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RESEARCH PAPER

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SUSTAINABLE PEST CONTROL: THE ROLE OF CORIANDER AS A REPELLENT PLANT AGAINST *Leptinotarsa decemlineata* SAY IN EGGPLANT CULTIVATION

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ABSTRACT

The study focuses on the potential repellent properties of coriander (*Coriandrum sativum* L.) against the Colorado potato beetle (*Leptinotarsa decemlineata* Say, CPB) when co-cultivated with eggplant (*Solanum melongena* L.). The growth stages of both plants and their relationship to beetle populations were examined. Stage I (Flowering period) and Stage II (Fruit development period) of coriander were shown to have a significant positive influence on reducing the beetle population. Furthermore, a positive correlation was observed between the adult CPB population and Stages I and II of eggplant growth, which are characterised by an increase in flower and fruit numbers when co-planted with coriander. Conversely, a negative correlation was observed between the beetle population and Stages II and III (Fruit maturation period) of eggplant growth in control plots (eggplant-only cultivation). Findings from 2018 and 2021 reinforced the repellent efficacy of coriander, showing a reduction in beetle populations during the coriander flowering, green fruit, and mature fruit stages. These findings indicate that the flowering stage of coriander coincides with the lowest adult beetle densities, suggesting that this phenological phase represents the most effective period for repellent cropping. Future studies should explore the potential role of coriander essential oils in enhancing this effect. This study contributes to the growing body of knowledge on natural pest management strategies.

Keywords: *Coriandrum sativum* L., companion plant, sustainable management, *Solanum melongena* L.

INTRODUCTION

In organic agriculture, which prohibits synthetic fertilizers and pesticides, sustainable pest management practices are essential for maintaining ecological balance and crop productivity [Gamage 2023]. One such practice is companion planting, a system that involves the strategic cultivation of mutually beneficial plant species in proximity. This method not only enhances biodiversity and soil health but also contributes to natural pest suppression by altering pest behaviour, masking host plant volatiles, and attracting natural enemies [Ratnadass et al. 2012].

Among companion plants, aromatic herbs have drawn considerable attention for their bioactive properties. Species such as garlic, rosemary, marigold, and coriander release volatile organic compounds (VOCs) that can repel pests and disrupt their host-finding behaviour. Recent studies have shown that intercropping aromatic plants with main crops, such as tomato, pep-

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per, or cabbage, can reduce pest densities, increase the abundance of beneficial insects, and enhance yields in both rural and urban agricultural systems [Tringovska et al. 2015, Saldanha et al. 2019, Park et al. 2022].

Coriandrum sativum L. (coriander), a member of the Apiaceae family, is increasingly recognised for its pest-repellent activity due to VOCs such as linalool, α-pinene, and camphor. These compounds not only act as olfactory repellents but also exhibit fumigant and contact toxicity against several insect pests [Abid et al. 2019, Elhalawany et al. 2019]. Coriander has also been reported to support populations of natural enemies, further strengthening its role within integrated pest management (IPM) strategies [El-Mogy et al. 2019]. However, field evidence specifically quantifying coriander's effects on the Colorado potato beetle (CPB) under field conditions remains limited [Lenardis et al. 2017, Lee et al. 2018].

A significant threat to solanaceous crops such as eggplant (*Solanum melongena* L.) is the Colorado potato beetle (*Leptinotarsa decemlineata* Say), a highly adaptable pest that causes extensive defoliation and yield loss. The species is notorious for its rapid development of resistance to chemical insecticides, posing challenges to conventional pest control [Wang et al. 2020, Junge et al. 2022]. In this context, there is an urgent need for environmentally sound alternatives that minimise chemical inputs while maintaining pest control efficacy.

Therefore, the present study aims to investigate the potential of *C. sativum* as a natural repellent against the Colorado potato beetle in eggplant cultivation. By assessing the effectiveness of coriander in reducing pest infestation and enhancing crop performance, this research seeks to contribute to sustainable pest management approaches in organic and low-input farming systems. The findings are expected to provide valuable insights for the development of alternative strategies that align with ecological principles while supporting the economic sustainability of vegetable production.

MATERIALS AND METHODS

Plant materials and experimental field

In this study, eggplant variety Pala-49 was used as the main plant, and a small-grained coriander (*Coriandrium sativum* L. microcarpum DC) population of Erzurum/Türkiye origin was used as the repellent plant. Certified seeds of eggplant were obtained from the Atatürk Central Horticulture Research Institute. Coriander seeds were provided by Isparta University of Applied Science, Faculty of Agriculture, Department of Field Crops, Herbs Garden. The fruit diameter of the coriander seeds used in the experiment was 3 mm, and the weight of 1000 grains was 7 g. The experiment was conducted in an organic plot in Ürünlü village, Nilüfer, Bursa, which holds an organic certification and is situated at an approximate elevation of 451 meters above sea level.

