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ASSESSMENT OF LARVAL DENSITY AND DAMAGE BY LEPIDOPTERAN SPECIES COMPLEX IN SOME SWEET AND DENT MAIZE CULTIVARS IN HATAY PROVINCE

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Abstract: This study aimed to evaluate the larval density and the complex damage caused by lepidopteran species on different maize (*Zea mays L.*) varieties grown as main- and second -crops in Hatay Province, Türkiye, during the 2024 growing season. Six maize varieties namely; P1541, Overland, Merit, Sherbet, Capella, and Agromar DS 0224 were cultivated under natural field conditions without using pest control measurements. Weekly larval sampling and damage assessments were conducted using the FAO W-sampling method, focusing on larval density, damage to leaves, stems, and cobs, and the number of feeding galleries. Results showed significant differences in larval infestation and damage among maize varieties and cropping seasons. In case of main-crop, larval density increased gradually over the sampling period, with P1541 exhibiting the highest average infestation (0.47 larvae/plant) and damage levels across leaves, stems, and cobs. P1541 also had the greatest number of feeding galleries and damaged plants (31.16%). Conversely, Sherbet variety displayed the lowest larval density and damage, indicating strong resistance traits. In case of second-crop, overall larval densities were found higher and more variable. P1541 again showed the highest maximum larval density (2.93 larvae/plant) and severe leaf and cob damage. Interestingly, Agromar DS 0224 recorded the highest stem damage and number of feeding galleries. Damage rates in P1541 reached 80.28%, significantly surpassing those in Agromar DS 0224 (64.00%), which demonstrated relatively better resistance under second-crop conditions. These findings underline the importance of varietal susceptibility and sowing time in pest pressure dynamics. Sowing time and varietal differences shown a significant influence on the extent of damage caused by the lepidopteran complex. This is consistent with earlier research highlighting the role of host plant resistance and environmental factors—such as crop phenology—as major determinants of pest infestation levels. By evaluating varietal performance under natural infestation conditions, this study offers valuable insights that can forecast the future integrated pest management strategies particularly, in the selection of suitable crop varieties.

Keywords: Maize, Lepidoptera, Varieties, Larval density, Damage rate, Hatay

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1. Introduction

Maize (*Zea mays* L.) is an annual crop belonging to Poaceae (grass) family and Cyperales order. It is widely cultivated around the world, and its annual production is increasing at a faster rate than that of other cereal crops (IGCMR, 2013). Maize is primarily used as animal feed, as a raw material in industry, and for the production of bioethanol and biodiesel. To a lesser extent, it is also consumed as human food, particularly in developing countries (Rosengrant et al., 2008; Ortiz et al., 2010; Konuşkan et al., 2024).

In sowing season 2023/2024, Türkiye produced a total of 37.74 million tons of maize. During the same period, the top five provinces with the highest grain maize production were reported as Konya (23%), Şanlıurfa (12%), Adana (11%), Mardin (7%), and Karaman (6%). Hatay province contributed 2% to the total maize production. (TURKSTAT, 2024).

The expansion of maize cultivation both globally as well as in Türkiye, has brought about an increase in entomological problems. The most significant pests of maize belong to the order Lepidoptera (Ayaz and Can, 2023). In a study conducted in 1981, it was reported that 83 insect species from seven different orders are harmful to maize crop, among those three lepidopteran species were identified as primary, and six as potential pests (Lodos, 1981). In addition, recent studies conducted in Türkiye have reported an increasing number of lepidopteran species causing damage to maize crops (Sertkaya et al., 2014; Pehlivan and Atakan, 2022). These species inflict damage on various parts of maize, including leaves, tassels, stems, ears, and roots. Although numerous studies on this subject have previously been carried out in our Türkiye (Kavut, 1977; Teoman, 1979;

Şimşek and Sezer, 1983; Kayapınar and Kornoşor, 1988; Kornoşor et al., 1992; İkincisoy, 1993; Kara, 1994; Sertkaya and Kornoşor, 1994; Bayram, 2003; Gözüaçık et al., 2007; Tiftikçi and Kornoşor, 2015; Gözüaçık, 2016; Demirel and Konuşkan, 2017; Ölmez et al., 2017; Ayaz and Can, 2023), there has been no comprehensive study addressing the complex damage caused by lepidopteran pests across various maize varieties.

