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Effect of Leaf Damage Ratios on Peanut (*Arachis hypogaea* L.) Production and Quality

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ABSTRACT

This study was carried out to determine the effects of leaf damage rates at different growth stages of peanut (*Arachis hypogaea* L.) cultivars under Eastern Mediterranean conditions of Turkey (Osmaniye Province). The study was conducted in completely randomized design in split-split-plots with three replications, in 2020 and 2021. Cultivars NC 7 and Halisbey were in the main plots, growth stages (R1, R2 and R3) in sub-plots, and leaf damages (control, 25, 50, and 75%) in the sub-sub-plots. Yield and various quality parameters were measured and recorded. The highest value of the number of pods per plant was obtained from the Halisbey (24.5±0.4) cultivar, the R2 period (23.5±0.6), and the control (25.7±0.6) treatment. The number of pods per plant decreased when the leaf damage increased. The highest pod yield was obtained from NC 7 cultivar (2302±8.2 kg ha^{-1}) and R1 period (2041±9.1 kg ha^{-1}). The order of leaf damage treatments in terms of yield was as the control (2536±8.8 kg ha^{-1}), 25% LD treatment (2011±8.0 kg ha^{-1}), 50% LD treatment (1906±11.9 kg ha^{-1}), and 75% LD (1481±7.6 kg ha^{-1}). Thus, it was determined that the selection of cultivars and integrated control against diseases and pests are important in order to reduce the effect of leaf damage on the quality and yield of peanuts in Osmaniye conditions.

Keywords: Groundnut, Cultivar NC 7, Cultivar Halisbey, Growth stages.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) has been originated from South America, belongs to the leguminous family and is also known as groundnut. The peanut plant was cultivated 8500 years ago in the Zana Valley in northern Peru, possibly on the eastern side of the Andes Mountains (Hammons *et al*., 2016). Peanut has been the most valuable food source for thousands of years, especially in China, India and America, and has an important role in human and animal nutrition due to its oil, protein, mineral and vitamins (List, 2016; Sahin *et al*., 2023).

Peanut has been widely used in the oil industry as well as in human and animal nutrition. Peanut is an important oil crop due to its high oil content (42-52%) and also an important protein source for animal nutrition with its 25-32% protein content (Shubo *et al*., 2004). Peanut is cultivated on an area of 29.5 million hectares with a total production of 43.5 million tons around the world. The world average yield of peanut is 1666 kg ha^{-1}. In Turkey, peanut was cultivated in approximately 55 thousand hectares, with 215 thousand tons of production and an average yield of 3940 kg ha^{-1} in 2022 (FAO, 2022; TUIK, 2022). Peanut yield in Turkey is higher than the world average due to the cultivation of peanut on fertile soils. In Turkey, 49% of peanut production is in Adana, 27.2% in Osmaniye, 11.6% in Sırnak province while the remaining is produced in other provinces. However, 95% of the marketing and processing of peanuts in Turkey is carried out in Osmaniye province (Isler and Gozuyesil, 2016).

Due to global climate change, natural disasters such as forest fires, floods, high

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temperatures, landslides, and deadly diseases (Covid-19, etc.) has threatened both human and nature in the world and in Turkey. In short, the world is now openly subjected to natural disasters, in addition to global warming (Chaudhry and Sidhu, 2022). Enyi (2008) reported that leaf damages in four legumes (peanut, soybean, cowpea and mung bean) reduced the number of pods per plant, pod and seed yield, and the damage imposed during pod formation, especially in peanuts, caused a decrease in pod yield. It was determined that, as the leaf damage increased, all plants showed a decrease in pod yield.

Singh *et al*. (2011) reported 30% increase in the yield of peanut by using fungicide. Moreover, it was recognized that late leaf spot (*Nothopassalora personata*) disease lesions covering all surface areas of the leaves caused premature aging of the plant as well as yield losses.

Mukhtar (2014) conducted an experiment in split-plot design, having control group and three leaf damage ratios (10, 20 and 30%), two time intervals (4 weeks after sowing, 6 weeks after sowing) and two peanut varieties (SAMNUT 21 and SAMNUT 23). At the end of the experiment, it was reported that the effect of leaf damage ratios on pod and stem yield differed according to the timing and variety. They reported that yield losses in peanut occurred as a result of biotic and abiotic factors such as hail, leaf pests, leaf diseases, wind, drought, and grazing of animals during the peanut production season.

