Turkish Journal of Field Crops
field-crops.org

DOI: 10.17557/tjfc.1682760
ISSN: 1301-1111
e-ISSN: 3023-6657
2025, 30(2), 300-309

Effect of Leaf Damage on Fat and Fatty Acids of Peanut (*Arachis hypogaea* L.)

Mustafa YILMAZ[1*], Cenk Burak ŞAHİN[2], Necmi İŞLER[2]

[1] *Texas A&M AgriLife Research, Lubbock, TX 79403, USA*
[2] *Hatay Mustafa Kemal University, Faculty of Agriculture, Department of Field Crops, Hatay, TÜRKİYE*

✉ *Corresponding author: mustafayilmaz80@hotmail.com*

ARTICLE INFO

Research Article
Received: 25 April 2025
Accepted: 11 November 2025
Published: 30 December 2025

Keywords:
Application stage
Fatty acids
Leaf damage
Oil content
Peanut

Citation: Yılmaz, M., Şahin, C. B., & İşler, N. (2025). Effect of leaf damage on fat and fatty acids of peanut (*Arachis hypogaea* L.). *Turkish Journal of Field Crops*, 30(2), 300-309. https://doi.org/10.17557/tjfc.1682760

ABSTRACT

Abiotic stresses triggered by climate change often damage peanut leaves (*Arachis hypogaea* L.) during developmental stages, and the effects of this damage on fat and fatty acids are unclear. Thus, this study examined the impact of leaf damage rates on the different growth stages of peanut (*Arachis hypogaea* L.) grown in the Eastern Mediterranean region of Osmaniye, Türkiye, during the main crop season. The experiment was conducted in a split-split plot design with three replications during 2020 and 2021 vegetation periods. Different yield and quality criteria were studied by placing independent variables, such as varieties (NC 7 and Halisbey) on main plots, growth stages (R1, R2, and R3) on sub-plots, and leaf damage levels (control, 25%, 50%, and 75%) on sub-sub-plots. The highest oil content was obtained in the Halisbey (48.30%±0.32) variety at the R3 stage (48.70%±0.32) and at 75% leaf damage (48.27%±0.21). The highest oleic acid was found in NC 7 variety (52.20%±0.33), at the R3 stage (51.19%±0.61), and %50 leaf damage (50.92%±0.72). The order of leaf damage treatments in terms of linoleic acid was as follows: in control (49.95%±0.31), in 75% leaf damage (50.37±0.60%), in 25% leaf damage (50.57%±0.54), and in 50% leaf damage (50.92%±0.72). As a consequence, it has been determined that the selection of varieties and integrated control against abiotic and biotic stresses are essential to reduce the effects of leaf damage on peanut fat and fatty acids.

1. INTRODUCTION

Peanut (*Arachis hypogaea* L.) from the Fabaceae family is the second-most important crop cultivated globally and makes a remarkable contribution to diets worldwide (Bodoira et al., 2022). Its seeds contain 45-55% oil, 20-30% protein, 18% carbohydrates, vitamins, and mineral substances, which are essential for both human and animal nutrition (Hammons et al., 2016; Sahin et al., 2022; Yilmaz & Jordan, 2022; Asik & Asik, 2023). Consuming peanuts can reduce the risk of cancer, diabetes, inflammation, alzheimer's, and gallstone disease (Variath & Janila, 2017).

Intensive studies have been carried out on the origin and distribution of peanuts, indicating that South America (South Bolivia-North West Argentina) has been accepted as its center of diversity (Tillman & Stalker, 2009). Peanut has been grown in South America since B.C. 500-750 years, and is used by humans as food and animal feed (Arioglu, 2014).

Peanut oil has superior properties compared to many other vegetable oils in terms of taste and durability due to its tocopherol content (Arioglu, 2014). The content of oil consists of 80% unsaturated fatty acids ((oleic acid 45-60%), linoleic acid (20-40%)) while the other part is from saturated acids including 5-10% palmitic acid, 3-7% stearic acid, 1-3 % behenic acid and 0.5-2% arachidic acid (Tillman & Stalker, 2009; Janila et al., 2016).

Today, agronomists and plant breeders focus their studies on yield and quality rather than plant survival (Ucak et al., 2017). As a result of these studies, high-yielding and high-quality products have begun to be obtained. Due to global warming in recent years, abiotic stresses (high temperature, drought, hail, storms, frost, floods, and forest fires) have negatively affected agricultural production and quality both in Türkiye and worldwide (Toker and Yadav, 2010; Tene et al., 2025). However, biotic stresses (such as diseases and pests) can also reduce leaf area, leading to declines in both yield and quality traits. Leaf spot diseases early (caused by *Cercospora arachidicola*) and late leaf spot diseases (caused by *Cercosporidium personatum*), damages caused by insect pests such as cotton leafworm or prodenia (*Spodoptera littoralis*), green worm (*Heliothis armigera*) cotton-lined leafworm (karadrina) in peanuts (*Spodoptera exigua*), and red spider (*Tetranychu* spp.) are the common biotic stress factors affecting peanut production (Isler & Gozuyesil, 2014). It has been reported that 35-40% damage occurs in peanuts and other plants when the necessary pesticide treatments are not performed against these and other similar pests, and 50-60% damage occurs when no control is made against fungal diseases (Adomou et al., 2005; Anonymous, 2025). Leaf spot disease (*Cercospora arachidis*) and leaf pest damage can reduce the light-capturing capacity of the plant, which ultimately reduces the rate of photosynthesis, or even hinders the process of photosynthesis by reducing the leaf area of the plant (Favero et al., 2009). The decrease in photosynthesis rate causes a decline in both vegetative and generative growth of the plant, potentially hindering peanut cultivation, particularly in terms of quality and yield (Anco et al., 2020). The most basic characteristics of cotton leafworm (prodenia) (*Spodoptera littoralis*), green worm (*Heliothis armigera*), and cotton-lined leafworm (karadrina) (*Spodoptera exigua*) pests consume peanut leaves (Arioglu, 2014; Isler & Gozuyesil, 2016). Due to the reduction in leaf area, the plant's ability to perform photosynthesis is impaired, limiting its capacity for adequate nutrient assimilation and storage. Moreover, it delays the healing of wound tissues formed in the plant and ultimately leads to yield and quality losses as a result of physiological damage (Kaya & Kovanci, 2000; Sarkaya Ahat, 2015). In general, favorable meteorological conditions are characterized by abundant and high-quality agricultural products, while severe cold in spring, strong winds or storms, heavy downpours and floods, drought, heat, hail, and forest fires significantly reduce agricultural production and even cause it to disappear completely (Reddy, 2015). Hail precipitation, one of the natural disasters with meteorological characteristics, causes significant damage and economic losses, particularly in the months when agricultural activities are most intense in Türkiye (Nadaroglu & Simsek, 2012).