Numerous morphological and biochemical characteristics of host plants can influence their resistance. Plant structure may affect herbivores and their natural enemies either positively or negatively. It is well-known that these traits can vary among different plant varieties, thereby influencing the host plant selection behavior of pests (Woodhead and Taneja, 1987; Krips et al., 1999; Rebe et al., 2004; Afzal and Bashir, 2007).

This study aims to evaluate the complex damage caused by lepidopteran species and their larval density in main- and second-crop of maize varieties cultivated in Hatay province, based on parameters such as larval density levels, damage to different plant parts (leaves, stems, and ears), and the number of feeding galleries.

2. Materials and Methods

2.1. Study Site

The study was conducted from 14th March, 2024 to 16th October, 2024 in Tel-Kalis (36°15'13.30“N, 36°29'55.26“E, 94 m) and Selam (36°12'59.90”N, 36°25'20.09”E, 90 m) cultivated areas situated at Agricultural Research and Application Center of Hatay Mustafa Kemal University, located in the Reyhanlı district on the eastern side of Hatay Province (Figure 1). The region has a subtropical climate. The average annual rainfall is recorded as 650 mm and the average annual temperature is reported as 18.3 °C (Anonymous, 2024).

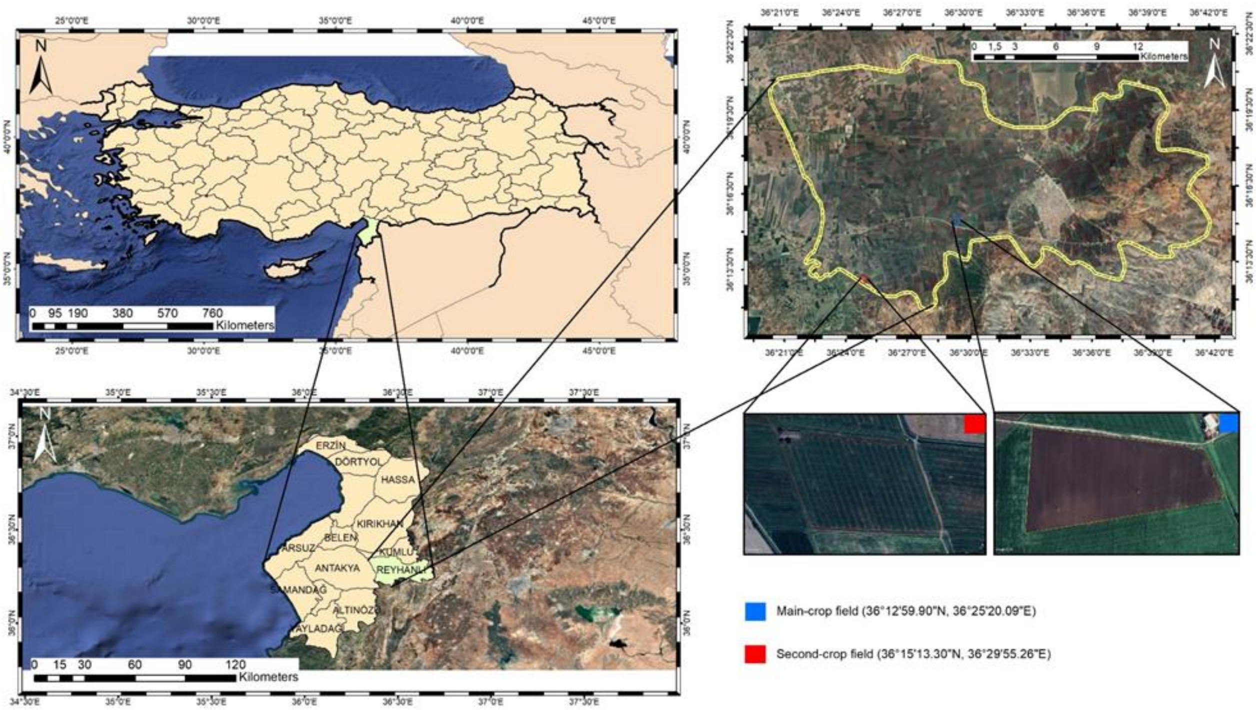

Figure 1. Location of the experimental field at Hatay.