Experimental design and cultivation methods

The experiment was established with three replications. The total experimental area was 60 m², consisting of three plots, each measuring 20 m² in size. Prior to plot establishment, approximately 50 kg of well-decomposed farmyard manure was applied to each 20 m² plot, totalling 150 kg for the entire area. Following the application of manure, the plots were tilled using a rotary hoe, and surface levelling was performed to prepare the soil for sowing. The preceding crop grown in the experimental field was faba bean (*Vicia faba* L.), which is known to contribute to soil nitrogen content due to its ability to fix nitrogen symbiotically. The plants used in the experiment were obtained through different methods: coriander and eggplant seeds were propagated separately. While coriander seeds were directly sown by hand into the field plots, eggplant seeds were germinated in seedling trays under greenhouse conditions and grown into transplants.

Eggplant seeds were sown on March 10 under controlled greenhouse conditions for later transplanting into the field. The seeds were sown into 48-cell plastic trays filled with a well-drained, chemical-free, and organically certified peat-based growing medium. The trays were kept in a polyethene-covered greenhouse, where the daytime temperature was maintained at 25 ±2 °C and the nighttime temperature at 18 ±2 °C, with a relative humidity range of 65% to 75%. A photoperiod of approximately 14–16 hours was maintained using natural daylight, supplemented with artificial lighting as needed. No chemical fertilizers or pesticides were used during the seedling stage. Instead, seedlings were fed twice at 10-day intervals using a liquid manure tea applied via root irrigation.

The manure tea was prepared by diluting well-decomposed farmyard manure at a ratio of 1 : 6 with water that had been left to stand for two days, allowing chlorine to evaporate and sediments to settle. When the seedlings were approximately 30–35 days old, they were transplanted into the field.

Coriander seeds were manually sown at a rate of 15 kg per hectare on May 10, 2018, for the first year. However, the experiment was paused from 2019 to 2020 due to the COVID-19 pandemic. The trials resumed in 2021, with coriander sown again on May 17. Irrigation of coriander plants was conducted at regular intervals, depending on the growth stage and environmental conditions. Surface irrigation was applied using a hose to ensure uniform water distribution across the plots. Irrigation frequency was determined based on soil moisture levels, and water stress was minimised.

When the coriander plants and eggplant seedlings reached similar growth stages, the eggplant seedlings were transplanted into the centre of plots surrounded by coriander plants, as well as into control plots without coriander. Coriander plants were densely sown along the borders of the plots, forming a hedge-like barrier. Eggplants were planted with a spacing of 80 × 100 cm between and within rows. Each replication included four rows with 16 eggplant plants. A total of 96 eggplant plants were used in the experiment, 48 in the coriander treatment and 48 in the control plots. The spacing between the eggplants and their distance from the surrounding coriander plants were kept uniform, approximately 100 cm.

Pest monitoring and phenological observations

Regular cultural practices were carried out for eggplant and coriander in the companion planting, while regular observations were made. While conducting adult counts, phenological observations of eggplant and coriander were also performed and recorded as follows: the period when flowering (F) begins (Stage I); the period when green fruit (GF) were observed (Stage II); the period when mature fruit (MF) were seen (Stage III) [Martínez-Ispizua et al. 2021]. The percentage of plants in the individual development stages presented in Table 1–2 was calculated as the ratio of the number of plants exhibiting the mentioned phenology stage to the total number of plants. During the study, potato beetle eggs and larvae were encountered; however, this research focused on the adults that had emerged after wintering and were heading towards the eggplants, as well as the newly developing offspring. Sampling of CPB adults took place when the eggplants reached stages I–III, with the sampling occurring close to the same time – between 9:00 and 11:00 am, when insect activity is high and the heat of the day has not yet built up. A sample of 4 plants per row was used. Insect

Table 1. CPB count dates and corresponding eggplant and coriander phenology in 2018

Weeks	Count dates	Eggplant phenology	Stage	Coriander phenology	Stage
1W	July 6	10% F	I	50% F	I
2W	July 13	25% F	I	85% F, 5% GF	I–II
3W	July 20	40% F, 10% GF	I–II	50% F, 30% GF	I–II
4W	July 27	60% F, 20% GF, 20% MF	I–II–III	25% F, 70% GF, 5% MF	I–II–III
5W	August 3	50% F, 30% GF, 20% MF	I–II–III	5% F, 80% GF, 15% MF	I–II–III
6W	August 10	50% F, 30% GF, 20% MF	I–II–III	55% GF, 35% MF	II–III
7W	August 17	30% F, 20% GF, 50% MF	I–II–III	45% GF, 55% MF	II–III
8W	August 24	20% F, 10% GF, 70% MF	I–II–III	25% GF, 75% MF	II–III
9W	August 31	5% F, 10% GF, 85% MF	I–II–III	100% MF	III
10W	September 7	100% MF	III	100% MF	III

F – flowering, GF – green fruit, MF – mature fruit

Table 2. CPB count dates and corresponding eggplant and coriander phenology in 2021