As mentioned above, the most widely grown varieties that can withstand leaf damage and its effects on fat and fatty acid quantity and quality have been investigated to combat the continuously increasing damage caused by pests, diseases, and climate change to peanut plants in Türkiye and worldwide. Therefore, this study aimed to elucidate the effects of leaf damage on fat and fatty acid contents in peanut during different development stages.

2. MATERIALS AND METHODS

Halisbey variety, which has recently gained popularity in Adana, and the NC 7 variety, which accounted for 95% of peanut farming in Türkiye, were used as plant materials (Isler & Gozuyesil, 2016). The experiment was conducted at the Directorate of Oilseed Research Institute's agricultural research location in Cevdetiye Town (37°07'30.11"N, 36°11'57.35"E, 65 m), Osmaniye, Türkiye.

According to the soil analysis of the experimental area, the soil had a high pH and iron concentration, a medium calcium level, but lacked sufficient lime and organic matter. The average climatic values for Osmaniye, where the experiment was conducted, for the years 2020, 2021, and the long-term period are presented in Figure 1.

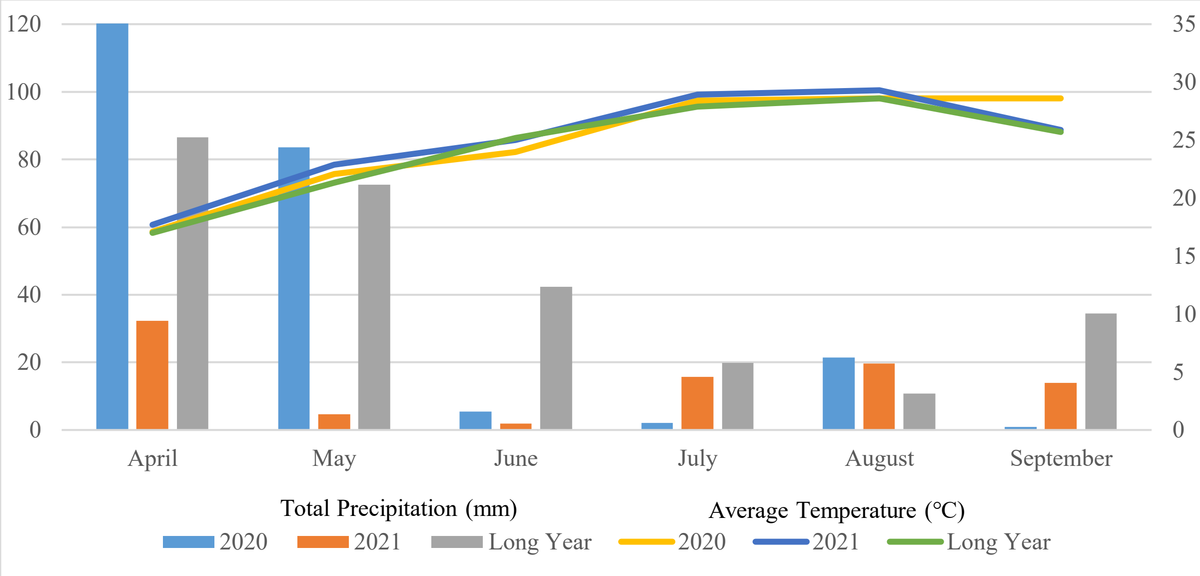

Figure 1. Climate parameters of the research field (2020, 2021 and long-year average).

The study was conducted in a split split-plot design with three replications during 2020 and 2021 growing seasons, where the varieties, NC 7 and Halisbey varieties were assigned to the main plots, flowering time (R1), gynophore formation time (R2), and pod formation time (R3) to the subplots, and leaf damage (LD) at several ratios (control, 25%, 50%, and 75%) to the sub-subplots. Each plot had four rows, each 5 meters long, and the planting density was kept at 70 cm between rows and 15 cm within rows.

Before planting 300 kg ha^{-1} of DAP was applied. Before the first irrigation, 200 kg ha^{-1} of urea was applied and 200 kg ha^{-1} of urea was applied before the third irrigation. The experiment's success depended on the timely and accurate completion of all necessary sprayings to stay inside the bounds of the manufactured damage. Additionally, all necessary cultural practices (such as weeding, watering, hoeing, spraying, etc.) were completed on schedule and using the right methods.

While damaging the leaves according to ratios, the number of branches of all the 20 plants in each plot was counted. Since the leaves in the peanut plant have a combined leaf structure on the branch, the number of leaves on the branch is equal. After determining the average number of branches in each plot, leaf reduction (control, 25%, 50% and 75%) was performed on the plants in the whole plot using scissors.

Specifics of all the actions that were carried out in accordance with the following years. On April 30, 2020, the experiment's first year of manual seeding was conducted. In the experiment's first year, leaves were damaged on June 12, 2020 (R1 stage), June 25, 2020 (R2 stage), and July 17, 2020 (R3 stage). On September 23, 2020, the varieties' first harvest was completed. On April 29, 2021, the experiment's second year of manual sowing was done by hand. The second year's treatment for leaf damage was implemented on June 11, 2021 (R1), June 22, 2021 (R2), and July 16, 2021 (R3). On September 27, 2021, the experiment's second harvest was completed. With the aid of scissors, damages were made at the rates of 25%, 50%, and 75% throughout each phase of leaf damage, but no leaves were injured in the control group.

In the experiment, analyses of fat (oil) content, saturated fatty acids, and unsaturated fatty acids were conducted in the laboratory of Hatay Mustafa Kemal University. Fatty acid compositions of peanut seeds were analyzed as described by Sahin et al. (2022) below:

The fatty acid profile of peanut seeds was determined using a Thermo Scientific ISQ Single Quadrupole GC-MS system equipped with a Time-Resolved FAME (TR-Fame) analysis capability. The separation was performed on a 60 m x 0.25 mm capillary column with a 0.25 µm film of 5% phenyl polysilphenylene-siloxane.