Biotic (diseases and pests) and abiotic (hail, flood, high temperature, forest fires, etc.) stress conditions affect peanut resulting in leaf losses for about last decades more than before.

In the present study, the effect of leaf losses in peanut on yield and important agricultural characteristics was investigated when no precautions were taken against biotic and abiotic stresses caused by climate change. There is no comprehensive study on this subject in peanut in the world and in Turkey. The results of the research will contribute to the knowledge of the effect of the reduction of the photosynthetic area in peanut plants caused by diseases, pests and climate change. Specifically, it will allow knowing the behavior of the most cultivated varieties of peanuts in the Turkey production region in terms of tolerance to defoliation and its effect on yield and quality.

MATERIALS AND METHODS

The NC 7 cultivar, which accounts for 95% of the peanut cultivation in Turkey, and the Halisbey cultivar, which has recently become widespread in the region, were used as plant material (Isler and Gozuyesil, 2016). The experiment was carried out at the agricultural research and examination location (37^{o} 07' 30.11" N; 36^{o} 11' 57.35" E, 65 m) in Cevdetiye Town belonging to the directorate of Oil Seed Research Institute.

The soil analysis of the experimental area indicated that the soil was high in pH and iron content, medium in calcium, and insufficient in lime, nitrogen, phosphorus, potassium and organic matter. The average climatic values of 2020, 2021 and 1987-2020 of Osmaniye, where the experiment was conducted, are given in Figure 1.

The research was carried out in split split-plot design in three replications, for 2 years i.e. 2020 and 2021. Cultivars (NC 7 and Halisbey) were placed on main plots, treatment stages [flowering time (R1), gynophore formation time (R2), pod formation time (R3)] were placed on sub-plots, and leaf damage ratios ratios (control, 25, 50, 75%) were placed on sub-sub-plots. Each plot consisted of 4 rows having 5 m length and the planting density was maintained as 70×15 cm. All the necessary cultural practices (i.e., spraying, hoeing, weed control, irrigation, etc.) were carried out on time and in accordance with the proper techniques.

While damaging the leaves according to the treatment 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

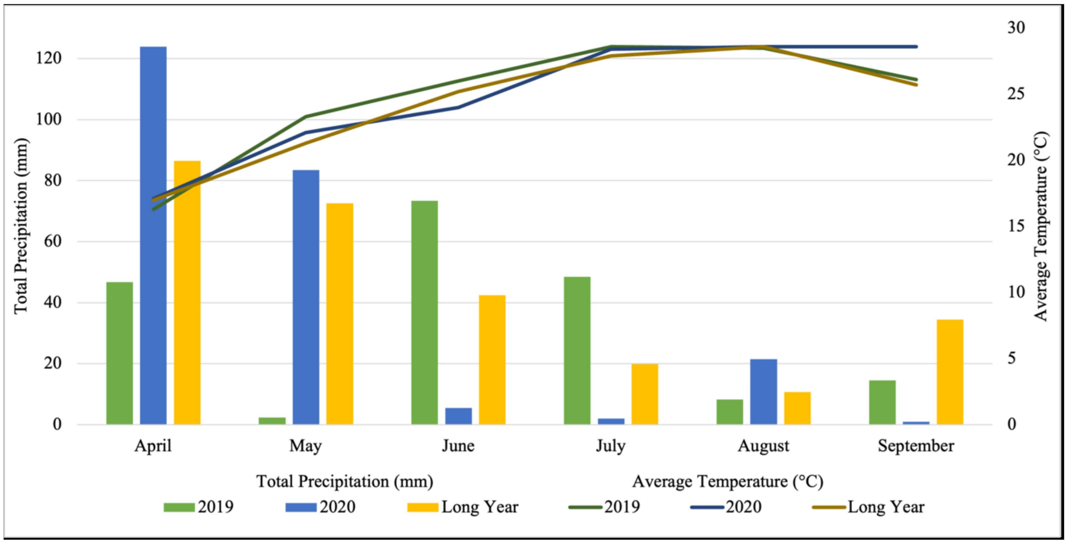

Figure 1. Climate parameters of the research field (2020, 2021 and 1987-2020 average).

leaf structure on the branch, the number of leaves on the branch was 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 with the help of scissor. Detail of all the activities performed according to the years are given in Table 1.

