J. Turk. Phytopath., Vol. 38 No. 1-3, 33-42, 2009 ISSN 0378 - 8024

The Effect of Charcoal Rot Disease (*Macrophomina phaseolina*), Irrigation and Sowing Date on Oil and Protein Content of Some Sesame Lines

Pınar SAĞIR* **Abuzer SAĞIR**** **Tahsin SÖĞÜT*****

* Plant Protection Research Station, 21110 Diyarbakır, Turkey
** Department of Plant Protection, Agricultural Faculty, Dicle University, 21280 Diyarbakır, Turkey
*** Department of Crop Science, Agricultural Faculty, Dicle University, 21280 Diyarbakır, Turkey e-mail: asagir@dicle.edu.tr

ABSTRACT

This study was conducted to determine the effect of charcoal rot disease (*Macrophomina phaseolina*) on oil and protein content of some sesame lines cultivated under different conditions at the experimental area of Dicle University Faculty of Agriculture, in 2006 and 2007. In this study, 6 sesame lines (B–60, C–7, C–36, C–53, Y–7 and Y–11) which are of Mediterranean and Southeastern Anatolia Region origin and 3 isolates which belong to the *M. phaseolina* fungus are treated. Before sowing, experimental area was inoculated artificially by disease factor. Sesame seeds were sown on 05 May 2006, 22 June 2006, 11 May 2007 and 22 June 2007, respectively. The experiment was established in a split-split plot design with three replications. At crop maturity, unhealthy and healthy plants on each plot were harvested separately, and adequate amount of seed samples were taken. In both years, the seeds from each plot were taken after harvest for determining oil and protein content. Average protein and oil content were recorded as 23.18% and 45.48%, respectively. Protein and oil contents were affected by sowing date, irrigation and disease. According to the obtained data, protein content of seeds obtained from unhealthy plants was found lower when compared to the healthy plants, and oil content was found higher. The highest protein content obtained from early sowing, dry conditions and healthy plants (25.99%), and the lowest content from late sowing, irrigated and unhealthy plants (20.64%). The highest oil content obtained from early sowing, irrigated and unhealthy plants (46.54%) and the lowest oil content from early sowing, irrigated and healthy plant (44.70%).

Key words: Sesame, protein, oil, sowing date, irrigation, charcoal rot disease, *Macrophomina phaseolina*

THE EFFECT OF CHARCOAL ROT DISEASE (*Macrophomina phaseolina*), IRRIGATION AND SOWING DATE ON OIL AND PROTEIN CONTENT OF SOME SESAME LINES

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the oldest cultivated plants which are grown all over the world and has been known since ancient ages. It has an important role in human nutrition by virtue of rich nutrients it has contained. Sesame seeds are used in baking cupcake, bread and cream-cake, as well as they are directly consumed as snack food by being roasted. Furthermore, sesame seeds are used in making tahini by way of seed crushing. Acquired product, i.e. tahini, can be directly consumed by being blended with honey and molasses, as well as it is also used as making sesame seed paste mixed with thick nuts and cereals (Atakişi, 1985; Arıoğlu et al., 2010). Oil at the rate of 40-60% is available in sesame seeds. Sesame oil is quite resistant to spoiling thanks to the "sesamol and sesamolin" it has contained. Sesame oil, the sustenance of which is high, is used as vegetable oil and margarine. As it is being used as foodstuff, sesame oil is also used in food industry as raw material (İlisulu, 1973; Baydar, 2005).

Sesame is successfully cultivated in irrigated and dry areas in Aegean, Mediterranean, Marmara and Southeastern Anatolia Region in Turkey. The importance of this cultivated plant is gradually increasing by the reasons of short vegetation period, low production cost and the possibility of its being cultivated as second crop (Arıoğlu et al., 2010). In Turkey, sesame cultivation is being carried out in an area of 31.824 ha and 23.460 ton crops are received in total (Anonim, 2010).

Sesame seeds are highly rich in protein. Within the scope of studies carried out, it was determined that the protein content varies between 20.0% and 25.18% (Bahkali, 1998; Ünal and Yalçın, 2008; Nzikou et al., 2009; Kanu, 2011). In addition to the protein and oil content, sesame seeds are quite rich in carbohydrates, mineral substances and fatty acids, too (Uzun et al, 2002; El Khier et al., 2008; Nzikou et al., 2009; Alyemeni et al., 2011).