Helium (99.9% purity) served as the carrier gas at a constant flow rate of 1 mL min^{-1}. The mass spectrometer was operated in electron impact (EI) mode with an ionization energy of 70 eV, scanning a mass range from *m/z*

1.2 to 1200 in full scan mode. Compound identification was achieved by comparing the acquired mass spectra against the Wiley 9 library using Xcalibur software.

A programmed temperature gradient was applied as follows: the initial oven temperature was held at 120°C for 1 minute, then ramped at 10°C/min to 175°C and held for 10 minutes. Subsequently, the temperature was increased at 5°C min^{-1} to 210°C (hold 5 min), and finally raised at 5°C min^{-1} to 230°C (hold 6 min). The injection was performed in split mode with a split flow of 20 mL min^{-1}.

The peanut oil content was determined using the formula given below.

$$\text{Oil content (\%)} = \frac{\text{Weight of oil extracted (g)}}{\text{Weight of the seed sample (g)}} \times 100$$

Iodine values (Chowdhury et al., 2015) and Oleic acid/Linoleic acid ratio were calculated with the help of the following formula:

$$\text{Iodine Values (IV)} = [(\text{oleic acid} \times 0.8601) + (\text{\% linoleic acid} \times 1.7321)]$$

$$\text{Oleic Acid/Linoleic Acid (O/L) Ratio} = \frac{\text{\% oleic acid}}{\text{\% linoleic acid}}$$

Experimental data were subjected to analysis of variance (ANOVA) for each year and for the mean of the years according to the split-split-plot design using SPSS 22 software. Means were compared using the Duncan's multiple range test (5%).

3. RESULTS AND DISCUSSION

Plants are affected not only by abiotic factors, such as temperature, storms, and floods, but also by biotic factors, including diseases and pests. Global warming threatens agricultural production and natural life, associated with these abiotic and biotic factors, especially over the last decades. As a result of the plant diseases/pests or the weather changes that occur in summer, various plant organs, particularly leaves, are damaged. Accordingly, these adverse conditions cause dramatic changes in plant yield and quality (Toker & Yadav, 2010; Tene et al., 2025).

The oil content and unsaturated fatty acids (oleic and linoleic acids) were significantly affected ($p < 0.05$) by all independent variables and their interactions (Table 1). Oil content ranged from 45.79% to 49.94% for the mean values of the years. The highest oil content was obtained at the 75% leaf-damage ratio and the R3 stage, with values of 48.27% and 48.70%, respectively. The oil content for cultivars, Halisbey and NC-7 had 48.30% and 47.43% respectively while the mean was 47.86% (Table 2).

Peanut is one of the world's most important oil, food, and feed crops. This plant is touted as a functional food because it is a source of antioxidants, minerals, vitamins, and bioactive compounds that support health, such as tocopherol, resveratrol, and arginine (Variath & Janila, 2017). The biotic and abiotic factors limit crop production especially in recent decades because of climate change such as hail in the summer or pests' damage. The hail that occurs in the summer is a serious problem for agricultural production and quality worldwide (Jelic et al., 2020). For instance, in 2021, a company offering insurance coverage for agricultural crops in Switzerland reported 14,000 cases of hail damage. It means almost one in two farms declared a loss (Kopp et al., 2022). Similar results were also reported from Türkiye; insured losses due to hail damage accounted for over 60% of all weather-related insured losses, which plays a significant role in the country's economy (Kahraman et al., 2016).

Numerous agronomic and breeding studies have been conducted to increase the oil content in peanuts (Pandey et al., 2012). Arioglu et al. (2016) found that the oil ratio varied between 45.64% and 52.49% whereas Gulluoglu (2016) stated that the oil rate in peanuts ranged 47.29% to 51.60%. Similarly, Asik et al. (2018) found that the oil ratio varied between 47.53% and 54.69% and Yasli et al. (2019) reported that the oil ratio in peanuts ranged from 49.60% to 51.50%. The oil ratio observed in our study was similar to the ratio found by other researchers. In addition, when the oil rate in our study was examined, it was found that the period and damage rate caused differences in peanut oil content. Especially in the R3 stage, with 75% leaf damage, it was observed that the oil rate increased. This situation increases the oil rate of the plant to protect itself from stress conditions.

Oleic and linoleic acids, the most important unsaturated fatty acids in peanut plants, ranged from 48.70% to 52.20% and from 23.85% to 28.29%, respectively. A 50% leaf damage ratio came to the forefront for oleic (50.92%) and linoleic (27.27%) acids. The maximum oleic acid (51.19%) was observed in at R3 stage while the maximum linoleic acid (26.65%) was observed at R1 stage (Table 2). The ratio of oleic acid, a type of unsaturated fatty acid that is very important for health, ranges from 50% to 60% in peanuts (Andersen & Gorbet, 2002). It is recorded that the oleic acid ratio is high and the linoleic and palmitic acid ratios are low in peanuts (Deshmukh et al., 2020). An increase in oleic acid ratio increases fungal growth, seed productivity and also partially regulates the production of *Aspergillus spp.* (Wilson et al., 2004; Xue et al., 2006). It was also reported that an increase in oleic acid content can reduce cell death, by maintaining the systemic resistance, makes the plant resistant to pathogens (Kachroo et al., 2007).

Linoleic acid content for the varieties was in the same order as the oil content, with values of 28.29% and 23.85% (Table 2). According to Dwivedi et al. (1993), the linoleic acid ratio decreased as leaf damage increased, and this difference varied among cultivars. However, the rate of linoleic acid in our experimental findings was high in the R1 and R2 stages, and it was observed that the rate of linoleic acid increased as the rate of leaf damage increased. Although 50% leaf damage had the lowest oil content, it achieved the desirable fatty acid composition with the maximum oleic and linoleic acid contents and the minimum saturated fatty acid content.

Table 1. Mean square values for oil content, oleic acid, linoleic acid, palmitic acid, and stearic acid.