Weeks	Count dates	Eggplant phenology	Stage	Coriander phenology	Stage
1W	July 16	35% F	I	65% F, 15% GF	I–II
2W	July 23	40% F, 10% GF	I–II	70% F, 30% GF	I–II
3W	July 30	50% F, 20% GF,10% MF	I–II–III	50% F, 30% GF, 20% MF	I–II–III
4W	August 6	40% F, 30% GF, 30% MF	I–II–III	20% F, 50% GF, 30% MF	I–II–III
5W	August 13	20% F, 30% GF, 50% MF	I–II–III	5% F, 40% GF, 55% MF	I–II–III
6W	August 20	20% F, 30% GF, 50% MF	I–II–III	25% GF, 75% MF	II–III
7W	August 27	5% F, 15% GF, 80% MF	I–II–III	100% MF	III
8W	September 3	15% GF, 85% MF	II–III	100% MF	III
9W	September 10	100% MF	III	100% MF	III
10W	September 17	100% MF	III	100% MF	III

F – flowering, GF – green fruit, MF – mature fruit, stage I – flowering period, stage II – fruit development period, stage III – fruit maturation period

counts were performed by counting specimens directly on the plants. The same methodology was used on the control plots. Data was collected over 10 weeks. Counts of the CPB adults were conducted weekly and recorded. No essential oils were extracted or applied; our field trial exclusively evaluated coriander–eggplant intercropping.

Data analysis

In this research, multiple linear regression analysis was utilised to examine the relationships between the adult population of *L. decemlineata* and the phenological stages of eggplant and coriander plants. The analysis of the data collected from 2018 and 2021 involved fitting a linear equation, with the adult population as the dependent variable and plant stages as independent variables. P-values less than 0.05 indicated statistically significant associations. An influence plot was generated to identify influential points and potential outliers, ensuring the robustness of the analysis. All statistical analyses were conducted using JMP software (version 7.0; SAS Institute Inc., Cary, NC, USA).

RESULTS

In 2018 and 2021, the adult population of *L. decemlineata* was monitored and documented weekly for both years, in relation to the phenological development of eggplant and coriander plants (Tab. 3).

In 2018, in plots where coriander and eggplant were planted together, the CPB adult population and plant-related 'Stage I', 'Stage II', and 'Stage III' data are shown in Figure 1. In plots where only eggplant was planted as a control plot, the CPB adult population and plant-related 'Stage I', 'Stage II', and 'Stage III' data are shown in Figure 2. The multiple linear regression analysis revealed a statistically significant positive relationship between the CPB adult population and the 'Stage I' and 'Stage II' data of the eggplant, planted together with coriander, with a p-value less than 0.05. The p-values for 'Stage I' and 'Stage II' data were 0.0118 and 0.0127, respectively. As the number of flowers and fruits increases, the CPB adult population tends to increase as well (Fig. 3A). The multiple linear regression analysis revealed a statistically significant negative relationship between the CPB adult population and the 'Stage II' and 'Stage III' data of the eggplant that was planted as a control, with a p-value less than 0.05. The p-values for 'Stage II' and 'Stage III' data were 0.0008 and 0.0390, respectively. Eggplants co-planted with coriander exhibited an increase in CPB adult number corresponding with 'Stage I' and 'Stage II' growth (Fig. 3A), whereas on the control eggplants, a decline in CPB adult number during 'Stage II' and 'Stage III' has been noted (Fig. 3B).

During the initial four-week period of 2018, observations indicate a reduced population density of adult CPB in plots incorporating both coriander and

Table 3. Phenology of eggplant and coriander, and *Leptinotarsa decemlineata* adult population in 2018 and 2021

Plant	Week	2018				2021			
		Stage I (%)	Stage II (%)	Stage III (%)	CPB (average adult number per)	Stage I (%)	Stage II (%)	Stage III (%)	CPB (average adult number per)
Coriander	1W	50	–		–	66	17	–	–
	2W	87	7	–	–	71	31	–	–
	3W	51	31	–	–	52	31	21	–
	4W	26	71	6	–	21	52	32	–
	5W	8	82	17	–	7	41	56	–
	6W	–	57	37	–	–	25	76	–
	7W	–	46	57	–	–	–	98	–
	8W	–	27	76	–	–	–	99	–
	9W	–	–	99	–	–	–	99	–
	10W	–	–	99	–	–	–	100	–
Eggplant co-planted with coriander	1W	11	–	–	*0.03*	35	–	–	*1.38*
	2W	27	–	–	*0.72*	42	11	–	*3.34*
	3W	42	8	–	*0.76*	52	21	12	*0.07*
	4W	62	22	21	*0.03*	41	32	31	*0.69*
	5W	52	31	22	*5.38*	23	32	52	*0.34*
	6W	51	31	22	*1.38*	22	31	52	*1.34*
	7W	31	21	51	*0.03*	8	16	82	*0.07*
	8W	20	11	72	*9.39*	–	17	86	*0.00*
	9W	6	10	88	*0.03*	–	–	99	*0.03*
	10W	–	–	99	*0.69*	–	–	100	*0.07*
Eggplant as a control	1W	12	–	–	*1.03*	37	–	–	*4.00*
	2W	27	–	–	*3.34*	42	10	–	*2.39*
	3W	42	11	–	*8.72*	52	21	12	*0.00*
	4W	62	32	22	*7.03*	42	31	31	*1.07*
	5W	62	31	23	*4.39*	22	33	52	*6.71*
	6W	51	31	21	*2.32*	22	32	51	*7.00*
	7W	32	21	52	*2.03*	6	16	81	*0.07*
	8W	22	11	70	*0.34*	–	17	81	*0.07*
	9W	6	12	86	*0.38*	–	–	99	*0.00*
	10W	–	–	99	*0.03*	–	–	100	*0.07*