One of the most important factors which affect the sesame cultivation negatively in our country and Southeastern Anatolia Region is charcoal rot disease/wilt disease. It has been determined that *Macrophomina phaseolina* (Tassi) Goid., *Fusarium oxysporum* f. sp. *sesami* (Zaprometoff) Castellani, *Rhizoctonia solani* Kühn., *Stemphylium* sp. fungus cause this disease (Tatlı and Sağır, 1992, Ataç et al., 1994, Gürkan, 1995). *M. phaseolina* fungus causes greater harm, especially in the event that host plants are weakened by stress and dehydrated. Disease factor may infect the plants in a wide temperature range from 20 ^{0}C to 35 ^{0}C, as based on the condition of soil water retention (Olaya and Abawi, 1996; Diourte et al., 1995). Within a survey study carried out in Diyarbakır and Şanlıurfa provinces in Southeastern Anatolia Region with the object of determining fungal diseases encountered in sesame, it has been stated that the average prevalence rate of wilt disease is 88.8%, disease rate is 8.9% and the major and most important factor is *M. phaseolina,* and also stated that this fungus has been obtained at

the rate of 65.62% in isolations made (Gürkan 1995). This pathogen causes wilting of growing plants completely by forming necrosis in root collar of the plant.

This study was carried out to determine the effect of charcoal rot disease (*Macrophomina phaseolina*) on protein and oil content of seeds gathered from sesame lines cultivated under different conditions.

MATERIALS AND METHODS

Some sesame lines which are of Mediterranean and Southeastern Anatolia Region origin were cultivated in the early and late period and under the irrigated and dry conditions, in Diyarbakır province. Experiments established in order to determine the effect of charcoal rot disease which is caused by *Macrophomina phaseolina* fungus on the protein and oil content of sesame seeds.

In 2006-2007 growing seasons, experiments were established in a field of the Research Area of Dicle University Faculty of Agriculture where is naturally contaminated by the disease factor (M*acrophomina phaseolina)* and the disease has been encountered in the previous years. In the study, 6 different sesame lines which are of Mediterranean origin (Y–7 and Y-11) and of Southeastern Anatolia Region origin (B-60,C-7, C-36 and C-53) were used as material.

The field experiments were laid out in a split-split plot design with three replications. Plots were 4 m long and 1.4 m wide with two rows spaced by 0.7 x 0.15 m.

In order that the occurrence of disease can be seen intensely, the soil was artificially inoculated by the disease factor *M. phaseolina* after it has been made ready for sowing later than the cultivation. Therefore, 3 *M. phaseolina* isolates previously isolated were left for incubation for a time period to last 15 days at 22 ^{o}C, after they were placed in sterilized petri and erlenmeyers that contained wheat-medium (1000 g wheat + 800 ml water). Afterwards, growing inoculum was broken into pieces and applied into 1 m^2 soil as to be 75 g on the date of 10 April 2006. As to make soil inoculation easily and homogeneously, after this inoculum was blended with sand at the rate of 1/5 (inoculum in 1 proportion + stream sand in 5 proportions), it was applied into the soil on each parcel evenly. Following the inoculation, the soil was tillaged by rotovator as to be 5-10 cm in depth and the homogeneous blending of inoculum with soil has realized (Sağır et al., 2009).

Before sowing, basal fertilizer was applied into the experimental plots in the dose of 100 N kg ha^{-1} and 100 P_2O_5 kg ha^{-1} as 20-20-0. Sesame seeds were manually sown to the lines which are opened on experimental plots at two different planting dates within the years 2006 and 2007 [(Dates for the 1st sowing time (early sowing) are

05.05.2006 and 11.05.2007; dates for the 2nd sowing time (late sowing) are 22.06.2006 and 22.06.2007)]. At the second sowing time, sowing was performed after soil was irrigated. After the emergence of plants and in the period when 3-4 actual leaves exist, thinning was performed in the way that 0.15 m intra-row spacing.

Usual agricultural procedures were maintained throughout the season and weed control was mechanically carried out. With the aim of weed control and soil ventilation, 3 hoeing treatments were performed. In case of need, plants on irrigated plots were provided with irrigation water, as 5 times in 2006 and 4 times in 2007, by means of furrow irrigation method.