Number of branches per plant, plant height, leaf area index, number of pods per plant, pod weight per plant, the first quality pod weight ratio, shelling percentage, pod yield, protein content, 100-seed weight and 100-pod weight were measured for 20 plants randomly selected from each plot following the harvest. For 100-seed and 100-pod weights, 4×100 seed/pod groups were taken from each plot and they were weighed, and averaged. Pod yield was determined through weighing the pods of all plants of a plot, except side effect rows. Seed nitrogen content was calculated by Kjeldahl method, and the conversion factor used for calculating protein content of seed was 5.46. Each pod containing two seeds were counted and were determined for the first quality pod ratio (Sahin *et al*., 2023).

Statistical Analysis

The data obtained in this research was analyzed using R v4 and SPSS 22 statistical programs according to ANOVA, the split-split-plot experimental design and Pearson's correlation. The comparison of the means was carried out according to the Duncan's multiple range test.

RESULTS AND DISCUSSION

Number of Branches per Plant

There was no statistical difference in most

Table 1. Dates of sowing, harvesting, and treatments.

	First year (2020)	Second year (2021)
Sowing date	April 30	April 29
1st Period of leaf damage (R1)	June 12	June 11
2nd Period of leaf damage (R2)	June 25	June 22
3rd Period of leaf damage (R3)	July 17	July 16
Harvesting date	September 23	September 27

interactions in the two-year average of number of branches per plant; however, a statistically significant difference was found among cultivar × growth stages × application (P < 0.01) (Table 2). According to the two-year data, the average number of branches per plant in Halisbey cultivar was 10.5, while this value was 7.9 in NC 7 cultivar. Regarding stages, the average number of branches per plant were 8.7, 8.9 and 10.1 in R3, R2, and R1 stages, respectively. More damage to branches and leaves at 75% LD ratio resulted in a smaller number of branches per plant (Table 2). Izge *et al*. (2007) reported that number of branches per plant varied between 4.0 and 21.0 while Meena *et al*. (2016) found that the number of plant branches varied between 3.89 and 4.53. The differences among studies were not affected only by varietal and environmental factors but also by increasing leaf losses.

Plant Height

There was no statistical difference in most interactions, except cultivar × stage interactions (P < 0.01) in the two-year plant height (Table 2). In two-year averages, the plant height of Halisbey cultivar was 53.8 cm while the plant height of NC 7 cultivar was 57.5 cm. The stages of application were divided into two different groups, R1 (56.5 cm) and R2 (56.2 cm) stage were in the same group while the R3 stage (54.1 cm) was in a different group. LD treatments were divided into two different groups among themselves, of which 50% LD and control resulted in maximum plant height with 57.0 cm, 56.4 cm values, respectively, while 25 and 75% LD resulted in lowest plant height with 54.8 cm and 54.3 cm values, respectively (Table 2). Abbott *et al*. (2019) stated that plant height in peanut varied between 18.6 cm and 30.0 cm and plant height decreased as the leaf damage ratio increased. Joseph *et al*. (2019) reported that plant height varied between 12.3 cm and 19.2 cm, depending on stages, damage level and variety. Izge *et al*. (2007) determined that the plant height ranges from 8.0 cm to 36.7 cm. The results obtained from this study was higher than the previously reported studies. It was observed that leaf damage, was an important stress factor, affecting the plant height directly. Besides, the plant was influenced a lot by the leaf damage exposed in pod formation. In the pod formation (R3) stage, the plant height decreased with increase in leaf damage ratio.

Leaf Area Index (LAI)

Most of the interactions were found significant (P < 0.01) for Leaf Area Index (LAI) in the two-year averages, except cultivar × application (Table 2). Based on two-year averages, LAI was 3.4 in NC 7 while it was 4.9 in Halisbey. Regarding application stages, the lowest LAI (3.8) was found in the R3 stage, while the highest LAI (4.4) was recorded in R1 stage, thus three different groups were formed. The control and 25% LD, which were in the same group, resulted in highest LAI i.e., 4.2 and 4.3, respectively, while 50 and 75% LD were in another group and resulted in the lowermost LAI i.e., 3.9 and 3.8, respectively (Table 2). Endan *et al*. (2006) and Geetha (2018) reported that changes in leaf area were statistically significant as the leaf damage rate increased in peanuts. Kurtakoti (2001) found that the LAI in soybean showed significant difference with various level of leaf damage and it varied between 0.6 and 3.6. Ibrahim *et al*. (2010) reported that as the leaf damage level in cowpea increased, there was a significant decrease in LAI and it varied between 0.1 and 2.4. The LAI decreases as the leaf damage rate increases. The differences in leaf area might be due to the different response of cultivars to leaf damage.