2.2. Experimental Design

A number of six maize varieties were used in the study (Table 1). The varieties namely; Overland, Merit, and Sherbet were cultivated as main-crops in the Tel-Kalis, while Capella and Agromar DS 0224 were cultivated assecond-crops in the experimental area situated at Selam. The P1541 variety was included in both cropping seasons, being sown as main-crop in the experimental field of Tel-Kalis while as second-crop at Selam. Overland, Merit, Sherbet, and P1541 varieties (main-crop) were sown on 14 March 2024 and emerged on 25 March 2024, while Capella, Agromar DS 0224, and P1541 (second crop) were sown on 27 June 2024 and emerged on 2 July 2024. Each variety of main-crop was cultivated in plots comprising 12 rows (row x row distance as 70 cm, and 17.7 cm within rows), with a total area of 1.25 da/plot. Second-crop varieties were sown in plots comprising of 4 rows (row x row distance as 70 cm, and 17.7 cm within rows) by, covering 0.50 da/plot. All experimental plots were further divided into four equal-sized subplots. The experiment was conducted using the randomized complete block design (RCBD) with four replications. To ensure optimal conditions for pest development, no plant protection measurements were applied to maize crop throughout its growing season.

Table 1. Maize varieties used in the study

Class	Variety	FAO Classification
Dent corn	P1541	650
Sweet corn	Overland	400
Sweet corn	Merit	300
Sweet corn	Sherbet	300
Dent corn	Capella	600
Dent corn	Agromar DS 0224	650

2.3. Data Collection

2.3.1. Sampling of lepidopteran larvae on each maize variety

Sampling of lepidopteran larvae was carried out using the FAO method (FAO, 2018). In this method, sampling is done by drawing the letter "W" throughout the whole experimental plot. At each turn, 5 plants were taken as sample. In this manner, a total of 25 plants were collected as experimental samples from each subplot. The practice of sampling of maize varieties, grown as main-crop was carried out for a period of 5 weeks started from 10th May, 2024 to 7th June, 2024, while sampling of maize varieties grown as second-crop, carried out for a period of 6 weeks started from 16th August, 2024 to 20th September, 2024. To avoid edge effects, plants located in the outer rows along all sides of each plot were excluded from sampling. The number of larvae found on the leaves, ears, tassels, and stems of the damaged maize crops was recorded.

2.3.2. Damage rate caused by lepidopteran larvae

A total of 25 plant samplings were selected randomly and observed on weekly basis from the subplot of each maize variety. The damage rate (Dr) caused by lepidopteran larvae was determined according to the following formula (equation 1) (Diabate et al., 2023);

$$Dr=(Dp \times 100)/Op \quad (1)$$

where Dr = damage rate (%); Dp = number of plants damaged by lepidopteran larvae; Op = Total number of plants observed.

2.3.3. Sampling of lepidopteran larvae on leaves, cobs and stems

When maize crops reached the R5-R6 (physiological maturation – end of mass gain) stage, 25 plants were observed from each subplot. The number of damaged leaves, damaged cobs and the number of galleries in these cobs, damaged stems and the number of galleries in these stems of maize crops damaged by lepidopteran larvae were recorded.

2.4. Statistical Analysis

The data obtained in the study were subjected to one-way analysis of variance (ANOVA), and significant differences between means were determined at the level of 5% using Tukey's test with Microsoft SPSS software (version 27.0.1; IBM Corp., Armonk, NY, USA).

3. Results

In Figure 2., the graph showing the population fluctuations of the lepidopteran larval density in main-crop maize varieties. In general, larval density showed a steadily increasing trend across all varieties. The lowest larval densities were recorded on 10th May 2024 on P1541 (0.13±0.05) and Sherbet (0±0) varieties, while in the Overland (0.06±0.05) and Merit (0.11±0.06) varieties, the lowest densities were observed on 17th May 2024. The highest larval densities occurred on 31st May 2024 on P1541 (0.68±0.08) and Overland (0.25±0.09) varieties, and on 7th June 2024 on the Merit (0.63±0.11) and Sherbet (0.20±0) varieties.