SoV	df	Oil content	Oleic acid	Linoleic acid	Palmitic acid	Stearic acid
Y	1	620.73**	474.62**	40.42*	3.90**	61.11**
R (Y)	4	0.85ns	0.11ns	2.40ns	0.08ns	0.05ns
V	1	27.29**	441.04**	710.18**	20.36**	10.21**
V × Y	1	0.13ns	76.58**	84.01*	1.05*	0.38**
Error 1	4	1.87	0.02	2.81	0.05	0.01
S	2	27.34**	23.84**	25.89**	0.37*	0.52**
S × V	2	8.73**	14.95**	2.78ns	1.06**	0.42**
S × Y	2	18.00**	6.99**	8.50ns	0.15ns	0.31**
S × V × Y	2	44.92**	0.28**	0.68ns	0.06ns	0.94**
Error 2	16	1.33	0.03	2.86	0.05	0.01
D	3	6.88**	5.89**	23.65**	0.31**	1.65**
D × Y	3	6.55**	23.89**	32.68**	1.86**	1.27**
D × V	3	11.82**	7.99**	11.15*	1.43**	1.04**
D × S	6	12.09**	18.14**	34.43**	0.84**	0.62**
D × V × Y	3	48.01**	7.73**	49.19**	0.73**	0.66**
D × S × Y	6	21.58**	4.64**	16.92**	0.71**	0.88**
D × V × S	6	19.17**	20.50**	15.96**	0.29**	0.58**
D × V × S × Y	6	24.42**	9.95**	8.44*	1.72**	1.22**
Error 3	72	1.34	0.03	2.78	0.07	0.01

SoV: Source of Variance; df: Degree of freedom; Y: Year; R: Replication; V: Varieties; S: Stages; D: Damage; ns: non-significant; * Significant at the $p < 0.05$ level; ** Significant at the $p < 0.01$ level.

Table 2. Mean values of oil content, oleic acid, linoleic acid, palmitic acid, and stearic acid.

	Oil content (%)	Oleic acid (%)	Linoleic acid (%)	Palmitic acid (%)	Stearic acid (%)
Varieties					
Halisbey	48.30±0.32 A	48.70±0.17 B	28.29±0.19 A	10.56±0.05 A	2.82±0.07 B
NC-7	47.43±0.22 B	52.20±0.33 A	23.85±0.44 B	9.81±0.07 B	3.35±0.05 A
Stages					
R1	47.65±0.29 y	50.40±0.28 y	26.65±0.48 x	10.25±0.07 x	2.96±0.11 z
R2	47.23±0.38 y	49.78±0.48 z	26.32±0.62 x	10.08±0.14 y	3.16±0.07 x
R3	48.70±0.32 x	51.19±0.61 x	25.25±0.72 y	10.21±0.90 x	3.13±0.08 y
Damage					
Control	48.18±0.55 ab	49.95±0.31 d	25.53±0.77 b	10.28±0.05 a	3.10±0.04 b
25%	47.65±0.43 bc	50.57±0.54 b	25.89±0.61 b	10.14±0.13 bc	3.03±0.09 c
50%	47.35±0.34 c	50.92±0.72 a	27.27±0.42 a	10.08±0.17 c	2.81±0.09 d
75%	48.27±0.21 a	50.37±0.60 c	25.60±0.42 b	10.24±0.12 ab	3.36±0.14 a
Years					
2020	49.94±0.26 A	52.27±0.12 A	25.54±0.26	10.02±0.06 B	2.43±0.04 B
2021	45.79±0.26 B	48.64±0.12 B	26.60±0.26	10.35±0.06 A	3.74±0.04 A
Mean	47.86±0.20	50.45±0.29	50.45±0.28	10.18±0.06	3.08±0.05

In this study, it was found that the remaining one-fourth was composed of five major saturated fatty acids: palmitic, stearic, behenic, arachidic, and lignoceric acids. These components were affected significantly ($p < 0.05$) by all independent variables and their interactions according to ANOVA (Table 1 and 3). Palmitic acid, the main saturated fatty acid in peanuts, ranged from 9.81% to 10.56%. The maximum palmitic acid contents were obtained from R1 stage and the control (non-damaged) group with 10.25% and 10.28%, respectively while the lowest values from R2 stage and 50% leaf damage with the same value (10.08%). The average value for palmitic acid was 10.18%. NC-7 had the lowest palmitic acid content as opposed to Halisbey (Table 2). The palmitic acid ratio was higher in applications without fungicide treatment for leaf diseases in different peanut cultivars (Dwivedi et al., 1993). The increase in oleic acid further reduces palmitic acid (Janila et al., 2016; Bera et al., 2018). Shibli et al. (2019) reported that palmitic acid content was significantly affected by varieties, and it varied between 9.32% and 12.03%. Kamdar et al. (2021) also reported similar results that palmitic acid ranged from 8% to 14% in peanut. In contrast, Yu et al. (2020) stated that palmitic acid in peanuts varied from 2.18% to 3.56%.

Stearic acid ranged from 2.82% to 3.35%, with the highest values observed in the R2 stage and at 75% leaf damage (3.16% and 3.36%, respectively). The lowest stearic acid content (2.81%) for leaf damage was obtained from 50% leaf damage same as palmitic acid. Halisbey came to the forefront with the lowest content against to NC-7 (Table 2). The mean value of the stearic acid was 3.08%. Dwivedi et al. (1993) determined that the stearic acid ratio was higher in applications without fungicide application on leaf diseases in different peanut cultivars. Ergun & Zarifikhosroshahi (2020) found that the rate of stearic acid varied between 2.64% and 3.36. Asik et al. (2018) recorded the stearic acid value varied between 2.39% and 4.19% whereas Yol & Uzun (2018) found that the rate of stearic acid varied between 2.4% and 4.9%. The ratio of palmitic and stearic acids found in our study was found similar with some studies.

Behenic acid was affected significantly ($p < 0.05$) by all independent variables and their interactions according to ANOVA (Table 3). Behenic acid ranged from 2.68% to 3.66% for the mean values of years. R2 stage and 75% leaf damage reached the maximum behenic acid with the values 3.31% and 3.29%, respectively. The lowest behenic acid content was obtained from R3 stage (3.02%) and 50% leaf damage (2.97%). The mean value for behenic acid was 3.17% (Table 4). The findings of behenic acid in this study were similar to those of Akcura et al. (2021), but were lower than the values reported by Candela et al. (2019). Dwivedi et al. (1993) found that the behenic acid ratio was higher in applications without fungicide application on leaf diseases in different peanut cultivars.

Table 3. Mean square values for behenic acid, arachidic acid, lignoceric acid, O/L ratio, and IV.

