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IMPACT OF WEED FLORA ON APHID AND THRIPS OCCURRENCE IN PEPPER (*Capsicum annuum* L.) IN THE STRUMICA REGION

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Abstract

During 2024 and 2025, a research at two localities in the Strumica region (Kuklish and Borievo) was conducted in order to determine the qualitative composition of weed vegetation, their density and their role as reservoirs for aphids and thrips. Weed surveys were conducted using 1 m^2 plots randomly placed around pepper fields, while aphid and thrips occurrence was assessed through regular visual inspections during the growing season. A total of ten weed species belonging to nine botanical families were identified in Kuklish and eight species in Borievo, around pepper fields. The most dominant species in both localities in 2024 were *Galinsoga parviflora Cav.*, *Chenopodium album Linn.*, and *Amaranthus retroflexus L.* In 2025, the dominant species in Kuklish were *G. parviflora*, *C. album*, and *Cyperus rotundus L.*, while in Borievo they were *G. parviflora*, *C. album*, and *Capsella bursa-pastoris L.* Weed density was higher in Kuklish than in Borievo, reaching 81.6 ± 11.19 and 62.0 ± 9.08 plants/m^2 in 2024, and 83.4 ± 15.69 and 70.8 ± 5.63 plants/m^2 in 2025, respectively. Aphids and thrips were recorded on both weeds and pepper plants, with higher infestation levels observed in Kuklish than in Borievo during both years. The number of infested pepper plants varied during the growing season. In both years of research and at both locations, thrips were more abundant than aphids. The results of the research showed that there was a strong positive correlation between the density and the abundance of aphids and thrips, especially thrips ($r=0.823$, $p<0.001$) and aphids ($r=0.747$, $p<0.001$), suggesting that weeds may act as alternative hosts for aphids and thrips. Therefore, effective weed management should be considered an important component of integrated pest management strategies in pepper production.

Key words: *weeds, alternative hosts, reservoirs, weed density, Galinsoga parviflora Cav., Chenopodium album Linn.*

INTRODUCTION

Pepper (*Capsicum annuum L.*) is one of the most important vegetable crops in our country and in the world, with great economic and nutritional value (Todevska, 2025). The production of this crop is often limited by various biotic factors, among which weeds and harmful insects are particularly important. Weeds pose a serious problem because they not only compete with cultivated plants for water, nutrients, and light, but also provide food, shelter, and reproductive sites for various pest organisms, like insect pests (Singh & Singh, 2016; Capinera J.L., 2005), plant pathogens (Webb et al., 2012; Gonzales et al., 1991), mites (Chandrasena et al., 2016), nematodes (Singh et al., 2010), etc.

Many of the weeds found in and around pepper crops are hosts to insects with piercing and sucking mouthparts, such as aphids (*Aphididae*), thrips (*Thripidae*), whiteflies (*Aleurodidae*) and others (Pal et al., 2012). These insects are the primary vectors of a number of viruses that cause viral diseases in pepper, such as Cucumber mosaic virus (CMV), Potato virus Y (PVY) and Tomato spotted wilt virus (TSWV) (Capinera J.L., 2005; Shi et al., 2024). Thus, the presence of weeds increases the likelihood of pepper being attacked by harmful insects, as well as transmitting viral diseases.

Determination of the qualitative composition of weed vegetation in and around pepper plantations and a demonstration of their importance as potential hosts for harmful insects and viruses was the aim of our research.

To the best of our knowledge, no studies investigating the relationship between weed communities and pest occurrence in pepper fields have been conducted in North Macedonia to date. Therefore, the present study represents the first contribution to understanding these interactions under local agroecological conditions.

MATERIAL AND METHODS

The study was conducted during 2024 and 2025 in pepper fields at two localities in the Strumica region: Kuklish and Borievo. Representative plots were selected, where weeds were recorded by placing square frames with an area of 1 m^2, randomly distributed. All weed species within the frame were identified and counted, and density was expressed as plants/m^2.

The occurrence of aphids and thrips was monitored on both weeds and pepper plants through regular visual inspections conducted throughout the growing season (10.05 – 30.06. 2024 and 07.05. – 30.06.2025), at 14-day intervals in both years of research. During each inspection, 10 randomly selected pepper plants per plot were examined. For weeds, all plants within the 1 m^2 frame were inspected. The presence of aphids was assessed by examining the undersides of leaves, stems, and growing tips, while thrips were recorded based on visible feeding damage and direct observation of adults and larvae on leaves, flowers, and fruits. The number of infested plants was recorded for each sampling and expressed as the mean number of infested plants per sampling unit.

The obtained data were statistically processed using descriptive statistics, whereby the mean value (Mean), standard deviation (SD) and coefficient of variation (CV%) were calculated for each measured variable in accordance with the methodology described in Sokal & Rohlf (1995).