Figure 3 showed the population fluctuations of the lepidopteran larval density in second-crop maize varieties. When compared to the main-crop varieties, larval population density in second-crop varieties followed a more variable pattern. The lowest larval densities were recorded on 16th August 2024 on Capella (0.75±0.01), Agromar DS 0224 (0.54±0.02), and P1541 (0.47±0.03). In contrast, the highest larval densities were observed on 20th September 2024 on the same varieties, with values of 2.32±0.10 on Capella, 2.17±0.12 on Agromar DS 0224, and 2.93±0.09 on P1541.

Table 2 presents a comprehensive overview of lepidopteran larval density and associated plant damage parameters across four main-crop maize varieties namely; P1541, Overland, Merit, and Sherbet. The analysis highlights significant differences ($P<0.001$) among varieties for all measured parameters.

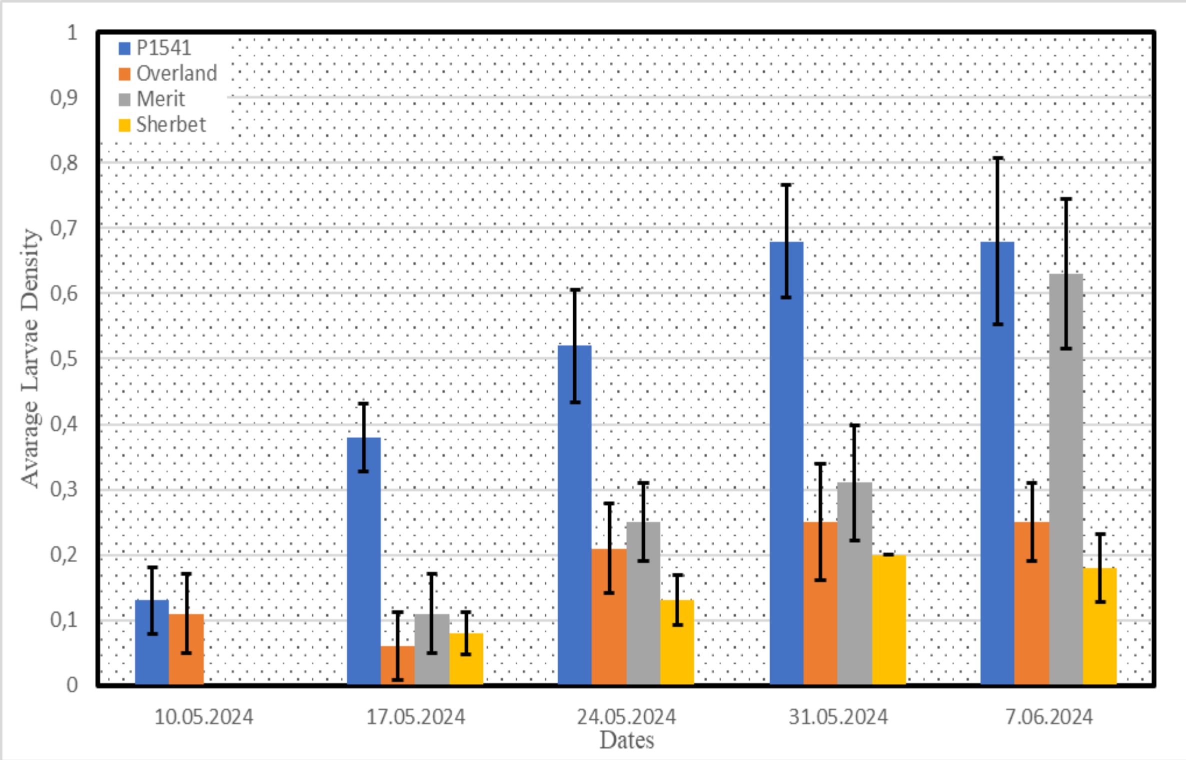

Figure 2. Temporal changes in lepidopteran larval density on four main-crop maize varieties in 2024.