Number of Pods per Plant

All interactions were found significant (P < 0.01) for the number of pods per plant in

Table 2. Mean values of number of branches per plant, plant height, leaf area index, number of pods per plant, pod weight per plant and 1st quality pod weight ratio.[a]

	Number of branches/Plant	Plant height (cm)	Leaf area index	Number of pods per plant	Pod weight per plant (g)	1st Quality pod weight ratio (%)
Cultivars	**	**	**	**	**	**
Halisbey	10.5±0.2 A	53.8±0.2 B	4.9±0.2 A	24.5±0.4 A	41.9±0.9 A	68.5±0.7 B
NC-7	7.9±0.3 B	57.5±0.5 A	3.4±0.9 B	21.7±0.4 B	37.5±0.8 B	70.6±0.6 A
Stages	**	**	**	**	ns	**
R1	10.1±0.4 x	56.5±0.7 x	4.4±0.2 x	23.2±0.6 xy	39.9±1.3	70.8±0.6 x
R2	8.9±0.4 y	56.2±0.7 x	4.2±0.2 y	23.5±0.6 x	39.2±1.2	67.9±0.9 y
R3	8.7±0.4 y	54.1±0.6 y	3.8±0.2 z	22.6±0.5 y	39.9±1.1	69.9±0.8 x
Damage	**	**	**	**	**	**
Control	10.6±0.4 a	56.4±0.6 a	4.2±0.3 a	25.7±0.6 a	44.4±1.3 a	66.6±1.0 b
25%	8.9±0.4 b	54.8±0.9 b	4.3±0.2 a	23.2±0.4 b	39.2±0.9 b	70.4±0.8 a
50%	9.1±0.4 b	57.0±0.8 a	3.9±0.3 b	22.4±0.5 c	40.4±1.3 b	70.9±0.7 a
75%	8.2±0.5 c	54.3±0.8 b	3.8±0.3 b	21.1±0.7 d	34.8±0.9 c	70.3±0.9 a
Years						
2020	10.3±0.4	60.8±0.4	4.0±0.1	27.4±0.5	51.2±1.1	74.2±0.6
2021	8.1±1.7	50.5±0.6	4.3±0.2	18.8±0.5	28.2±06	64.9±0.9
Mean	9.2±0.2	55.6±0.4	4.2±0.1	23.1±0.3	39.7±0.7	69.6±0.5
C×S	ns	**	**	**	**	ns
C×D	ns	ns	ns	**	ns	**
S×D	ns	ns	**	**	**	ns
C×S×D	**	ns	**	**	**	ns

[a] Letters show different groups in each column. ** $p < 0.01$; ns: Non-significant.

two-year averages (Table 2). Based on the two-year average, Halisbey and NC 7 cultivars were placed in two different groups with 21.7 pods plant^{-1} and 24.5 pods plant^{-1}, respectively. The lowest (22.6 pods plant^{-1}) were recorded in R3 stage while the highest (23.5 pods plant^{-1}) were recorded in R2 stage. Regarding LD ratios, the number of pods per plant for each ratio was in a different group with maximum pods/plant recorded in the control (25.7 pods plant^{-1}), followed by 25% LD (23.2 pods plant^{-1}), 50% LD (22.4 pods plant^{-1}) and 75% LD ratios (21.1 pods plant^{-1}) (Table 2). Endan *et al*. (2006) determined that the number of pods per plant varied between 5.5 pods plant^{-1} and 10.3 pods plant^{-1}. Enyi (2008) reported that there is a positive relationship between the number of pods per plant and the pod weight per plant in peanut, and defoliation or reducing the number of leaves to half at the fruit setting stage reduces the number of pod per plant. Singh *et al*. (2011) reported that the number of pods per plant varied between 15.2 pods plant^{-1} and 29.5 pods plant^{-1}. Joseph (2014) found that the number of pods per plant varied from 14.7 pods plant^{-1} to 35.3 pods plant^{-1}. Mukhtar (2014) stated that the number of pods per plant varied between 19.0 pods plant^{-1} and 21.0 pods plant^{-1} when leaves were damaged. Geetha (2018) reported that the number of pods per plant varied between 3.3 pods plant^{-1} and 23.7. In the present study, the recorded number of pods per plant was similar to the results obtained from Singh *et al*. (2011), Joseph (2014), Mukhtar (2014), and Geetha (2018) who reported a positive correlation between number of branches and pods per plant.