Following the maturation of plants at the end of the growing season, healthy and unhealthy plants on each plot were harvested separately and laid on a nylon cover. After plants have completely dried out, seeds were separated from the plants by being shaken.

After seeds in adequate amount (20 grams) had been received for each plot and milled properly, they were put into nylon bags by being labeled and preserved in deepfreeze at -18 ^{0}C. Before carrying out protein and oil analyses, seed samples were kept in Pasteur's furnace at 70 ^{0}C for approximately two hours and by this means, dehumidification of excessive humidity has been ensured. In order to determine the protein and oil contents, a 25 g sample of dry seeds from each plot were finely grounded. The each sample was analyzed for crude protein content with a model LECO FP-528 analyzer (LECO Corp., Joseph, MI), three reading for protein was taken from three sub-samples and their average value was recorded. The crude protein content in seeds was estimated by applying the factor N x 6.25 to the seed N content. Sesame flour was extracted into petroleum ether using soxhlet apparatus for 4h as per process of the instrument (AOAC, 1960). Oil contents were determined by weight differences. All values are mean of observations in three independent samples. Seed protein and oil contents were expressed in % on a dry matter basis.

The data were analysed by a standard procedure for analysis of variance, and the significance of differences among sample means was determined by LSD test using SPSS 17.0. In this way, the effect of sowing date, irrigation and charcoal rot disease in sesame which was caused by *Macrophomina phaseolina* fungus on protein and oil content were determined.

RESULTS AND DISCUSSION

Average protein and oil contents of sesame lines which were cultivated under different conditions were shown in Table 1. As it seems in Table 1, the protein content of sesame lines ranged from 22.55% to 23.61%, and oil content of them varied between 44.85% and 46.90%. The highest protein and oil content was obtained respectively from

the lines of Y-7 and C-7. Bahkali et al. (1998) reported that the protein content of the seeds of white hulled and dark hulled sesame of which different geographical origins varies between 23.13% and 25.18% and the oil content of them ranges from 47.02% to 49.07%. Ünal and Yalçın (2008) determined that the average protein content of seed samples taken from 4 different sesame types (Gölmarmara, Özberk, Muganlı, Çamdibi) cultivated in different regions of Turkey is 21.00% and the oil content is 54.26%, and Baydar et al.(1999) determined that the oil contents of 16 fine lines picked out of 160 sesame lines varies between 57.2% and 63.25%.

Table 1. Average protein and oil content of sesame lines (%)

Lines	Protein Content (%)	Oil Content (%)
1(B-60)	23.31a	45.18b
2(C-7)	23.14a	46.90a
3(C-36)	22.55b	45.64b
4(C-53)	23.29a	44.85b
5(Y-7)	23.61a	45.36b
6(Y-11)	23.15a	44.96b
Average	23.18	45.48

*Values within a column followed by different letters differ significantly (P< 0.05) according to LSD test.

According to the findings obtained, protein and oil contents of sesame lines varied statistically by the years, sowing time, irrigation and status of disease (Table 2). When all these factors are taken into consideration, the average protein content of six sesame lines found as 23.18% and the oil content as 45.48%. Just as in the previous studies carried out in this respect, it was detected that the protein and oil contents of sesame seeds vary by the color of seed hull, growing regions, the point of which capsule exists on the plant and sowing date (Mosjidis and Yermanos., 1984; Bahkali et al., 1998; Baydar and Turgut, 1994; Ünal and Yalçın, 2008; Kanu, 2011).

In early and late sowings, it was found that the protein content of sesame seeds received from unhealthy plants cultivated under irrigated and dry farming conditions was lower in comparison with the ones received from healthy plants and the oil content was higher. It was determined that the average protein content of unhealthy plants is 20.64-24.86% and the oil content of them was 44.85-46.54%, and respectively, the protein and oil contents of healthy plants were 21.31-25.99% and 45.61-44.70% (Table 3). Any source or reference indicating the effect of *Macrophomina phaseolina* fungus on oil and protein content of sesame seed could not be reached.

Although the sowing time, irrigation and the interaction between disease and lines could not be found statistically significant, the highest average protein content has

been obtained from early sowing, dry and healthy plants (25.99%) and the lowest average protein content from late sowing, irrigated and unhealthy plants (20.64%). The highest average oil content was obtained from early sowing, irrigated and unhealthy plants (46.54%), and the lowest average oil content was obtained from early sowing, irrigated and healthy plant seeds (44.70%) (Table 3).

