastichon*). *Afr. J. Agric. Res. 6*: 4902-4905.

Teres, S., Barceló-Coblijn, G., Benet, M., Alvarez, R., Bressani, R., Halver, J., and Escriba, PV. (2008). Oleic acid content is responsible for the reduction in blood pressure induced by olive oil. *Proceeding of the National Academy of Sciences, 105*(37): 13811–13816.

Ünal, MK., and Yalçın, H. (2008). Proximate composition of Turkish sesame seeds and characterization of their oils. *Grasas Aceites. 59*(1): 23-26.

Uzun, B., Arslan, C., Karhan, M., and Toker, C. (2007). Fat and fatty acids of white lupin (*Lupinus albus* L.) in comparison to sesame (*Sesamum indicum* L.). *Food Chemistry, 102*: 45–49.

Weiss, EA. (2000). *Oilseed Crops*. Second Ed. Oxford, UK: Blackwell Science .

Wenliang, W., Xiaoqiong, Q., Linhai, W., Yanxin, Z., Wei, H., Donghua, L., Haixia, L., and Xiurong, Z. (2011). Characterization of the sesame (*Sesamum indicum* L.) global transcriptome using Illumina paired-end sequencing and development of EST-SSR markers BMC. *Genomics, 12*: 451.

Yılmaz, A., Boydak, E., Beyyavaş, V., Cevheri, I., Haliloğlu, H., and Güneş, A. (2005). Research on growing possibilities of some sesame (*Sesamum indicum* L.) cultivars as double crop under Şanlıurfa ecological irrigated conditions. (In TR). *6th National Field Crops Congress*. Proceedings Book I, pp 425-429.