Pod Weight per Plant

All factors, except interaction of cultivar × damage, was found significant for two-year average of pod weight per plant ($P < 0.01$) (Table 2). In average of the two-years, the pod weight per plant of NC 7 cultivar was 37.5 and 41.9 g plant^{-1} in Halisbey cultivar. Regarding stages, the lowest pod weight per plant was obtained from the R2 (39.2 g plant^{-1}) stage and the highest from the R1 and R3 (39.9 g plant^{-1}) stage. In the applications, three different groups were determined and the highest value was obtained from the control group with 44.4 g plant^{-1}, followed by 50% LD (40.4 g plant^{-1}) and 25% LD (39.2 g plant^{-1}) in the same group, respectively. The lowest value was obtained from 75% LD (34.8 g plant^{-1}) application (Table 2). Joseph (2014) reported that leaf damage was statistically significant pod weight per plant varied between 5.3 and 20.8 g plant^{-1}. Geetha (2018) stated that, as the rate of leaf damage increased, the pod weight per plant decreased and the pod weight per plant varied between 0.1 and 5.0 g plant^{-1}. Abbott *et al*. (2019) determined that the pod weight per plant varied between 4.2 and 31.6 g plant^{-1}. In our study, pod weight values per plant showed parallelism. The pod setting was related to the number of branches, therefore, number of pods and pod weight values decreased when the leaf damage ratio increased.

1st Quality Pod Ratio

Cultivars × damage interactions were found to be statistically significant for the first quality pod weight ratio in the average of two years experiment ($P < 0.01$) (Table 2). In the average of two years, the rate of the first quality pod number was 68.5% in Halisbey, whereas it was 70.6% in NC 7. R1 (70.8%) and R3 (69.9%) stages in the same group and had the highest rate of the first quality pod number in terms of stages. The R2 (67.9%) stage in the other group had the lowest value. In terms of applications, 50% LD (70.9%), 25% LD (70.4%), and 75% LD (70.3%) applications were found in the same group, the lowest was the control (66.6%) application in the other group (Table 2). Cantonwine *et al*. (2006), in their study to determine the effect of leaf spot disease on cultivars, found the rate of the first quality pod number varied between 72.7 and 75.4%. Izge *et al*. (2007), in their study to determine the varieties resistance to cercospora leaf spot disease, reported that the rate of the first quality pod number was statistically significant and varied between 63.33 and 87.66%. Izge *et al.* (2007), in their study to determine the varieties resistance to cercospora leaf spot disease, reported that the rate of first quality pod number was statistically significant and varied between 63.3 and 87.7%. Singh *et al.* (2011), in their study to determine the resistance to leaf spot diseases in peanuts stated that the rate of the first quality pod number was statistically significant and varied between 72.7 and 75.4%. Although there was lower pod number depending on increasing leaf damage ratio, the higher first quality pod weight ratio was observed in the highest leaf damage ratio.

Hundred-Pod Weight

In the two-year average of 100-pod weight of the experiment, period × application interaction and cultivar × period × damage interactions were found statistically significant ($P < 0.01$) (Table 3). When the two-year average was examined, 100-pod weight was 180.9 g in NC 7, whereas it was 192.7 g in Halisbey. R1 (191.0 g) and R3 (186.9 g) stages were in the same group for 100-pod weight, while the R2 (182.6 g) stage with the lowest value was in a different group. The control group with the highest value (189.5 g) was found in the same group with 50% LD (189.1 g) and 25% LD (188.5 g), whereas 75% LD (180.2 g) with the lowest value was found in the other group (Table 3). Asik *et al*. (2018) determined the weight of 100-pod cultivars between 113.1 and 312.7 g. Following the study conducted by Asık *et al*. (2018), our study showed parallelism in terms of 100-pod weight data. Comparison could not be made because 100-pod weights were not checked in the leaf damage trials, 100-pod weight is related to pod yield and may vary depending on different ecological conditions, cultivation techniques, and genotype. It was also observed that the 100-pod weight decreased as the leaf damage rate increased. Probably, as the rate of leaf damage increases, the decrease in 100-pod weight maintains the 100-pod weight of the plant against the damage.