As a consequence, it was determined that sowing time, irrigation conditions, sesame type/line and disease status had an effect on oil and protein contents of sesame seeds. It will be useful to carry out studies especially in respect of disease.

Table 2. Protein and oil content (%) of sesame lines as affected by years, sowing time, irrigation and charcoal rot disease.

Factors	Characters	Protein Content (%)	Oil Content (%)
Years	2006	23.48a	44.80b
	2007	22.87b	46.09a
Sowing Time	Early	23.92a	45.25a
	Late	22.43b	45.71a
Irrigation	Irrigated	21.69b	45.75a
	Dry	24.66a	45.21b
Disease	Unhealthy	22.68b	45.89a
	Healthy	23.67a	45.07b
Average		23.18	45.48

*Values within a column followed by different letters differ significantly ($P< 0.05$) according to LSD test.

Table 3. Mean values of protein and oil contents (%) of sesame lines as affected by sowing time, irrigation and charcoal rot disease.

Sowing Time	Irrigation	Disease	Lines	Protein (%)	Oil (%)	Average Protein (%)	Average Oil (%)
Early	Irrigated	Unhealthy	1(B-60)	21.90	47.13	21.65	46.54
			2(C-7)	20.76	49.93		
			3(C-36)	20.81	48.28		
			4(C-53)	21.58	43.16		
			5(Y-7)	23.06	45.31		
			6(Y-11)	21.81	45.45		
		Healthy	1(B-60)	23.30	46.00	23.16	44.70
			2(C-7)	22.96	44.51		
			3(C-36)	22.83	43.11		
			4(C-53)	23.76	43.31		
			5(Y-7)	23.00	45.71		
			6(Y-11)	23.15	45.58		
	Dry	Unhealthy	1(B-60)	24.65	45.00	24.86	44.85
			2(C-7)	24.85	45.50		
			3(C-36)	23.88	46.25		
			4(C-53)	25.38	45.53		
			5(Y-7)	25.43	43.73		
			6(Y-11)	25.05	43.60		
		Healthy	1(B-60)	26.26	44.93	25.99	44.83
			2(C-7)	25.75	47.08		
			3(C-36)	25.71	44.85		
			4(C-53)	26.21	44.20		
			5(Y-7)	26.30	43.65		
			6(Y-11)	25.71	44.26		
Late	Irrigated	Unhealthy	1(B-60)	20.68	45.73	20.64	46.13
			2(C-7)	20.46	47.76		
			3(C-36)	20.60	42.41		
			4(C-53)	20.01	43.31		
			5(Y-7)	20.60	49.28		
			6(Y-11)	21.51	48.30		
		Healthy	1(B-60)	21.66	46.91	21.31	45.61
			2(C-7)	21.76	45.45		
			3(C-36)	20.80	48.90		
			4(C-53)	21.66	44.51		
			5(Y-7)	21.53	45.33		
			6(Y-11)	20.45	42.55		
	Dry	Unhealthy	1(B-60)	23.70	42.68	23.55	45.95
			2(C-7)	23.83	48.81		
			3(C-36)	21.85	43.93		
			4(C-53)	23.80	47.78		
			5(Y-7)	24.61	46.73		
			6(Y-11)	23.60	45.78		
		Healthy	1(B-60)	24.38	43.05	24.22	45.15
			2(C-7)	24.73	46.15		
			3(C-36)	23.96	47.36		
			4(C-53)	23.95	46.98		
			5(Y-7)	24.40	43.13		
			6(Y-11)	23.91	44.21		

THE EFFECT OF CHARCOAL ROT DISEASE (*Macrophomina phaseolina*), IRRIGATION AND SOWING DATE ON OIL AND PROTEIN CONTENT OF SOME SESAME LINES

ÖZET

KÖKBOĞAZI ÇÜRÜKLÜĞÜ (*Macrophomina phaseolina*), SULAMA VE EKİM ZAMANININ BAZI SUSAM HATLARININ YAĞ VE PROTEİN İÇERİKLERİ ÜZERİNE ETKİSİ

Bu çalışma, kökboğazı çürüklüğü hastalığı (*Macrophomina phaseolina*)' ın farklı koşullarda yetiştirilen bazı susam hatlarının protein ve yağ içeriklerine olan etkisini belirlemek amacıyla, 2006-2007 yıllarında Dicle Üniversitesi Ziraat Fakültesi Araştırma alanında yapılmıştır.