Stage I – flowering period, stage II – fruit development period, stage III – fruit maturation period eggplant (Fig. 1). In contrast, control plots featuring solely eggplant (Fig. 2) exhibited a notable peak in adult population during the third and fourth weeks, averaging approximately 7 to 8.7 individuals per week. The suppressed population levels in the co-cultivation plots of coriander and eggplant could potentially be attributed to the potent repellent properties exhibited by coriander during its flowering and green fruit developmental stages against adult CPB. By the eighth week, the control plot suffered significant leaf damage instigated by the beetles, leading to their subsequent departure and a reduction in the overall adult beetle population. Interestingly, a surge in the adult beetle population was observed during the eight weeks in the plots co-cultivated with coriander and eggplant. This observation could potentially suggest a diminished repellent efficacy of coriander coinciding with an escalation in the quantity of mature fruits present on the plant.

In 2021, in plots where coriander and eggplant were planted together, the adult population and plant-related data for 'Stage I', 'Stage II', and 'Stage III' are shown in Figure 4. In plots where only eggplant was planted, the CPB adult population and plant-related 'Stage I', 'Stage II' and 'Stage III' data are shown in Figure 5. The multiple linear regression analysis revealed a statistically significant negative relationship between the CPB adult population and the 'Stage III' data of the eggplant, with a p-value less than 0.05 ($P = 0.04619$). An increase in 'Stage III' data tends to decrease the CPB adult population (Fig. 6A). The multiple linear regression analysis revealed a statistically significant positive relationship between the CPB adult population and the number of fruits in the eggplant, with a p-value less than 0.05 ($P = 0.0254$) – as in Figure 6B. In 2021, the control plots consisting only of eggplants (Fig. 5) recorded a peak in CPB adult population during the fifth and sixth weeks, with an approximate weekly average of 7 individuals. Interestingly, the adult population in the co-cultivation plots of coriander and eggplant (Fig. 4), where 70% of flowering occurred, was notably lower (0.5 –1 adult) compared to the control plots. Specifically, during the fifth week,

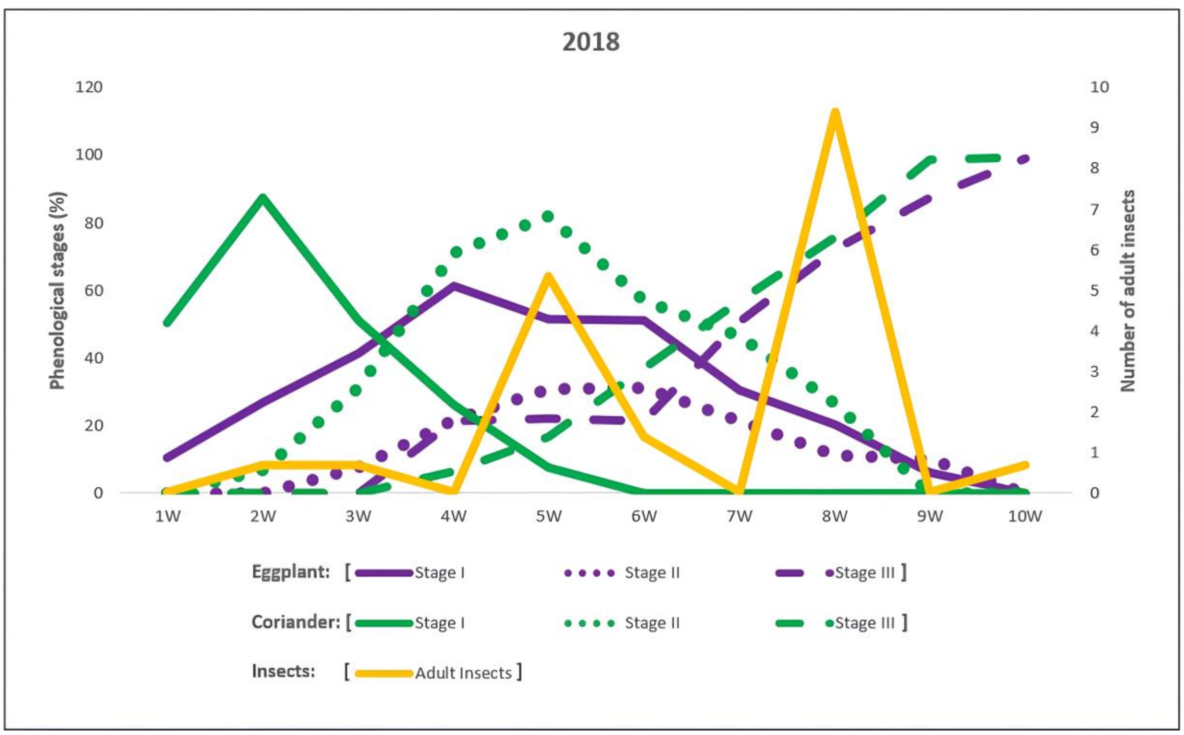

Fig. 1. *Leptinotarsa decemlineata* adult population and plant parameters comparison in coriander and eggplant co-cultivation in 2018. Stage I – flowering period. Stage II – fruit development period. Stage III – fruit maturation period

when 7% flowering, 41% green fruit, and 56% mature fruit stages were observed in the co-cultivation plots, the adult beetle population was significantly reduced (approximately weekly average of 0.3 individuals), as opposed to the relatively high population in the control plots. By the sixth week, despite the presence of 25% flowering and 76% mature fruit stages in the co-cultivation plots, the adult beetle population remained low, whereas it experienced a peak in the control plots (approximately a weekly average of 7 individuals).