Hundred-Seed Weight

In the two-year average of 100-seed weight, most of the interactions were found to be statistically significant ($P < 0.01$), except cultivar × period × application (Table 3). In average of two-years, 100-seed weight of NC 7 was 87.3 g, whereas it was 88.2 g in Halisbey. The 100-seed weight in different stages varied between 86.9 g (R2 stage) and 88.7 g (R3 stage). In practice, the control (90.4 g) had the highest value and the lowest value was found in 75% LD (84.1 g), and they took place in two different groups (Table 3). Anderson *et al*. (1993), in their study to determine resistance of peanut plant against C*ercosporidium personatum* disease, reported that the weight of 100-seeds varied between 38.3 g and 91.9 g, and the weight of 100 seeds decreased as the disease severity increased. Joseph (2014) reported that the leaf damage rate in peanut was statistically significant at 100-seed weights. Bwala (2018) reported that early leaf spot disease in different peanut cultivars was statistically significant at 100-seed weights and varied between 35.6 g and 40.9 g. A similarity has been observed between the findings of previous studies and our study. Probably, the reason for the variation between the literature sources and the studies in which the 100-seed weight was different is due to the varieties with different genetic characteristics. While there was no change in the 100-seed weight of leaf damage period, the 100-seed weight decreased as the leaf damage rate increased. The decrease in 100 seed weight as the leaf damage rate increases may protect the leaf damage and

Table 3. Mean values of 100-pod weight, 100 seed-weight, shelling percentage, pod yield and protein content. [a]

	100-Pod weight (g)	100-Seed weight (g)	Shelling percentage (%)	Pod yield (kg ha^{-1})	Protein content (%)
Varieties	**	ns	**	**	ns
Halisbey	192.7±2.1 A	88.2±0.8	59.9±0.4 B	1670±6.3 B	26.99±0.11
NC-7	180.9±1.6 B	87.3±0.7	67.7±0.4 A	2302±8.2 A	26.84±0.16
Stages	**	ns	**	**	ns
R1	191.0±1.9 x	87.6±0.8	64.5±0.9 x	2041±9.1 x	26.97±0.14
R2	182.6±2.3 y	86.9±0.9	62.3±0.9 y	1987±12.2 y	27.06±0.18
R3	186.9±3.1 x	88.7±0.9	64.7±0.8 x	1929±11.8 z	26.72±0.18
Damage	**	**	**	**	**
Control	189.5±1.9 a	90.4±1.1 a	64.9±0.8 a	2536±8.8 a	27.02±0.22 ab
25%	188.5±2.3 a	87.5±0.8 b	64.6±1.0 a	2011±8.0 b	26.66±0.27 b
50%	189.1±3.4 a	88.8±0.8 ab	63.3±1.2 b	1906±11.9 c	26.83±0.12 ab
75%	180.2±3.4 b	84.1±0.8 c	62.4±1.2 b	1481±7.6 d	27.15±0.12 a
Years					
2020	185.4±1.7	87.4±0.7	60.9±0.8	1922±8.5	26.76±0.21
2021	188.2±2.2	88.1±0.7	66.8±05	2050±5.9	27.07±0.15
Mean	186.9±1.5	87.7±0.5	63.8±0.5	1986±6.4	26.92±0.98
C × S	ns	**	ns	**	**
C × D	ns	**	ns	**	**
S × D	**	**	ns	**	**
C × S × D	**	ns	ns	**	ns

[a] Letters show different groups in each column. ** $p < 0.01$; ns: Non-significant.

provide a defence mechanism against damage.

Shelling Percentage

In the average of the two-years of shelling percentage, all interactions were found to be non-significant ($P > 0.01$) (Table 3). The shelling percentage was 59.9% in Halisbey and 67.7% in NC 7. In terms of stages, R3 (64.7%) and R1 (64.5%) stages with the highest value were in the same group, while the R2 stage (62.3%) was the lowermost and took place in a different group. When two different groups occurred in the applied leaf damage, the shelling percentages were listed as the control group (64.9%), 25% LD (64.6%), 50% LD (63.3%) and 75% LD (62.4%) treatments, respectively ($P < 0.01$) (Table 3). Anderson *et al*. (1993) reported that the shelling percentage was statistically significant and the shell/core ratio varied between 62.8%-76.1%. Joseph (2014) stated that leaf damage in peanuts affected the shelling percentage statistically and the shelling percentage varied between 56.7 and 75.1%. Caliskan *et al*. (2008) reported that the shelling percentage of different peanut varieties varied between 54.3 and 72.10% in Hatay conditions. Our findings showed parallelism with Joseph (2014) and Caliskan *et al*. (2008) who worked in terms of shelling percentage. Results of Anderson *et al*. (1993), on the other hand, differed from the other studies. The decrease in the shelling percentage as the leaf damage rate increases may be due to the variety and application difference. However, as the damage rate increases, the nutrients contained in the plant can be transported to the damaged part of the plant to reduce the damage to the vegetative organs of the plant.