Çalışmada, Akdeniz ve Güneydoğu Anadolu Bölgesi kökenli 6 susam hattı (B–60, C–7, C–36, C–53, Y–7, Y–11) ile *M. phaseolina* fungusuna ait 3 izolat kullanılmıştır. Ekimden önce deneme alanı hastalık etmeni ile yapay olarak inokule edilmiştir. Susam tohumları, 05.05.2006, 22.06.2006, 11.05.2007 ve 22.06.2007 tarihlerinde ekilmiştir. Denemeler, bölünen bölünmüş parseller deneme desenine göre, üç tekerrürlü olarak kurulmuştur.

Mevsim sonunda bitkilerin olgunlaşmasından sonra, her parseldeki hasta ve sağlam bitkiler ayrı ayrı hasat edilerek yeteri miktarda tohum örnekleri alınmıştır. Tohum örnekleri değirmende öğütüldükten sonra dipfirizde muhafaza edilmiştir. Protein analizi için her örnekten 0.25 g alınarak LECO-FP-528 cihazında (LECO Corp, Joseph, MI) analiz edilerek ham azot (% N) bulunmuştur. Elde edilen % N oranları 6.25 faktörü ile çarpılarak (% N x 6.25) tohum protein oranları belirlenmiştir. Yağ analizleri için aynı şekilde hazırlanan örneklerden 5 g alınarak Soxhlet cihazında 70 ^{0}C sıcaklıkta organik çözücü (dimethylether) ile ekstraksiyon yöntemine göre analiz edilmiş ve elde edilen değerler % 'de olarak hesaplanmıştır.

Susam hatlarının ortalama protein oranı %23.18, yağ oranı ise % 45.48 olarak bulunmuştur. Protein ve yağ oranları, ekim zamanı, sulama koşulları ve hastalık durumuna göre farklılık göstermiştir. Elde edilen verilere göre, hastalıklı bitkilerden elde edilen tohumların protein içeriği, sağlıklı bitkilere göre daha düşük yağ oranları ise daha yüksek bulunmuştur. En yüksek protein oranı; erken ekim, susuz ve sağlam bitkilerden (%25.99), en düşük ise geç ekim, sulu ve hasta bitkilerden (%20.64) elde edilmiştir. En yüksek yağ oranı; erken ekim, sulu ve hasta bitkilerden (%46.54), en düşük yağ oranı ise; erken ekim, sulu ve sağlam bitki tohumlarından (%44.70) elde edilmiştir.

Anahtar Kelimeler: Susam, protein, yağ, ekim zamanı, sulama, kökboğazı çürüklüğü, *Macrophomina phaseolina*

LITERATURE CITED

Alyemeni, M. N., A. Y. Basahy and H. Sher, 2011. Physico-Chemical Analysis and Mineral Composition of Some Sesame Seeds (*Sesamum indicum* L.) Grown in The Gizan Area of Saudi Arabia. Journal of Medicinal Plants Research, 5(2): 270-274.

Anonim 2010. Türkiye İstatistik Kurumu. Bitkisel Üretim İstatistikleri Veri Tabanı.www.tuik.gov.tr

AOAC, 1960. Official Methods of Analysis. Association of Official Agricultural Chemistry, Washington, D.C.

Arıoğlu, H., Ö. Kolsarıcı, A. Tanju Göksu, L. Güllüoğlu, M. Arslan, S. Çalışkan ,T.Söğüt, C. Kurt Ve F. Arslanoğlu, 2010. Yağ Bitkileri Üretiminin Artırılması Olanakları. TMMOB Ziraat Mühendisleri Odası, Ziraat Mühendisliği Teknik Kongresi Bildiriler Kitabı-1,11-15 Ocak 2010 Ankara. S.361-376. Kitap sayfası 578

Ataç A., Çetin V. ve İpkin B., 1994. Akdeniz Bölgesinde Susamlarda Kök ve Kökboğazı Çürüklüğü Hastalıkları. Bitki Koruma Bülteni, 34(1-2): 49-54.

Atakişi, İ.K,,1985.Yağ Bitkileri Yetiştirme ve Islahı. Ç:Ü:Z:F: Ders Notu Yayınları 47, Adana,120 s.