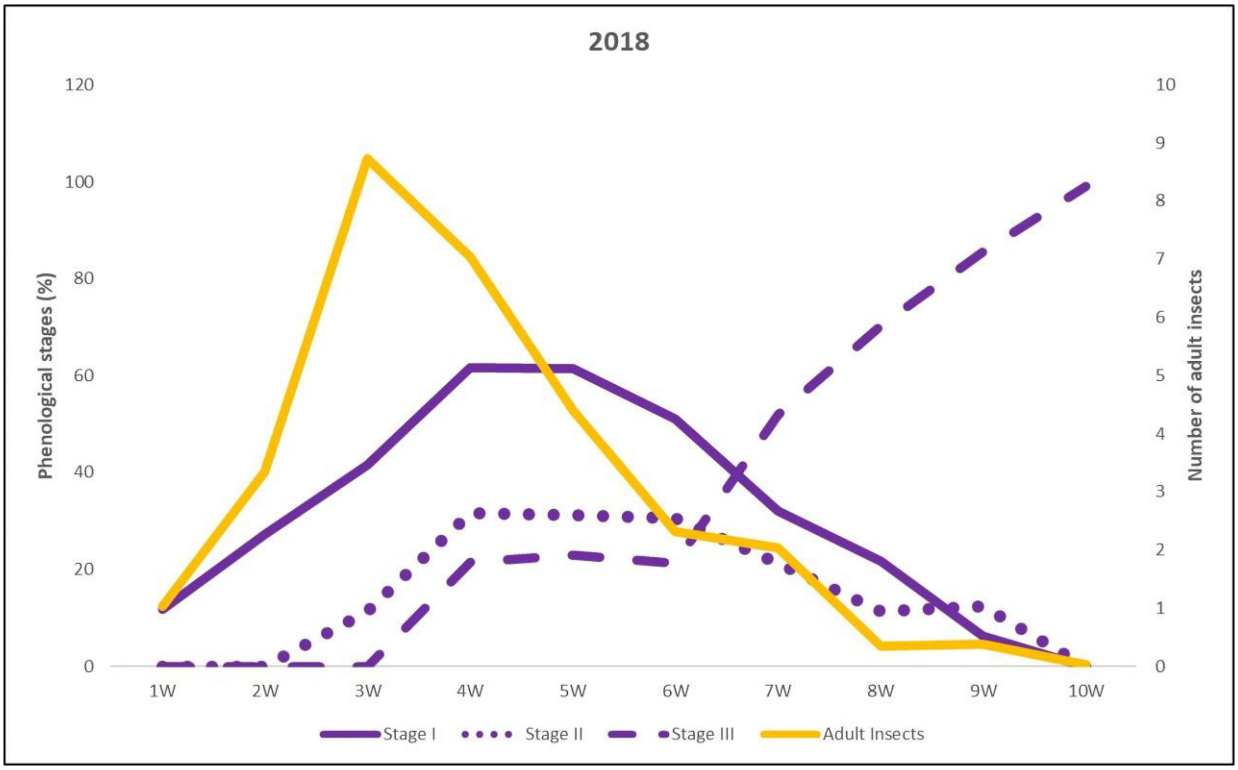

Fig. 2. *Leptinotarsa decemlineata* adult population and plant parameters comparison in eggplant-only control plots in 2018. Stage I – flowering period. Stage II – fruit development period. Stage III – fruit maturation period