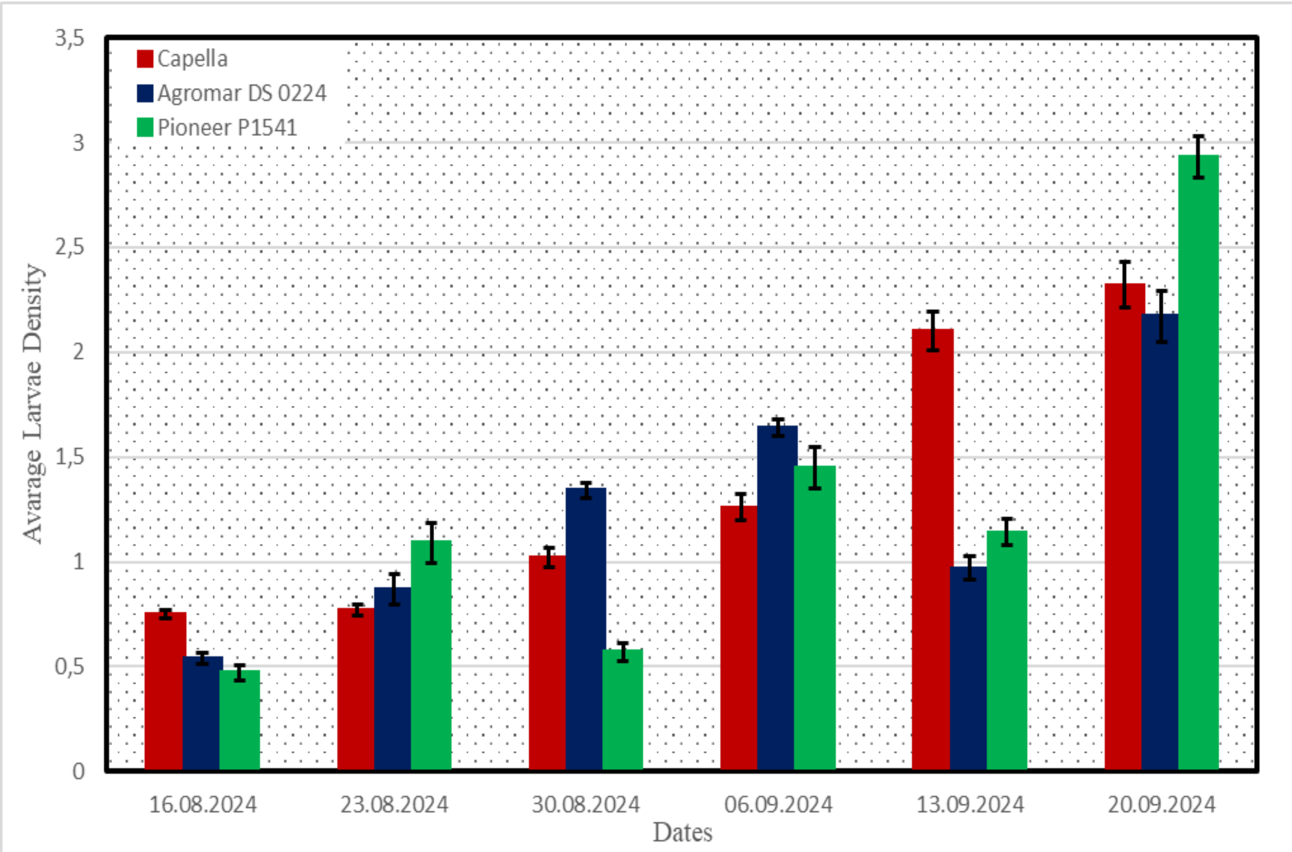

Figure 3. Temporal changes in lepidopteran larval density on three second-crop maize varieties in 2024.

Table 2. Lepidopteran larval density and damage parameters in main-crop maize varieties