Bahkali, H., M. A. Hussain and A. Y. Basahy, 1998. Protein and Oil Composition of Sesame Seeds (*Sesamum indicum*, L.) Grown in the Gizan area of Saudi Arabia. International Journal of Food Sciences and Nutrition, 49(6): 409-414.

Baydar, H. Ve İ.Turgut, 1994. Farklı Ekim Zamanlarının Susam (*Sesamum indicum* L.)'da Yağ Oranı, Yağ Aitleri Kompozisyonu ve Yağ Stabilite Kriterleri Üzerine Etkisi. Turkish Journal of Agricultural and Foresty, 18:387-391.

Baydar, H., 2005. Susamda (*Sesamum indicum* L.) Verim, Yağ, Oleik ve Linoleik Tipi Hatların Tarımsal ve Teknolojik Özellikleri. Akdeniz Üniversitesi Ziraat Fakültesi Dergisi, 18(2): 267-272.

Baydar, H., İ. Turgut, K. Turgut, 1999. Variation of Certain Characters and Line Selection for Yield, Oil, Oleic and Linoleic Acids in the Turkish Sesame (*Sesamum indicum* L.) Populations. Turkish Journal of Agriculture and Forestry, 23: 431-441.

Diourte M,, Star S. J., Jeger M. J., Stack J. P. and Rosenow D. T. 1995. Charcoal Rot (*Macrophomina phaseolina*) Resistance and the Effect of Water Stres on Disease Development in Sorghum. Plant Pathology, 44: 196-202.

Gürkan M., 1995. Diyarbakır ve Şanlıurfa İllerindeki Susam Ekim Alanlarında Görülen Fungal Hastalıkların Belirlenmesi Üzerine Araştırmalar. Yüksek Lisans Tezi, Gaziosmanpaşa Üniversitesi Fen Bilimleri Enstitüsü, Tokat, 35 s.

Kanu, P. J. 2011. Biochemical Analysis of Black and White Sesame Seeds from China. American Journal of Molecular Biology, 1: 145-157.

llisulu, K., 1973. Yağ Bitkileri ve Islahı. Çağlayan Kitap evi, İstanbul, 366 s.

Mosjidis, J. A. and D. M. Yermanos, 1984. Plant Position Effect on Seed Weight, Oil Content, and Oil Composition in Sesame. Euphytica, 33 (2): 427-432.

El Khier, N. K. S., K. E. A. Ishag and A. A. Y. El Gasim, 2008. Chemical Composition and oil Characteristics of Sesame Seed Cultivars Grown in Sudan. Research Journal of Agriculture and Biological Sciences, 4(6): 761-766.

Nzikou, J. M., L. Matos, G. Bouanga-Kalou, C. B. Ndangui, N. P. G. Pambou- Tobi, A. Kimbongulia, Th. Silou, M. Linder and S. Desobry, 2009. Chemical Composition on the Seeds and Oil of Sesame (*Sesamum indicum* L.) Groen in Congo- Brazzaville. Advance Journal of Food Science and Technology 1(1): 6-11.

Olaya G. and Abawi G. S. 1996. Effect of Water Potential on Micelial Growth and on Production and Germination of Scleratia of *Macrophomina phaseolina.* Plant Disease 80: 1347-1350.

Sağır, P., A. Sağır ve T. Söğüt.,2009.Bazı Susam Hatlarının Kökboğazı Çürüklüğü Hastalığı (*Macrophomina phaseolina*)'na Karşı Reaksiyonları ve Hastalık Gelişiminin Belirlenmesi. HR.Ü. Z.F.Dergisi, 13(4):49-56.

Tatlı, F. ve A. Sağır 1992. Güneydoğu Anadolu Bölgesi'nde İkinci Ürün Mısır, Susam ve Soya' da Görülen Bazı Fitopatolojik Sorunlar. Güneydoğu Anadolu Bölgesi'nde İkinci Ürün Tarımı ve Sorunları Sempozyumu. 26- 29 Ekim 1992, Şanlıurfa.

Uzun, B., S. Ülger, M. İ. Çağırgan, 2002. Comparison of Determinate and Indeterminate Types of Sesame for Oil Content and Fatty Acid Composition. Turk J. Agric For 26: 269-274.

Ünal, M. K. and H. Yalçın, 2008. Proximate composition of Turkish Sesame Seeds and Characterization of Their Oils. Grasas y Aceites, 59 (1): 23-26.