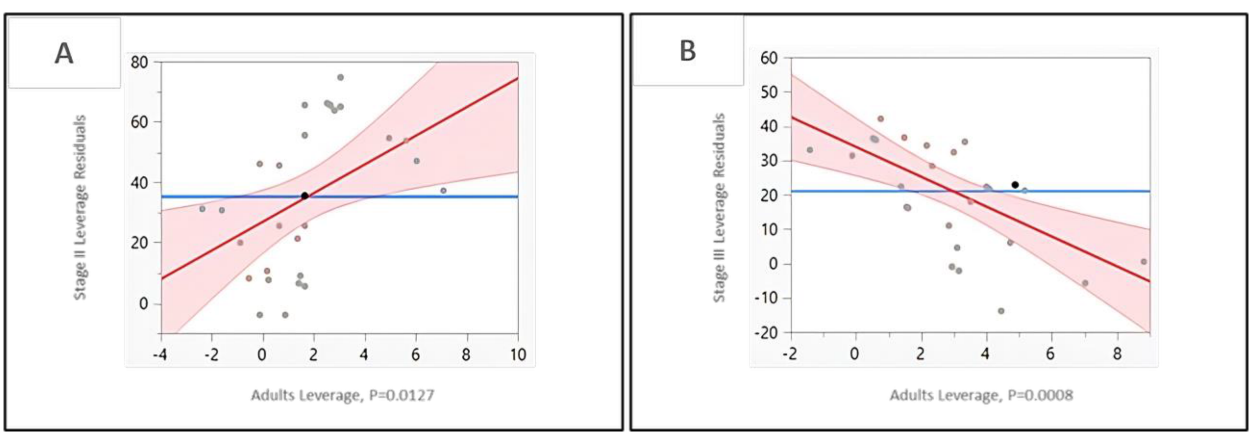

Fig. 3. Relationship between the Colorado potato beetle adult population and host plant developmental stage in 2018. (A) Coriander and eggplant co-cultivation, (B) Eggplant-only control plots. In both cases, an influence plot based on leverage and residual values is presented to identify influential observations and potential outliers

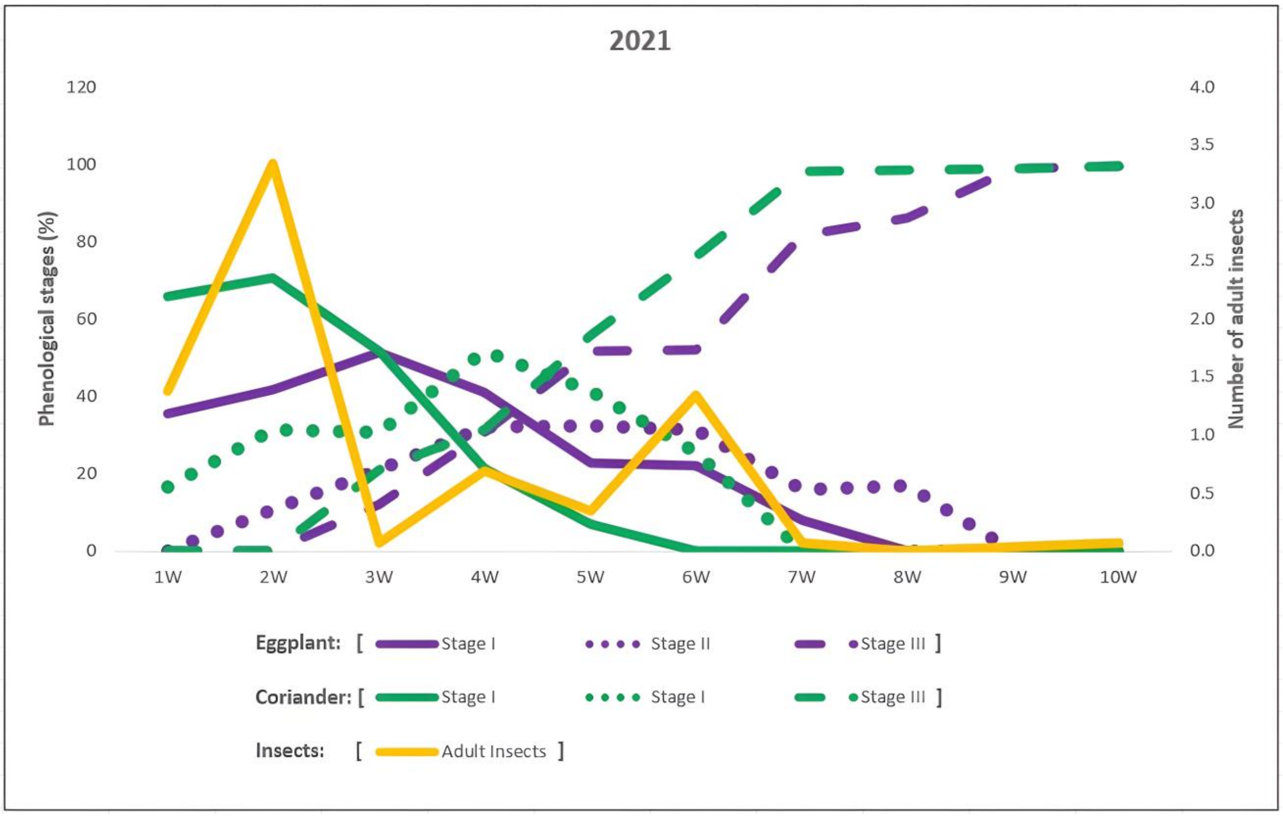

Fig. 4. *Leptinotarsa decemlineata* adult population and plant parameters comparison in coriander and eggplant co-cultivation in 2021. Stage I – flowering period. Stage II – fruit development period. Stage III – fruit maturation period