To determine statistically significant differences in weed density and aphid and thrips attack between the two localities (Kuklish and Borievo), Student's independent samples t-test (Student, 1908) was applied with a significance level of $p<0.05$.

The strength and direction of the linear relationship between the total weed density and aphid and thrips attack were determined using Pearson's correlation analysis (Pearson, 1895). All statistical analyses were conducted based on five repetitions ($n=5$) per locality, and year of research.

RESULTS AND DISCUSSION

T The results of the research showed almost the same qualitative composition but different dominance of weeds in the two localities, Kuklish and Borievo. There were almost no weeds in the pepper plantations due to the protection measures taken during production. A total of ten weed species belonging to nine botanical families were identified in Kuklish and eight species in Borievo, around the pepper fields. These weeds do not have a major impact on direct competition with pepper but are of particular importance as reservoirs of insects and viruses.

G. parviflora and *C. album* were dominant species at both localities (Table 1). These two species, along with A. retroflexus, showed the highest densities in 2024 in both Kuklish and Borievo. In 2025, a shift in species dominance was observed. In Kuklish, *Cyperus rotundus L.* emerged as one of the dominant species, while in Borievo *Capsella bursa-pastoris L.* showed increased abundance. Despite these changes, *G. parviflora* and *C. album* remained consistently dominant across both years and locations.

The dominance of *G. parviflora, C. album* and *A. retroflexus* observed in both years of the research is in accordance with the research of Stojanova (2025) and Pal et al. (2012), who list these species as hosts of pests. This indicates the fact that both localities already have established stable weed communities that enable the maintenance of the population of pest insects.

Table 1. Weed species composition and total number of plants recorded per species in pepper fields at two localities in the Strumica region (2024-2025).

Weed species	2024		2025		Potential insect hosts
	Kuklish	Borievo	Kuklish	Borievo	
Chenopodium album Linn.	66	59	73	67	Leaf aphids, thrips (Piron, 2017; Smith, 2011)
Amaranthus retroflexus L.	34	41	23	39	Leaf aphids, thrips, whitefly (Piron, 2017; Smith, 2011; Shahzad et al., 2013)
Galinsoga parvifloraCav.	90	81	96	88	Leaf aphids, thrips, whitefly, leafhoppers (Piron, 2017; Pal, 2012; Smith, 2011; Shahzad et al., 2013; Nault & Ammar, 1989)
Capsela bursa-pastoris L.	44	36	38	41	Leaf aphids (Piron, 2017; Smith, 2011)
Convolvulus arvense L.	20	15	18	21	Leaf aphids, whitefly (Piron, 2017; Smith, 2011; Shahzad et al., 2013)
Portulaca oleracea L.	35	29	37	36	Leaf aphids, thrips (Piron, 2017; Smith, 2011)
Echinochloa crus-galli L.	38	28	38	35	Leaf aphids (Piron, 2017)
Cyperus rotundus L.	36	/	48	/	Whitefly (Shahzad et al., 2013)
Datura stramonium L.	22	/	23	/	Leaf aphids, thrips, whitefly (Piron, 2017; Smith, 2011; Shahzad et al., 2013)
Polygonum convolvulus L.	23	21	23	27	Aphids, leaf miners, beetles, Hemiptera (Abozaid et al., 2015; Piron, 2017; Nault & Ammar, 1989)
Total	**408**	**310**	**417**	**354**	

Table 2. Descriptive statistics (Mean, ± SD, CV%) of weed density and insect infestation in pepper fields at two localities (2024-2025).

Variable / Statistics		Kuklish 2024	Kuklish 2025	Borievo 2024	Borievo 2025
Weed density	Mean	81.60	83.40	62.00	70.80
	± SD	±11.19	±15.69	±9.08	±5.63
	CV (%)	13.7	18.8	14.6	8.0
Aphids on weeds	Mean	29.60	26.20	23.60	25.00
	± SD	±9.84	±6.69	±5.41	±3.32
	CV (%)	33.2	25.5	22.9	13.3
Thrips on weeds	Mean	38.00	29.60	21.00	22.40
	± SD	±8.37	±5.37	±4.06	±4.93
	CV (%)	22.0	18.1	19.3	22.0
Aphids on pepper	Mean	3.00	2.80	2.40	3.00
	± SD	±2.00	±1.64	±2.19	±2.00
	CV (%)	66.7	58.7	91.3	66.7
Thrips on pepper	Mean	4.40	3.80	1.40	1.80
	± SD	±1.14	±2.28	±1.14	±1.10
	CV (%)	25.9	60.0	81.4	60.9

*Values for weed density are expressed as number of plants per square meter (plants m^{-2}); values for aphids and thrips represent the mean number of infested plants per sampling unit (1 m^2 frame).