Pod Yield

All interactions were significant in the two-year average of the pod yield ($P < 0.01$) (Table 3). In the average of two years, the pod yield was 1,670 kg ha^{-1} in Halisbey and 2.302 kg ha^{-1} in NC 7. In terms of stages, the pod yield was lowest i.e.1,929 kg ha^{-1} in the R3 stage, and was the highest i.e., 2,041 kg ha^{-1} in R1 stage. The treatments were divided into four different groups among themselves, and the maximum pod yield i.e. 2.536 kg ha^{-1} was recorded in the control group, while yield of 75, 25 and 50% LD treatments, each in a different group, were determined as 1,481, 1,906 and 2,011 kg ha^{-1}, respectively (Table 3). Butzler (1998), in his study of leaf damage and integrated fungicide treatment in peanut, reported that the pod yield was statistically significant and the pod yield varied between 3,031 and 6,002 kg ha^{-1}. Baughman (2006) stated that, as the rate of leaf damage in peanuts increases, there would be a statistical decrease in yield. Cantonwine *et al*. (2006), in their study to determine the effect of leaf spot disease on cultivars, reported that pod yield varied between 2,663 to 5,316 kg ha^{-1}. Izge *et al*. (2007) observed that pod yield was statistically significant and varied between 1,280 and 3,585 kg ha^{-1}. Mukhtar (2014) reported that different leaf levels (amount, ratio and leaf density) in peanuts reduced pod yield and were statistically significant. The pod yield values of our study showed similarities with the studies in the literature. It was observed that the pod yield decreased as the leaf damage rate increased in peanuts and the damage in the near-harvest periods. As the rate of leaf damage increases, a vegetative and physiological damage occurs in the plant. While the plant is trying to cover the vegetative damage, it is thought that the pod yield, which is a generative feature, cannot be achieved, so, the pod yield is low.

Protein Content

Most of the interactions, except cultivar × period × damage, were significant for the two-year average of protein ratio ($P < 0.01$) (Table 3). The protein ratio was 26.84% in NC 7 and 26.99% in Halisbey. Regarding stages, the highest protein ratio was found in the R2(27.06%) and the lowest in the R3(26.72%). The treatments were divided into three different groups among themselves and 27.15% with 75% LD treatment was the most, whereas 26.66% with 25% LD treatment was the lowest (Table 3). Arioglu *et al*. (2016) found that the protein ratio varied between 23.68 and 29.27%. Gulluoglu (2016) stated that the protein ratio varied between 24.40-26.15%. Asik *et al*. (2018) found that the protein ratio varied between 21.91% and 32.38%. The protein ratio found in our experiment showed parallelism with the literature studies. As the leaf damage rate increased, the protein content increased. It is likely that the protein content in leaves and other organs can be transported to the seeds for seed protection.

Correlation

The Pearson correlation coefficients and significance levels for the characteristics examined in the two-year average data are shown in Table 4. For pod weight per plant, a significant and positive correlation was determined between the number of pods per plant, plant height, and number of lateral branches. Among the number of pod per plant and plant height, pod yield and shelling percentage, the first quality pod weight ratio and plant height, a significant and positive correlation was observed between 100-seed weight and 100-pod weight. It was determined that there was a significant and negative relationship between the shelling percentage and the number of branches per plant. Our findings were similar to the study conducted by Sahin *et al*. (2023).