SoV	df	Behenic acid	Arachidic acid	Lignoceric acid	O/L Ratio	IV
Y	1	34.48**	14.40**	0.33**	0.94ns	59.70ns
R (Y)	4	0.07ns	0.05ns	0.01ns	0.65ns	6.23ns
V	1	0.28**	1.27**	3.00**	13.70**	789.40**
V × Y	1	0.02*	0.24**	0.27**	0.58ns	69.72*
Error 1	4	0.01	0.01	0.01	0.65	8.87
S	2	0.98**	0.35**	0.12**	1.43ns	37.97*
S × V	2	0.36**	0.10**	0.14**	0.85ns	0.25ns
S × Y	2	0.78**	0.46**	0.21**	0.80ns	8.33ns
S × V × Y	2	0.10**	0.11**	0.03**	0.41ns	2.52ns
Error 2	16	0.02	0.01	0.01	0.66	8.53
D	3	0.72**	0.22**	0.20**	0.72ns	105.46**
D × Y	3	0.77**	0.18**	0.04**	1.52ns	74.30**
D × V	3	0.32**	0.19**	0.41**	0.50ns	61.87**
D × S	6	0.78**	0.70**	0.25**	1.65*	57.28**
D × V × Y	3	0.49**	0.28**	0.28**	1.24ns	193.59**
D × S × Y	6	0.52**	0.30**	0.09**	0.77ns	50.11**
D × V × S	6	0.74**	0.21**	0.26**	0.93ns	52.14**
D × V × S × Y	6	0.14**	0.06**	0.06**	0.25ns	34.38**
Error 3	72	0.02	0.01	0.01	0.65	8.38

SoV: Source of Variance; df: Degree of freedom; Y: Year; R: Replication; V: Varieties; S: Stages; D: Damage; ns: non-significant; * Significant at the $p < 0.05$ level; ** Significant at the $p < 0.01$ level

Similar results were also seen for arachidic acid, which was significantly affected ($p < 0.05$) (Table 3). Arachidic acid varied between 2.34-2.53% and the highest values were observed in R2 stage and 75% leaf damage with 2.51% and 2.53%, respectively. Besides, R3 stage and 50% leaf damage reached the same lowest arachidic acid content with the value of 2.34%. The average value for all variables was found to 2.43% (Table 4). The arachidic acid findings in our study were lower than those reported by Sogut et al. (2016), Golukcu et al. (2016), Salamatullah et al. (2021). Dwivedi et al. (1993) showed that taking precautions against fungal infections in different cultivars of peanuts resulted in higher arachidic acid levels than in the control group.

Table 4. Mean values of behenic acid, arachidic acid, lignoceric acid, oleic/linoleic (O/L) content, and iodine value (IV).

	Behenic acid (%)	Arachidic acid (%)	Lignoceric acid (%)	O/L	IV
Varieties					
Halisbey	3.12±0.03 A	2.34±0.02 B	1.22±0.03 A	1.73±0.02 B	90.90±0.30 A
NC-7	3.21±0.07 B	2.53±0.05 A	0.93±0.04 B	2.35±0.15 A	86.22±0.75 B
Stages					
R1	3.17±0.05 y	2.46±0.04 y	1.13±0.5 x	1.93±0.05	89.51±0.63 x
R2	3.31±0.03 x	2.51±0.03 x	1.06±0.03 y	1.95±0.07	88.40±0.82 xy
R3	3.02±0.09 z	2.34±0.07 z	1.03±0.07 z	2.24±0.23	87.76±1.02 y
Damage					
Control	3.22±0.05 b	2.43±0.03 b	0.98±0.03 d	2.03±0.08	87.19±1.15 b
25%	3.18±0.04 c	2.42±0.04 b	1.12±0.04 b	2.01±0.08	88.34±0.67 b
50%	2.97±0.13 d	2.34±0.09 c	1.04±0.07 c	1.89±0.06	91.03±0.34 a
75%	3.29±0.03 a	2.53±0.04 a	1.15±0.07 a	2.23±0.30	87.68±1.24 b
Years					
2020	2.68±0.02 B	2.12±0.02 B	1.12±0.02 A	2.12±0.10	89.20±0.49
2021	3.66±0.02 A	2.75±0.02 A	1.03±0.02 B	1.96±0.10	87.91±0.49
Mean	3.17±0.04	2.43±0.03	1.07±0.03	2.04±0.08	88.56±0.49

Lignoceric acid was also affected significantly (Table 3) and ranged from 0.93% to 1.22%. While the maximum values were obtained from R1 stage (1.13%) and 75% leaf damage (1.15%), R3 stage (1.03%) and control group (0.98%) had the minimum values. The mean value for lignoceric acid was 1.07%. NC-7 came to the forefront with the lowest behenic and lignoceric acid contents compared to Halisbey (Table 4). Asik et al. (2018) reported that the rate of lignoceric varied between 1.15% and 1.53%. Ergun & Zarifikhosroshahi (2020) reported that the lignoceric acid ratio ranged between 0.83% and 1.49%. The lignoceric acid ratio in our trial was found to be similar to the literature studies. Dwivedi et al. (1993) showed that a certain difference was recorded in the performance of different peanut cultivars under the effects of leaf diseases of peanut plants, however no difference was observed between control and treated groups. This study had similar results with these studies for behenic, arachidic, and lignoceric acids. Increasing leaf damage to 75% decreased saturated fatty acid ratios in peanuts.

Oleic/Linoleic acid (O/L) ratio was affected significantly ($p < 0.05$) by varieties and stage × leaf damage interaction (Table 3). O/L ratio ranged from 1.73 to 2.35 with the mean of 2.04. Even if it was found insignificant for leaf damage and stage, the highest O/L ratio was observed in 75% leaf damage and R3 stage with 2.23 and 2.24, respectively. NC-7 came to the forefront for the varieties with a value of 2.35 compared to Halisbey (Table 4). Iodine Value (IV), a further important quality parameter for oil, was found to be significant ($p < 0.05$) for the leaf damage ratio and its interactions with other independent variables (Table 3). IV varied between 86.22-90.90, with the mean value for 88.56. The maximum value was obtained from 50% leaf damage and R2 stage with 91.03 and 89.51, respectively. Unlike the O/L ratio, Halisbey had the highest value (90.90) compared to NC-7 (86.22) (Table 4). On the other hand, the highest O/L ratio, one of the significant parameters for oil quality, was obtained from 75% leaf damage which also had the lowest IV. O/L ratio and IV, two of the most important quality parameters for oil, define the shelf-life, storability, and quality of peanut oil and peanut-based products (Lopez et al., 2001; Asibuo et al., 2008; Gali et al., 2021). It was stated by Yol et al. (2017) and Ergun & Zarifikhosroshahi (2020) that low IV and high O/L ratio provide a good stability and long shelf life for peanuts. High oleic acid content is a valuable nutrient for augmented thermos-oxidative stability and human health. Besides, IV is an indicator for the unsaturated fatty acids in oil (Lopez et al., 2001). Dwivedi et al. (1993) found that the O/L ratio was higher in applications without fungicide treatment for leaf diseases in different peanut cultivars. In our studies, although no differences were observed between groups in practice or over time, the O/L ratio increased as the damage rate increased.