Weed density was higher in Kuklish compared to Borievo, both in 2024 (81.60 ± 11.19 vs. 62.00 ± 9.08 plants/m^2) and in 2025 (83.40 ± 15.69 vs. 70.80 ± 5.63 plants/m^2), indicating a consistently higher presence of weed vegetation at the Kuklish site (Table 2).

The coefficient of variation (CV%) shows that Kuklish had greater variability in weed density in 2025 (CV=18.8%), while Borievo was more evenly distributed (CV=8.0%). This indicates the existence of hot-spots with higher weed concentrations in Kuklish, in contrast to Borievo where weeds were more evenly distributed.

Thrips infestation of weeds was consistently higher than aphid infestation at all sites in both years. For example, in Kuklish in 2024, thrips had a mean value of 38.00 versus 29.60 for aphids. Insect infestation of pepper was significantly lower than that of weeds (1.4–4.4 versus 21.0–38.0), confirming the role of weeds as primary reservoirs of the insects.

The high CV% of aphids and thrips on pepper (up to 91.3%) indicates an uneven distribution and variability in their infestation, probably related to the heterogeneous distribution of weeds across the field.

The Student's independent samples t-test was used to determine whether the differences in weed density and insect infestation between the two sites (Kuklish and Borievo) were statistically significant. The analysis was performed separately for 2024 and 2025 (Table 3).

Table 3. Student's independent samples t-test results for weed density and insect infestation between Kuklish and Borievo localities (2024-2025).

Variable (Kuklish vs Borievo)	t (2024)	p (2024)		t (2025)	p (2025)		Conclusion
Weed density	3.040	0.0161	*	1.690	0.1295	ns	Significant in 2024
Aphids on weeds	1.195	0.2664	ns	0.360	0.7285	ns	Insignificant
Thrips on weeds	4.087	0.0035	**	2.209	0.0581	ns	Significant in 2024
Aphids on pepper	0.452	0.6631	ns	-0.173	0.8671	ns	Insignificant
Thrips on pepper	4.160	0.0032	**	1.768	0.1151	ns	Significant in 2024

*$p<0.05$ **$p<0.01$ ***$p<0.001$; ns = not statistically significant ($p>0.05$). The comparison is Kuklish versus Borievo for each variable.

Weed density was significantly higher in Kuklish (81.60 ± 11.19 plants/m^2) compared to Borievo (62.00 ± 9.08 plants/m^2) in 2024 (t=3.040, p=0.0161, *). In 2025, the difference between Kuklish (83.40 ± 15.69 plants/m^2) and Borievo (70.80 ± 5.63 plants/m^2) was not significant (t=1.690, p=0.1295), although in absolute terms Kuklish still had a higher density. Weed thrips were significantly more abundant in Kuklish (38.00 ± 8.37) compared to Borievo (21.00 ± 4.06) in 2024 (t=4.087, p=0.0035, **). The same applies to thrips on pepper, where Kuklish (4.40 ± 1.14) showed a significantly higher infestation compared to Borievo (1.40 ± 1.14) in 2024 (t=4.160, p=0.0032, **). In 2025, the differences between the two sites for thrips were not statistically significant, although the value for thrips on weeds was close to the threshold of significance (p=0.0581). The aphid infestation did not show a statistically significant difference between Kuklish and Borievo on either weeds or pepper, neither in 2024 nor in 2025. This suggests that aphids have a more even spatial distribution independent of the site, unlike thrips which showed a more pronounced relationship with the site with higher weed biomass.

Pearson's correlation analysis was applied to determine the strength and direction of the relationship between total weed density (plants/m^2) and the number of plants attacked by aphids and thrips, on combined data from both sites and both years (n=20).

Table 4. Pearson's correlation coefficients between weed density and aphid and thrips infestation in pepper fields (n=20).

Correlation (n=20)	**r**	p-value	Significance	Interpretation
Weeds ~ Aphids on Weeds	**0.747**	0.0002	***	Strong positive
Weeds ~ Thrips on Weeds	**0.823**	<0.0001	***	Very strong positive
Weeds ~ Aphids on Peppers	**0.353**	0.1264	ns	Weak, insignificant
Weeds ~ Thrips on Peppers	**0.645**	0.0021	**	Moderately positive

** p<0.01 *** p<0.001; ns = not statistically significant. |r| value = 0.7–1.0 = strong; 0.4–0.7 = moderate; <0.4 = weak correlation.

The results (Table 4) show a very strong positive correlation between weed density and thrips presence on weeds (r=0.823, p<0.0001). This is the highest coefficient obtained in the analysis and directly supports the hypothesis that higher weed density is closely related to higher thrips infestation. This result is in line with previous research (Lewis, 1997), which emphasizes the role of the thrips as pests in horticultural crops.