Parameters		Main-Crop Maize Varieties				P-value
		P1541	Overland	Merit	Sherbet	
Larvae Density	Avarage	0.47±0.01 a	0.17±0.01 c	0.26±0.01 b	0.11±0.008 d	<0.001
	Min.	0.13±0.02 a	0.06±0.02 a	0±0 b	0±0 b	<0.001
	Max.	0.68±0.06 a	0.25±0.03 b	0.63±0.05 a	0.20±0 b	<0.001
Damaged Plant Parts	Leaves	1.09±0.1 a	0.13±0.02 b	0.08±0.01 b	0±0 b	<0.001
	Cobs	0.25±0.01 a	0.07±0.02 b	0.06±0.01 b	0.03±0.01 b	<0.001
	Stems	0.3±0.02 a	0.02±0.01 b	0.25±0.04 a	0.12±0.02 b	<0.001
Num. of Gall.	Cobs	0.3±0.02 a	0.08±0.02 b	0.06±0.01 b	0.04±0.01 b	<0.001
	Stems	0.54±0.02 a	0.02±0.01 d	0.3±0.04 b	0.14±0.02 c	<0.001
Average Values	Damaged Plants	7.79±0.22 a	2.95±0.24 c	4.21±0.24 b	2.45±0.14 c	<0.001
	Healthy Plants	17.20±0.23 a	22.04±0.24 b	20.79±0.24 c	22.54±0.14 b	<0.001
	DR (%)	31.16±0.91	11.83±0.99	16.83±0.95	9.83±0.57	<0.001

*P-value= Probability values, DR: Damage rate percentage. Means followed by different letters in the same row are significantly different from each other (P<0.05).

Larval density varied significantly among the varieties. P1541 showed the highest average larval density (0.47±0.01), significantly exceeding that of Overland (0.17±0.01), Merit (0.26±0.01), and Sherbet (0.11±0.008). Minimum and maximum larval densities followed the similar trends, with P1541 consistently showing higher values. For instance, the maximum larval density on P1541 was recorded as 0.68±0.06, which was considerably higher than on Sherbet, where it was only 0.20±0.

The extent of plant damage correlated with larval density patterns. Leaf damage was highest on P1541 (1.09±0.1), while Overland (0.13±0.02) and Merit (0.08±0.01) showed significantly less damage, and no leaf damage was detected on Sherbet. Similar trends were observed for cob and stem damage, where P1541 suffering significantly higher injury (0.25±0.01 for cobs and 0.30±0.02 for stems) as compared to the other varieties. Interestingly, significantly higher stem damage (0.12±0.02 on Sherbet and 0.02±0.01 on Overland) was recorded on the Sherbet variety, which had a lower overall larval density, than on the Overland variety.

The number of galleries, reflecting larval feeding activity within plant tissues, further supports these observations. P1541 showed the highest number of galleries in both cobs (0.30±0.02) and stems (0.54±0.02), significantly surpassing those in Overland, Merit, and Sherbet varieties. These feeding galleries can contribute to the structural weakening of plants and yield losses.

Regarding plant health status, P1541 had the greatest number of damaged plants on average (7.79±0.22), while Sherbet and Overland varieties showed fewer damaged plants (2.45±0.14 and 2.95±0.24, respectively). Conversely, the highest numbers of healthy plants were recorded in Sherbet (22.54±0.14) and Overland (22.04±0.24), indicating better resistance or tolerance to lepidopteran infestation. The damage rate (Dr), representing the percentage of damaged plants, was highest in P1541 (31.16±0.91%) and markedly lower in Sherbet (9.83±0.57%), emphasizing differences in susceptibility among varieties.

Table 3 summarizes the lepidopteran larval density and related damage metrics for three second-crop maize varieties namely; Capella, Agromar DS 0224, and P1541. Unlike the main-crop varieties, average larval density did not differ significantly among these varieties (p = 0.130), with values ranging from 1.25 to 1.37 larvae/plant.

Nevertheless, minimum larval densities showed significant differences (P<0.001), with Capella (0.75±0.02) having higher minimum larval densities compared to Agromar DS 0224 (0.54±0.02) and P1541 (0.47±0.03). Maximum larval densities also varied significantly (p=0.002), with P1541 showing the highest maximum density (2.93±0.09), surpassing Capella (2.32±0.11) and Agromar DS 0224 (2.17±0.10).

Damage to plant parts showed significant variation among varieties. Leaf damage was most severe in P1541 (9.37±0.15) followed by Capella (8.94±0.11), and both significantly higher than Agromar DS 0224 (8.31±0.20) (p = 0.004). Conversely, cob damage was significantly higher in Agromar DS 0224 (1.25±0.02) and P1541 (1.27±0.04) compared to Capella (1.02±0.02) (P<0.001). Stem damage was highest and showed similarity withCapella (0.81±0.06) and Agromar DS 0224 (0.86±0.05), whereas P1541 experienced significantly less stem damage (0.58±0.02) (P = 0.007).