The Pearson correlation coefficients and significance levels for the characteristics examined in the two-year average data of this study are shown in Table 5. Arachidic acid showed a strong positive correlation with behenic acid (r = 0.919) and stearic acid (r = 0.750). Additionally, linoleic acid showed a significantly high correlation with IV (r = 0.900), whereas a significant negative correlation was observed between linoleic acid and O/L (r = -0.809), as expected. There was also a significant negative correlation between O/L ratio and IV (Table 5). Generally, applications with a high O/L ratio have low IV. These findings were similar to those of studies by Yol et al. (2017).

Table 5. Pearson correlation coefficients between features for mean values.

	OC	OA	LA	PA	SA	BA	AA	LCA	O/L
OA	0.237**	1							
LA	-0.020	-0.537**	1						
PA	-0.058	-0.555**	0.170*	1					
SA	-0.386**	-0.261**	-0.253**	-0.025	1				
BA	-0.506**	-0.654**	0.050	0.133	0.730**	1			
AA	-0.523**	-0.443**	-0.064	-0.030	0.750**	0.919**	1		
LCA	0.043	-0.401**	0.388**	0.153	-0.275**	0.139	0.041	1	
O/L	-0.008	0.343**	-0.809**	-0.108	0.122	-0.067	0.005	-0.247**	1
IV	0.099	-0.117	0.900**	-0.086	-0.432**	-0.279**	-0.304**	0.251**	-0.776**

OL: Oil content, OA: Oleic acid, LA: Linoleic acid, PA: Palmitic acid, SA: Stearic acid, BA: Behenic acid, AA: Arachidic acid, LCA: Lignoceric acid, O/L: Oleic/Linoleic (O/L) content, IV: Iodine value, ** $p > 0.05$

4. CONCLUSION

Fluctuations in the global climate with the passage of time are making it difficult for both people and living things in nature to live. Sudden climate changes continue to affect all plants. It has been observed that the peanut plant has a compound leaf structure, with 1,500-3,000 leaves, though this number varies by variety. Peanut is an interesting plant in terms of flowering, due to its agronomic and biological structure. From an agronomic and biological perspective, peanut is also notable for its unique flowering behavior. Observations from the study showed that following leaf damage, new leaves continued to develop until harvest. As a result of the study, it was determined that leaf damage increased the oil content, oleic acid, linoleic acid, palmitic acid, stearic acid, behenic acid, arachidic acid, and lignoceric acid, and decreased the O/L ratio and iodine value. However, despite the rise in oil and fatty acid levels, heavy leaf damage caused a considerable reduction in economic yield due to the marked decline in per-hectare productivity. The findings suggest that the increases in oil content and fatty acids observed under leaf damage may represent a physiological defense mechanism of the peanut plant against stress. Overall, leaf damage and its timing had significant effects on oil content and fatty acid composition, with values increasing proportionally to the severity of leaf damage.

ACKNOWLEDGEMENT

A portion of the information offered in this research article was drawn from the first author's PhD dissertation. We sincerely appreciate Hatay Mustafa Kemal University Coordinatorship of Scientific Research Projects for funding this research (Project number: 19.M.045) and Osmaniye Oil Seed Research Institute for supplying the genotypes used in this study.

REFERENCES

Adomou, M., Prasad, P. V. V., Boote, K. J., & Detongnon, J. (2005). Disease assessment methods and their use in simulating growth and yield of peanut crops affected by leafspot disease. Annals of Applied Biology, 146(4), 469-479. https://doi.org/10.1111/j.1744-7348.2005.040122.x

Akcura, S., Ismail, T. A. S., Kokten, K., Kaplan, M., & Bengu, A. S. (2021). Effects of irrigation intervals and irrigation levels on oil content and fatty acid composition of peanut cultivars. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 49(2), 12224-12224. https://doi.org/10.15835/nbha49212224

Anco, D. J., Thomas, J. S., Jordan, D. L., Shew, B. B., Monfort, W. S., Mehl, H. L., & Campbell, H. L. (2020). Peanut yield loss in the presence of defoliation caused by late or early leaf spot. Plant Disease, 104(5), 1390-1399. https://doi.org/10.1094/PDIS-11-19-2286-RE

Andersen, P. C., & Gorbet, D. W. (2002). Influence of year and planting date on fatty acid chemistry of high oleic acid and normal peanut genotypes. Journal of Agricultural and Food Chemistry, 50(5), 1298-1305.

Anonymous. (2025). Plant pests agricultural control technical instructions https://www.tarimorman.gov.tr/TAGEM (Accessed April 2, 2025).

Arioglu, H. H. (2014). The Oil Seed Crops Growing and Breeding. The Publication of University of Cukurova, Faculty of Agriculture, Adana, Turkey.

Arioglu, H. H., Bakal, H., Gulluoglu, L., Kurt, C., & Onat, B. (2016). The determination of some important agronomical and quality properties of peanut varieties in main crop conditions. Biotech Studies, 25(2), 24-29.

Asibuo, J. Y., Akromah, R., Safo-Kantanka, O., Adu-Dapaah, H. K., Ohemeng-Dapaah, S., & Agyeman, A. (2008). Chemical composition of groundnut, *Arachis hypogaea* (L) landraces. African Journal of Biotechnology, 7(13), 2203-2208.