Also significant is the correlation weeds ~ aphids on weeds (r=0.747, p=0.0002). Although slightly lower, this strong correlation confirms that weeds also serve as reservoirs for aphids, maintaining their populations in and around the fields.

The moderate but significant correlation between weed density and thrips on pepper (r=0.645, p=0.0021) indicates that higher weed presence is also associated with higher thrips transmission to the pepper itself — weeds function not only as alternative hosts, but also as a source of infection for the pepper.

The only non-significant relationship was weeds ~ aphids on pepper (r=0.353, p=0.126). This finding suggests that aphid migration to pepper is conditioned not only by weed density, but also by other factors — pepper phenophase, climatic conditions, or the presence of natural enemies.

This correlation analysis supports the hypothesis that weeds represent a significant reservoir and source of insect pests, especially thrips, in pepper production (Altieri, 1999; Gaba et al., 2014).

CONCLUDING REMARKS

From the results obtained, we can conclude the following:

• A total of ten weed species belonging to nine botanical families were identified in and around the pepper plantations, with a greater diversity of species in Kuklish than in Borievo. The same weed composition was present in the two years of the research, with Galinsoga parviflora and Chenopodium album being the dominant species in both sites.

• The results of the statistical analysis showed that the Kuklish site is characterized by a higher density of weed flora compared to the Borievo site, with the difference being statistically significant in 2024 ($t=3.040$, $p<0.05$), while in 2025 the two sites showed a more similar level of weed infestation.

• Regarding thrips and aphid infestation, thrips infestation was significantly higher at the Kuklish site compared to Borievo in 2024, both in weeds ($t=4.087$, $p<0.01$) and pepper ($t=4.160$, $p<0.01$), while no statistically significant differences were found for aphids between sites.

•Pearson's correlation analysis confirmed that there is a strong positive statistically significant correlation between weed density and the presence of thrips on weeds ($r=0.823$, $p<0.001$), as well as between weed density and aphids on weeds ($r=0.747$, $p<0.001$). A moderate positive correlation was also found between weed density and pepper thrips ($r=0.645$, $p<0.01$), while the relationship between weeds and pepper aphids was not statistically significant ($r=0.353$, $p>0.05$).

Therefore, weeds represent a significant reservoir of harmful insects and their regular and timely control in pepper production may contribute to reducing the risk of aphid and thrips attacks.

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ВЛИЈАНИЕ НА ПЛЕВЕНАТА ФЛОРА ВРЗ ПОЈАВАТА НА ЛИСНИ ВОШКИ И ТРИПСИ КАЈ ПИПЕРКАТА (*Capsicum annuum L.*) ВО СТРУМИЧКИОТ РЕГИОН

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Резиме

Во текот на 2024 и 2025 година, спроведени се истражувања на два локалитета во Струмичкиот Регион (Куклиш и Бориево) со цел да се утврди квалитативниот состав на плевелната вегетација, нивната густина и улогата како резервоари за лисни вошки и трипси. Вкупно десет вида плевели кои припаѓаат на девет ботанички фамилии беа идентификувани во Куклиш и осум вида во Бориево, во и околу полињата со пиперки. Најдоминантни видови во двата локалитета во 2024 година беа *Galinsoga parviflora Cav., Chenopodium album Linn.* и *Amaranthus retroflexus L.* Во 2025 година, доминантни видови во Куклиш беа *G. parviflora, C. album* и *Cyperus rotundus L.*, додека во Бориево беа *G. parviflora, C. album* и *Capsella bursa-pastoris L.* Густината на плевелите беше поголема во Куклиш во споредба со Бориево, достигнувајќи 81,6 ± 11,19 и 62,0 ± 9,08 растенија/m^2 во 2024 година и 83,4 ± 15,69 и 70,8 ± 5,63 растенија/m^2 во 2025 година, соодветно. Лисни вошки и трипси беа регистрирани и на плевелите и на пиперката. Бројот на заразени растенија со пиперка варираше во текот на вегетацијата. И во 2024 и во 2025 година и на двата локалитета трипсите беа побројни од лисните вошки, а нападот од вошки и трипси беше поголем во Куклиш отколку во Бориево. Резултатите од истражувањето покажаа дека постои силна корелација помеѓу присуството на плевели и појавата на штетни инсекти, особено трипси (r=0,823, p<0,001) и лисни вошки (r=0,747, p<0,001), што укажува дека плевелите дејствуваат и како алтернативни домаќини за лисни вошки и трипси. Затоа, заштитата на културата од плевели треба да биде клучен елемент во стратегиите за контрола на штетници во производството на пиперки.

Клучни зборови: *плевели, алтернативни домаќини, резервоари, густина на плевели, Galinsoga parviflora Cav., Chenopodium album Linn.*

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