In case the number of feeding galleries, reflecting larval feeding activity within the plants, was significantly higher in Agromar DS 0224 and P1541 for cobs (2.00±0.01 and 2.13±0.07, respectively) compared to Capella (1.55±0.05) (P<0.001). Similarly, stem galleries were most numerous in Agromar DS 0224 (2.39±0.05) followed by Capella (1.50±0.02) with P1541 showing the fewest galleries (0.84±0.04) (P<0.001).

As far as the plant health is concerned, P1541 showed the highest average number of damaged plants (20.07±0.18) closely followed by Capella (19.17±0.09) and then with Agromar DS 0224 showing significantly fewer damaged plants (17.96±0.13) (P<0.001). Conversely, Agromar DS 0224 had the highest number of healthy plants (7.03±0.13), significantly more than Capella (5.85±0.10) and P1541 (4.92±0.18) (P<0.001).

The damage rate (Dr) percentages further underline these trends. P1541 and Capella had similarly high Dr values of 80.28% and 76.71%, respectively, significantly exceeding that of Agromar DS 0224 at 64.00% (P<0.001).

Table 3. Lepidopteran larval density and damage parameters in second-crop maize varieties

Parameters		Second-Crop Maize Varieties			P-value
		Capella	Agromar DS 0224	P1541	
Larvae Density	Avarage	1.37±0.04 a	1.25±0.01 a	1.27±0.05 a	0.130
	Min.	0.75±0.02 a	0.54±0.02 b	0.47±0.03 b	<0.001
	Max.	2.32±0.11 a	2.17±0.10 a	2.93±0.09 b	0.002
Damaged Plant Parts	Leaves	8.94±0.11 a	8.31±0.20 b	9.37±0.15 a	0.004
	Cobs	1.02±0.02 b	1.25±0.02 a	1.27±0.04 a	<0.001
	Stems	0.81±0.06 a	0.86±0.05 a	0.58±0.02 b	0.007
Num. of Gall.	Cobs	1.55±0.05 b	2±0.01 a	2.13±0.07 a	<0.001
	Stems	1.5±0.02 b	2.39±0.05 a	0.84±0.04 c	<0.001
Average Values	Damaged Plants	19.17±0.09 b	17.96±0.13 c	20.07±0.18 a	<0.001
	Healthy Plants	5.85±0.10 b	7.03±0.13 a	4.92±0.18 c	<0.001
	DR (%)	76.71±0.36 a	64±2.15 b	80.28±0.72 a	<0.001

*P-value= Probability values, DR: Damage rate percentage. Means followed by different letters in the same row are significantly different from each other (p<0.05).

4. Discussion

The present study reveals significant varietal and seasonal differences in lepidopteran larval infestation and associated damage parameters in both main- and second-crop of maize under the agroecological conditions of Hatay province, Türkiye. P1541 variety of maize consistently experienced the highest levels of larval density and damage severity in both growing seasons, underscoring its high susceptibility to lepidopteran pests. In contrast, varieties such as Sherbet (main crop) and Agromar DS 0224 (second crop) demonstrated higher tolerance or resistance, with significantly lower infestation rates and plant damage indicators.

These findings are in line with several earlier studies emphasizing the role of host plant resistance in pest management. For instance, Afzal et al. (2009) investigated the resistance levels of twenty maize genotypes against *Chilo partellus* (Swinhoe) under field conditions. They categorized the varieties into low, moderate, and highly susceptible groups based on infestation percentages. Importantly, their results showed that genotypic variation played a significant role in pest resistance, and resistant varieties showed not only lower larval density but also significantly less internal stem tunneling and ear damage. The same researchers observed that the susceptible varieties often showed higher larval survival and feeding efficiency, indicating a strong preference-performance relationship of *C. partellus* on specific genotypes. This supports our findings, where P1541 appears to provide a favorable environment for larval development and survival, resulting in higher damage levels, particularly in terms of cobs and stems. Similarly, Diabate et al. (2023) determined the response of three maize varieties namely; EV8766-SR-MRP, PR9131-SR, and CEW-SR—to *Spodoptera frugiperda* (J.E. Smith) and *Ostrinia nubilalis*. Among the genotypes evaluated, EV8766-SR-MRP exhibited the lowest larval intensity (7.50%) and damage rate (23.33%), clearly contrasting with PR9131-SR and CEW-SR, which suffered markedly higher levels of infestation and tissue damage. Diabate et al. (2023) also found that larval damage extended to critical crop structures, especially ears and stems, which directly affected crop architecture and potential yield. These results highlight the value of resistant cultivars in integrated pest management (IPM), as damage suppression in EV8766-SR-MRP was attributed to both antixenosis (non-preference) and antibiosis (reduced larval survival or development). Analogous resistance traits were likely expressed by Sherbet and Agromar DS 0224 in our study, which experienced limited tissue damage and fewer feeding galleries despite similar environmental pressures.