CONCLUSIONS

Due to the global climate change, extreme weather events (such as hail) occur in summer periods in Turkey, as in many parts of the world. Global climate change causes an increase in the rate of plant diseases and pests all over the world. This situation causes leaf damage and reduction in leaf number of peanut plants. The results of this experiment indicate that

Table 4. Pearson correlation coefficients between features (Mean).[a]

	PW	NP	PY	FQP	SP	HSW	HPW	PH	NB	LAI
PW	1									
NP	.838**	1								
PY	0.019	0.068	1							
FQP	.487**	.444**	-0.037	1						
SP	-.418**	-.383**	.555**	-0.101	1					
HSW	0.108	0.079	.177*	0.015	.229**	1				
HPW	0.086	0.09	0.023	.184*	0.101	.510**	1			
PH	.652**	.517**	.165*	.490**	-.198*	0.127	-0.074	1		
NB	.535**	.491**	-.175*	0.066	-.616**	.170*	.170*	.329**	1	
LAI	0.014	0.143	-0.047	-0.122	-.270**	-0.03	.199*	-.182*	.283**	1
PC	-0.087	-.179*	-0.044	-.252**	-.230**	0.012	-.166*	0.028	.257**	0.112

[a] PW: Pod Weight, NP: Number of Pods per plant, PY: Pod Yield, FQP: First Quality Pod ratio, SP: Shelling Percentage, HSW: 100-Seed Weight, HPW: 100-Pod Weight; PH: Plant Height, NB: Number of Branches per plant, LAI: Leaf Area Index, PC: Protein Content.

leaf damages at R1 and R2 stages do not cause much economic damage in quality and yield of the peanut plant, while the damage, especially at R3 stage, causes a decrease in the economic level. Peanut growers need to follow these times and it will be essential to take the necessary precautions. When 25% LD in peanut plant causes a 20% decrease in pod yield, further increase in the damage rate up to 75%, reduces the pod yield by 42%. As the severity of the damage increases, the pod yield decreases, which causes economic loss. When the cultivars were compared, it was found that the NC 7 tolerated the damage better than the Halisbey and the NC 7 performed better in terms of pod yield.

Thus, it has been determined that biotic and abiotic damages that may occur as a result of global climate change and conditions in the world and in Turkey will adversely affect peanuts and the selection of varieties is important against damages. Special attention should be paid to the selection of varieties in locations where extreme climatic conditions are observed and diseases and pests are intense. It is thought that this study will contribute to new research and farmer extension activities.

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تأثیر نسبت‌های صدمه برگ بر تولید و کیفیت بادام‌زمینی (*Arachis hypogaea* L.)

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چکیده

هدف این پژوهش تعیین اثرهای مقدار صدمه برگ در مراحل مختلف رشد ارقام بادام زمینی (*Arachis hypogaea* L.) در شرایط مدیترانه شرقی ترکیه (استان عثمانیه) انجام شد. این پژوهش در قالب طرح کاملاً تصادفی در کرت های خرد شده در سه تکرار در سال های ۱۳۹۹ و ۱۴۰۰ انجام شد. ارقام NC 7 و Halisbey در کرت های اصلی، مراحل رشد (R1، R2 و R3) در کرت های فرعی و خسارت برگ (شاهد، ۲۵، ۵۰ و ۷۵ درصد) در کرت های فرعی-فرعی قرار گرفتند. عملکرد و پارامترهای مختلف کیفی اندازه گیری و ثبت شد. بیشترین تعداد غلاف در بوته از رقم Halisbey (۲۴.۵±۰.۴)، دوره R2 (۲۳.۵±۰.۶) و شاهد (۲۵.۷±۰.۶) به دست آمد. با افزایش صدمات برگ، تعداد غلاف در بوته کاهش یافت. بیشترین عملکرد غلاف از رقم NC 7 (۲۳۰۲±۸.۲ کیلوگرم در هکتار) و دوره R1 (۲۰۴۱±۹.۱ کیلوگرم در هکتار) به دست آمد. ترتیب تیمارهای صدمات برگ از نظر عملکرد به صورت تیمار شاهد (۲۵۳۶±۸.۸ کیلوگرم در هکتار)، تیمار ۲۵% LD (۲۰۱۱±۸.۰ کیلوگرم در هکتار)، و تیمار ۵۰% LD (۱۹۰۶±۱۱.۹ کیلوگرم در هکتار) ، و LD ۷۵%(1481±7.6 کیلوگرم در هکتار) بود. بنابراین مشخص شد که انتخاب ارقام و مبارزه تلفیقی با بیماری ها و آفات به منظور کاهش اثر صدمات به برگ بر کیفیت و عملکرد بادام زمینی در شرایط استان عثمانیه با اهمیت است.