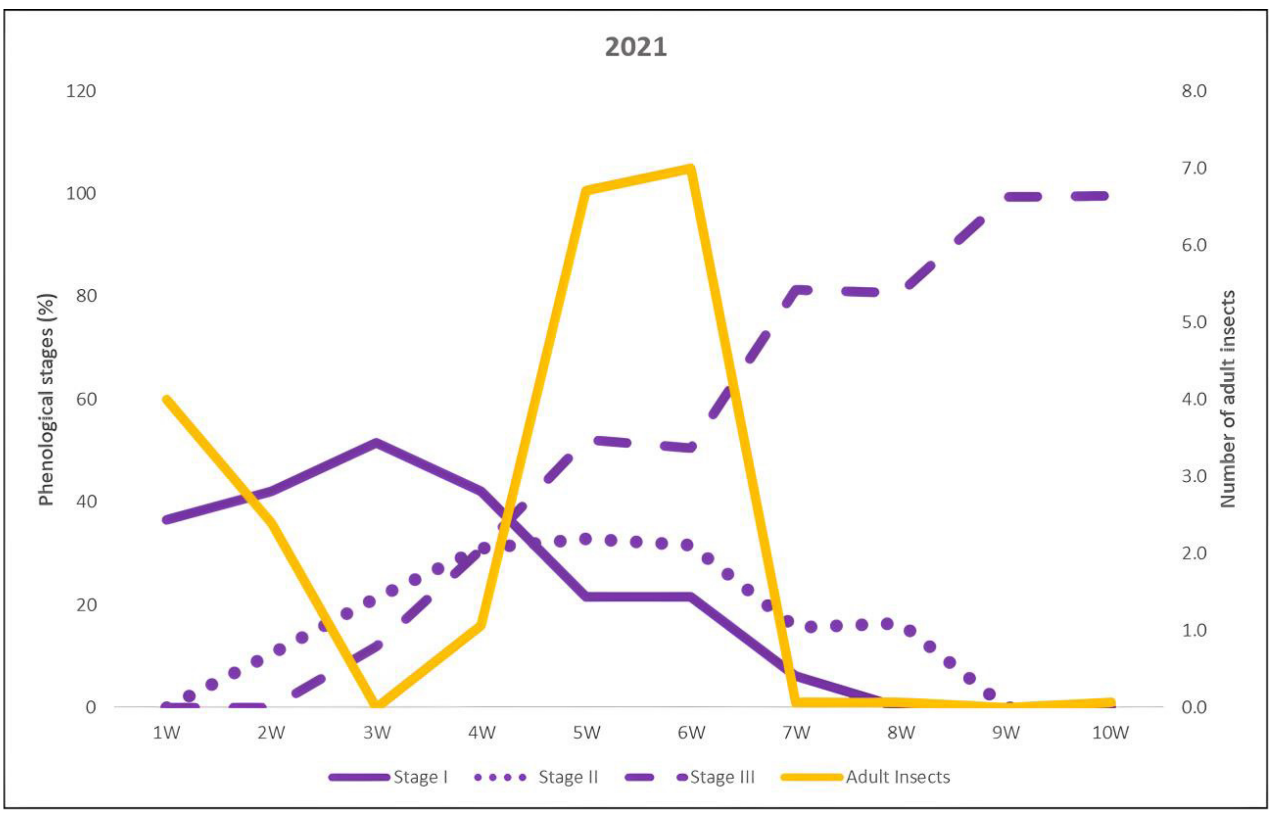

Fig. 5. *Leptinotarsa decemlineata* adult population and plant parameters comparison in eggplant-only control plots in 2021. Stage I – flowering period. Stage II – fruit development period. Stage III – fruit maturation period

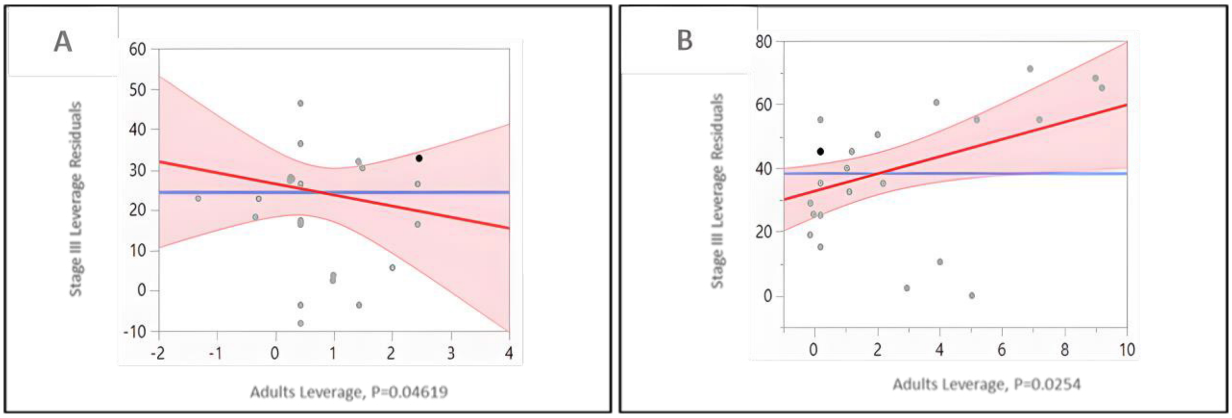

Fig. 6. Relationship between the Colorado potato beetle adult population and host plant developmental stage in 2021. (A) Coriander and eggplant co-cultivation, (B) Eggplant-only control plots. In both cases, an influence plot is presented to show influential observations and potential outliers

Considering this set of data, it can be inferred that the flowering, green fruit, and mature fruit stages of coriander manifest notable repellent properties.