Asik, F. F., & Asik, B.B. (2023). Macro and micro element composition of some peanut (*Arachis hypogaea* L.) varieties in Turkey. Journal of Agricultural Sciences, 29(1), 38-46. https://doi.org/10.15832/ankutbd.962154

Asik, F. F., Yildiz, R., & Arioglu, H. H. (2018). The determination of new peanut varieties for Osmaniye Region and their important agronomic and quality characteristics. Journal of Agriculture and Nature, 21(6), 825-836. https://doi.org/10.18016/ksutarimdoga.vi452842.

Bera, S. K., Kamdar, J. H., Kasundra, S. V., Dash, P., Maurya, A. K., Jasani, M. D., & Varshney, R. K. (2018). Improving oil quality by altering levels of fatty acids through marker-assisted selection of ahfad2 alleles in peanut (*Arachis hypogaea* L.). Euphytica, 214, 1-15. https://doi.org/10.1007/s10681-018-2241-0

Bodoira, R., Cittadini, M. C., Velez, A., Rossi, Y., Montenegro, M., Martínez, M., & Maestri, D. (2022). An overview on extraction, composition, bioactivity and food applications of peanut phenolics. Food chemistry, 381, 132250. https://doi.org/10.1016/j.foodchem.2022.132250

Candela, F. M., Giordano, W. F., Quiroga, P. L., Escobar, F. M., Mañas, F., Roma, D. A., & Sabini, M. C. (2020). Evaluation of cellular safety and the chemical composition of the peanut (*Arachis hypogaea* L.) ethanolic extracts. Heliyon, 6(10). https://doi.org/10.1016/j.heliyon.2020.e05119

Chowdhury, F. N., Hossain, D., Hosen, M., & Rahman, S. (2015). Comparative study on chemical composition of five varieties of groundnut (*Arachis hypogaea*). World Journal of Agricultural Science, 11(5), 247-254. https://doi.org/10.5829/idosi.wjas.2015.11.5.1864

Deshmukh, D. B., Marathi, B., Sudini, H. K., Variath, M. T., Chaudhari, S., Manohar, S. S., & Pasupuleti, J. (2020). Combining high oleic acid trait and resistance to late leaf spot and rust diseases in groundnut (*Arachis hypogaea* L.). Frontiers in Genetics, 11, 487438. https://doi.org/10.3389/fgene.2020.00514

Dwivedi, S. L., Nigam, S. N., Subrahmanyam, P., Jambunathan, R., Nagabhushanam, G. V., Reddy, P. M., & McDonald, D. (1993). Effect of foliar diseases control by chlorothalonil on pod yield and quality characteristics of confectionery groundnuts (*Arachis hypogaea* L). Journal of the Science of Food and Agriculture, 63(3), 265-271.

Ergun, Z., & Zarifikhosroshahi, M. (2020). A comparative analysis of oil content and fatty acid in different varieties of *Arachis hypogaea* L. from Turkey. International Journal of Agriculture Forestry and Life Sciences, 4(1), 42-47.

Favero, A. P., Moraes, S. A. D., Garcia, A. A. F., Valls, J. F. M., & Vello, N. A. (2009). Characterization of rust, early and late leaf spot resistance in wild and cultivated peanut germplasm. Scientia Agricola, 66, 110-117. https://doi.org/10.1590/S0103-90162009000100015

Gali, S., Reddy, D. L., Rajesh, A. P., John, K., Sudhakar, P., & Rao, V. S. (2021). Genetic variability studies in large seeded peanut (*Arachis hypogaea* L.). The Pharma Innovation Journal, 10(9), 2065-2069.

Golukcu, M., Toker, R., Tokgoz, H., & Kadiroglu, A. (2016). Oil content and fatty acid composition of some peanut (*Arachis hypogaea*) cultivars grown in Antalya conditions. Gıda, 41(1), 31-36.

Gulluoglu, L., Bakal, H., Onat, B., El-Sabagh, A., & Arioglu, H. (2016). Characterization of peanut (*Arachis hypogaea* L.) seed oil and fatty acids composition under different growing season under Mediterranean environment. Journal of Experimental Biology And Agriculture Sciences, 4(5), 465-571. http://dx.doi.org/10.18006/2016.4(5S).564.571

Hammons, R. O., Herman, D., & Stalker, H. T. (2016). Origin and Early History of the Peanut. In Peanuts. USA: American Oil Chemists' Society Press.

Isler, N., & Gozuyesil, R. (2016). Determination of problems related to peanut cultivation in Osmaniye province. Biotech Studies, 25(2), 36-41.

Janila, P., Pandey, M. K., Shasidhar, Y., Variath, M. T., Sriswathi, M., Khera, P., & Varshney, R. K. (2016). Molecular breeding for introgression of fatty acid desaturase mutant alleles (ahFAD2A and ahFAD2B) enhances oil quality in high and low oil containing peanut genotypes. Plant Science, 242, 203-213. https://doi.org/10.1016/j.plantsci.2015.08.013

Jelic, D., Megyeri, O. A., Malečić, B., Belušić Vozila, A., Strelec Mahović, N., & Telišman Prtenjak, M. (2020). Hail climatology along the northeastern Adriatic. Journal of Geophysical Research: Atmospheres, 125(23), e2020JD032749. https://doi.org/10.1029/2020JD032749

Kachroo, A., Shanklin, J., Whittle, E., Lapchyk, L., Hildebrand, D., & Kachroo, P. (2007). The Arabidopsis stearoyl-acyl carrier protein-desaturase family and the contribution of leaf isoforms to oleic acid synthesis. Plant Molecular Biology, 63, 257-271. https://doi.org/10.1007/s11103-006-9086-y

Kahraman, A., Tilev-Tanriover, S., Kadioglu, M., Schultz, D.M., & Markowski, P. M. (2016). Severe hail climatology of Turkey. Monthly Weather Review, 144(1), 337-346. https://doi.org/10.1175/MWR-D-15-0337.1

Kamdar, J. H., Jasani, M. D., Ajay, B. C., Rani, K., Manivannan, N., Vasanthi, R. P., & Bera, S. K. (2021). Fatty acid desaturase-2 (ahFAD2) mutant alleles in peanut (*Arachis hypogaea* L.) pre-breeding lines: an insight into the source, features, discourse, and selection of novel pre-breeding lines. Genetic Resources and Crop Evolution, 68, 529-549. https://doi.org/10.1007/s10722-020-00999-0

Kaya, M., & Kovancı, B. (2000). Bursa İlinde Yeşilkurt, *Helicoverpa armigera* (Hübn.) (*Lepidoptera: Noctuidae*)'nın Biyolojisi Üzerinde Araştırmalar. Yuzuncu Yil University Journal of Agricultural Sciences, 10(1), 37-43.