In another relevant study, Demirel and Konuşkan (2017) assessed damage caused by *O. nubilalis* on sweet corn varieties over two consecutive years in the Reyhanlı district of Hatay. Their findings revealed significant year-to-year variation in damage levels, with stalk damage ranging from 32.45% to 59.34% and cob damage from 14.31% to 25.73%, depending on variety and environmental factors. Of particular relevance, in 2016, Merit variety showed the highest stalk damage (59.34%), a result that aligns with our observations that although Merit did not showed the highest larval density, it still suffered considerable stem damage (0.25±0.04), suggesting a partial susceptibility or weak structural defense against internal feeders.

The interaction between sowing time and pest pressure was further explored by Achhami et al. (2015) and they conducted a study on, maize stem borer infestation under different sowing dates. Their study revealed that early sowing in January led to significantly higher larval damage, longer tunnel lengths, and more exit holes compared to late sowing in July. The infestation parameters varied with phenological stages, with maize crops in earlier stages being more vulnerable to pest infestation. Although overall grain yield was not significantly affected, the physical damage was significant. This seasonal effect parallels our own observations, where second-crop maize varieties sown in late June experienced markedly higher larval densities and damage intensities than the main-crop varieties. The increased pest activity in the second season can likely be attributed to more favorable environmental conditions for lepidopteran population increase, such as warmer temperatures and higher host plant availability during the reproductive stage of maize.

This study reaffirms the critical role of maize varietal selection and sowing time in influencing lepidopteran pest dynamics and plant damage outcomes. Among the tested varieties, P1541 clearly emerged as the most susceptible, with consistently higher larval densities, more extensive feeding damage, and elevated damage rates in both main- and second- crops. In contrast, Sherbet (main crop) and Agromar DS 0224 (second crop) showed relatively higher tolerance, positioning them as potentially more suitable cultivars for IPM strategies in the region. These findings not only contribute to our understanding of maize-larval interactions in the Eastern Mediterranean agroecosystem but also underscore the necessity of incorporating host resistance traits into pest management programs to reduce the application of chemical and enhance crop sustainability.

5. Conclusion

This study demonstrated significant differences in lepidopteran larval density and associated complex damage between main- and second -crop maize varieties cultivated in Hatay province. The variety P1541 consistently showed the highest larval densities and damage rates, indicating its higher susceptibility to lepidopteran pests. In contrast, Sherbet (main crop) and Agromar DS 0224 (second crop) showed higher tolerance or resistance, making them promising candidates for IPM programs. Furthermore, the significantly higher larval densities and damage levels observed in second-crop maize compared to main-crop highlight the critical influence of sowing time on pest pressure. This suggests that environmental conditions during the second cropping season favor lepidopteran population development and damage severity under the agro-ecological conditions of the region. The findings emphasize the importance of selecting suitable maize varieties and optimizing cropping schedules to minimize pest attack, reduce reliance on chemical controls, and promote sustainable maize production. Future research should focus on understanding the genetic and physiological bases of resistance mechanisms to further enhance IPM strategies.

Author Contributions

The percentages of the authors' contributions are presented below. All authors reviewed and approved the final version of the manuscript.

	İ.E.B.	N.D.	Ö.K.	H.A.
C	20	20	20	20
D	100			
S		100		
DCP	40	30	15	15
DAI	40	30	15	15
L	40	30	15	15
W	40	30	15	15
CR	30	40	20	10
SR	30	40	20	10
PM	30	40	20	10
FA	20	20	40	20

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declare no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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