DISCUSSION

Based on reports that aromatic companion plants (including coriander) can repel herbivores, we evaluated a coriander–eggplant intercrop as a VOC-mediated tactic against *L. decemlineata* under field conditions [Asare-Bediako et al. 2010, Khafagy et al. 2020].

Several scholarly studies have explored the potential of diverse plant species, including those characterised by aromatic properties, for pest management. Yousef et al. [2024] undertook a comparative meta-analysis focusing on three essential crops (wheat, maise, and soybean) to investigate how diversification schemes in-field (intercropping) and agri-environmental schemes (flower strips, hedgerows and field margins) affect arthropod abundance. In contrast, monoculture systems, which rely on a single crop, negatively impact natural enemies and increase the populations of pests. These findings suggest that diversified farming practices can be an effective strategy to promote a healthy and sustainable insect community in the analysed cropping systems. Although the study did not focus on coriander, it offers important insights into the potential implications of diversified farming practices for insect communities in this crop group. Consistent with this, we observed lower adult CPB at key stages in coriander–eggplant plots versus eggplant-only controls, whereas in 2021, adult counts in controls increased with fruit number ($p \leq 0.05$), and the fruit–beetle association is interpreted as phenological co-variation.

This pattern is plausibly consistent with stage-dependent variation in coriander essential oil content. Previous studies indicate that essential oil concentration increases from approximately 0.23% at full flowering to 0.37% during the green fruit stage, and peaks at up to 2.5% in mature fruit stages [Telci et al. 2006, Ramezani et al. 2009]. These periods coincided with the weeks in which CPB adults were most reduced in our mixed plots. Although coriander essential oil and its constituents exhibit bioactivity in laboratory assays, their composition and efficacy vary with the plant organ and phenological stage, as well as the extraction protocol. These sources of variability limit standardisation and complicate on-farm "homemade" preparations. Our study, therefore, focused on living-plant intercropping rather than oil applications; future work should benchmark field-rate EO sprays under standardised extraction/formulation before agronomic recommendations are made.

The present study's findings on the impact of intercropping coriander and eggplant on the CPB adult population align with previous research that demonstrates the efficacy of intercropping and companion planting in pest management. Kheam et al. [2024] found that volatile organic compounds emitted by specific plant species can alter insect behaviour and reduce colonisation of primary host plants, which may contribute to the observed decrease in the *L. decemlineata* adult population in the coriander-eggplant intercropping system. Moreover, Afrin et al. [2017] reported that intercropping mustard with coriander significantly reduced pest infestations while preserving honeybee populations, suggesting the potential of coriander as a companion plant for pest management. Breitenmoser et al. [2022] emphasised the importance of choosing suitable intercropping species to manage pest populations and promote biodiversity in winter oilseed rape agroecosystems. Similarly, Tajmiri et al. [2017] found that strip-intercropping potatoes with annual alfalfa successfully managed Colorado potato beetle populations and increased the presence of natural predators. These findings support the notion that intercropping can help control *L. decemlineata* adult populations when suitable companion plants are used.

In support of this, the dominant essential oil compounds identified in coriander, such as linalool (up to 87.5%), α-pinene (up to 10.9%), camphor (up to 5.1%), and γ-terpinene (up to 11.2%) are all known to exert neurotoxic or deterrent effects on insect pests [Pande et al. 2010, Mageed et al. 2012, Freires et al. 2014]. These volatiles likely interfere with pest orientation and host detection, contributing to the reductions observed in CPB populations.

Alioghli et al. [2022] reported that specific potato-safflower intercropping patterns effectively managed Colorado potato beetle populations and improved crop yields. This finding further corroborates the potential of well-designed intercropping systems for pest management, as observed in the present study. Lastly, Ben-Issa et al. [2017] highlighted the importance of selecting appropriate companion plants based on their interactions with the target pest and compatibility with the main crop. The current study demonstrates the potential of coriander as a companion plant for eggplant to mitigate *L. decemlineata* adult populations, contributing to the growing body of evidence supporting the use of companion planting for sustainable pest management in agricultural systems.

CONCLUSIONS

The observed results demonstrate that co-cultivating coriander and eggplant significantly influences the CPB adult population, highlighting the importance of considering these plant species during cultivation. Further investigation into the underlying causes and mechanisms of these relationships is warranted, as this could potentially contribute to the advancement of more efficacious strategies in horticultural practices and integrated pest management. In summary, trials conducted in 2018 and 2021 revealed that the number of adult CPB decreased during both the flowering and fruit development stages of coriander. It could potentially be due to the presence of essential oils in coriander. Further research is necessary to understand better the potential role that these essential oils play in reducing the CPB population. Further studies should also be undertaken to determine the presence and composition of secondary metabolites in companion plants based on their growth stages.

CONTRIBUTIONS

S.B., O.K., N.S.G. reviewed and edited the draft. All authors have read and approved the final version to be published.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

FUNDING

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AVAILABILITY OF DATA AND MATERIAL

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

CONFLICT OF INTEREST

The authors affirm that they have no recognisable financial interests or personal relationships that could have impacted the research findings presented in this manuscript.

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