Kopp, J., Schröer, K., Schwierz, C., Hering, A., Germann, U., & Martius, O. (2023). The summer 2021 Switzerland hailstorms: weather situation, major impacts and unique observational data. Weather, 78(7), 184-191. https://doi.org/10.1002/wea.4306

Lopez, Y., Smith, O. D., Senseman, S. A., & Rooney, W. L. (2001). Genetic factors influencing high oleic acid content in Spanish market-type peanut cultivars. Crop Science, 41(1), 51-56. https://doi.org/10.2135/cropsci2001.41151x

Nadaroglu, Y., & Simsek, O. (2012). Hail damage in agriculture and ways of protection. https://www.mgm.gov.tr/FILES/genel/makale/doluzarari.pdf (Accessed April 2, 2025)

Sahin, C. B., Yilmaz, M., & Isler, N. (2022). Determination of oil quality and fatty acid compositions of some peanut (*Arachis hypogaea* L.) genotypes grown in Mediterranean Region. Turkish Journal of Field Crops, 27(1), 142-148. https://doi.org/10.17557/tjfc.1095649

Salamatullah, A. M., Alkaltham, M. S., Ozcan, M. M., Uslu, N., & Hayat, K. (2021). Effect of maturing stages on bioactive properties, fatty acid compositions, and phenolic compounds of peanut (*Arachis hypogaea* L.) kernels harvested at different harvest times. Journal of Oleo Science, 70(4), 471-478. https://doi.org/10.5650/jos.ess20320

Sarkaya Ahat, C. (2015). The Effects of Sequence Application of Pesticides on Degradation Kinetics for Tomatoes and Pepper Fruits. MSc, Adnan Menderes University, Aydın, Turkey.

Shibli, S., Siddique, F., Raza, S., Ahsan, Z., & Raza, I. (2019). Chemical composition and sensory analysis of peanut butter from indigenous peanut cultivars of Pakistan. Pakistan Journal of Agricultural Research, 32(1), 159-169. http://dx.doi.org/10.17582/journal.pjar/2019/32.1.159.169

Sogut, T., Ozturk, F., & Kizil, S. (2016). Effect of sowing time on peanut (*Arachis hypogaea* L.) cultivars: II. Fatty acid composition. Agriculture and Agricultural Science Procedia, 10, 76-82. https://doi.org/10.1016/j.aaspro.2016.09.018

Reddy, P. P. (2015). Impacts of Climate Change on Agriculture. Climate Resilient Agriculture for Ensuring Food Security. New Delhi: Springer India.

Pandey, M. K., Monyo, E., Ozias-Akins, P., Liang, X., Guimarães, P., Nigam, S. N., & Varshney, R. K. (2012). Advances in Arachis genomics for peanut improvement. Biotechnology Advances, 30(3), 639-651. https://doi.org/10.1016/j.biotechadv.2011.11.001

Tene, T.M., Eker, T., Canci, H., Babacan, U, Cengiz, M.F. & Toker, C. (2025). Star of biochemical traits of heat-tolerant and heat-sensitive Phaseolus genotypes in coping with heat stress. Plant Growth Regulation, 1-18. https://doi.org/10.1007/s10725-025-01340-4.

Toker, C & Yadav, S.S. (2010). Legumes Cultivars for Stress Environments. In: S.S. Yadav et al. (eds.), Climate Change and Management of Cool Season Grain Legume Crops, pp:351-376. https://doi.org/10.1007/978-90-481-3709-1_18,

Tillman, B. L., & Stalker, H. T. (2009). Peanut. In J. Vollmann, J., & I. Rajcan (Eds.), Oil Crops (pp. 287-315). Springer New York.

Xue, H. Q., Upchurch, R. G., & Kwanyuen, P. (2006). Ergosterol as a Quantifiable Biomass Marker for Diaporthe haseolorum and Cercospora kikuchi. Plant disease, 90(11), 1395-1398. https://doi.org/10.1094/PD-90-1395

Wilson, R. A., Calvo, A. M., Chang, P. K., & Keller, N. P. (2004). Characterization of the Aspergillus parasiticus Δ12-desaturase gene: a role for lipid metabolism in the Aspergillus–seed interaction. Microbiology, 150(9), 2881-2888. https://doi.org/10.1099/mic.0.27207-0

Ucak, A. B., Cil, A., Tuysuz, M. D., Sahin, H., & Sarli, E. (2017). Determination of water stress tolerant peanut (*Arachis hypogaea*) lines. Journal of Agriculture and Nature 20, 246-251.

Variath, M. T., & Janila, P. (2017). Economic and academic importance of peanut. In: R. Varshney, M. Pandey, & N. Puppala. (Eds.), The Peanut Genome (pp. 7-26). Springer Cham.

Yasli, S., Isler, N., & Sahin, C. B. (2020). The effect of single and twin planting patterns on yield and important agricultural characteristics of main cropped peanut under Diyarbakir conditions. Journal of Agriculture and Nature, 23(1), 91-98. https://doi.org/10.18016/ksutarimdoga.vi.552168

Yilmaz, M., & Jordan, D. L. (2022). Effect of plant density on yield and quality of peanut (*Arachis hypogaea* L.) cultivars. Turkish Journal of Field Crops, 27(2), 217-223. https://doi.org/10.17557/tjfc.1148572

Yol, E., Ustun, R., Golukcu, M., & Uzun, B. (2017). Oil content, oil yield and fatty acid profile of groundnut germplasm in mediterranean climates. Journal of the American Oil Chemists' Society, 94(6), 787-804. https://doi.org/10.1007/s11746-017-2981-3

Yol, E., & Uzun, B. (2018). Influences of genotype and location interactions on oil, fatty acids and agronomical properties of groundnuts. Grasas Y Aceites, 69(4), e276-e276. https://doi.org/10.3989/gya.0109181

Yu, H., Liu, H., Wang, Q., & Van Ruth, S. (2020). Evaluation of portable and benchtop NIR for classification of high oleic acid peanuts and fatty acid quantitation. Lwt, 128, 109398. https://doi.org/10.1016/j.lwt.2020.109398