

Field Efficacy of Various Control Agents on *Cassida vittata* Vill (Coleoptera: Chrysomelidae) and Associated Natural Enemies in Sugar Beet (*Beta vulgaris* L) Crop

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Research Article

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Abstract

Background

In Egypt, *Beta vulgaris* (sugar beet) is a vital strategic crop second only to sugarcane for local sugar production. *Cassida vittata* Villers is widely recognized as a significant agricultural pest that feeds on the foliage of sugar beet crops in Europe, North Africa, and the Middle East.

Results

At the Experimental in Qalubia Governorate, Egypt, field tests were carried out for two consecutive growing seasons (2023–2024 and 2024–2025), to evaluate the efficiency of four compounds (Emamex, Dipel2x, Biosect and Mineral oil) against *Cassida vittata* vill and two natural enemies, *Coccinella undecimpunctata* L. and *Chrysoperla carnea* steph. Emamex was the most effective compound against the larvae which recorded mean percentage reduction (77.70 and 83.68%) and adults (82.86 and 85.29%) of the beet tortoise beetle *C. vittata* in first and second season respectively, according to the field results, which also showed the most noticeable effect on the related natural enemies. On the other hand, the bio-pesticides observed a progressive, incremental efficacy over time. While, mineral Oil demonstrated the lowest overall efficacy of all assessed treatments in both seasons. Therefore, we recommend using these compounds in rotation within integrated pest management (IPM) programs.

Conclusions

Emamex was most effective against *C. vittata* but harmed beneficial insects, while Mineral Oil performed the worst. For balanced pest management, it is advised to rotate biopesticides with strategic Emamex applications to protect natural enemies.

Background

In Egypt's agricultural economy, sugar beet (*Beta vulgaris* L.) represents the second cornerstone of sugar production, following sugarcane. It continues to be a vital strategic crop both locally and internationally, critical for ensuring the supply of sucrose and reducing issues related to food security **SCRI (2021)**.

In 2025, in Egypt, sugar beet cultivated area reached about 700,000 feddan which produced about 40–50 tons an average 2 ton /feddan of white sugar per acre (**Anonymous 2025**).

However, the productivity of this crop is heavily constrained by a number of economic insect pests, most notably the sugar beet tortoise beetle, *Cassida vittata* Vill. (Coleoptera: Chrysomelidae) (**El-Khouly 2019**). The intensive feeding of both larvae and adults on the foliage induces a distinctive 'shot-hole' defoliation pattern (**Ebadah et al., 2022**), which ultimately poses a severe threat to the sugar beet's quantitative root yield and qualitative sucrose content (**Shalaby et al., 2020**). The heavy use of synthetic chemical

insecticides has been a major component of *C. vittata* treatment for decades. Despite their effectiveness, the ongoing and careless use of conventional insecticides has resulted in concerning side effects, such as the emergence of pest resistance, secondary pest outbreaks, environmental contamination, and dangerous residues on food and in the soil ecosystem (**Abdel-Raheem et al., 2023**). As a result, adopting Integrated Pest Management (IPM) techniques has become crucial for contemporary sustainable agriculture. This shift highlights the investigation of environmentally acceptable substitutes that provide targeted efficacy while reducing ecotoxicological effects on non-target organisms, such as innovative bio-insecticides, entomopathogenic microorganisms, and mineral oils. Due to their low environmental persistence and strong toxicity against coleopteran pests through distinct neurological mechanisms of action, spinosyns and avermectin derivatives, such as emamectin benzoate, have been prominent among these alternate explanations. Microbial control agents, such as the entomopathogenic fungus *Beauveria bassiana* and the entomopathogenic bacterium *Bacillus* species, provide promising biological pathways by piercing the host cuticle or acting as stomach poisons, respectively (**Abdel-Raheem et al., 2023; El Aalaoui et al., 2025**). Furthermore, mineral oils generated from petroleum are a useful mechanical tool in integrated pest management (IPM), lowering pest populations by physical asphyxiation and anti-feedant qualities without quickly causing resistance.

Thus, the goal of this study was to assess and compare the field efficacy of some compounds against the sugar beet beetle, *C. vittata*, in natural field conditions and their associated natural enemies. The results are intended to provide an eco-friendly, optimum suppression hierarchy that can be successfully included into programs for the sustainable protection of sugar beet crops.

Material and Methods

1. Field studies

At the Experimental in Qalubia Governorate, Egypt, field tests were carried out for two consecutive growing seasons (2023–2024 and 2024–2025), to evaluate the efficiency of four compounds against *Cassida vittata* vill and two natural enemies, *Coccinella undecimpunctata* L. and *Chrysoperla carnea* steph. The experimental area was set up using a Randomized Complete Block Design (RCBD) and took approximately about 1/8 of an feddan (500 m²) with plot size 5x5m². Seeds of a commercial sugar beet (*Beta vulgaris* L., cv. 'Kaumira') variety were sown manually on November 5th in both seasons. The experimental area was divided into ridges 60 centimeters apart, and plowed twice. On one side of the ridge, hills were sown at a depth of 2-3 centimeters and intra-row spacing of twenty centimeters. Hand thinning was done to leave one robust plant per hill thirty days following seeding (at the four-leaf stage), all conventional farming and fertilization methods were scrupulously adhered to without the use of pesticides, until the pests infestation reached the point of economic harm (15 larvae/100 plant) and (20-30 adult/ 100 plant) according to the official recommendations Agricultural Pesticides Committee (**APC, 2023**).

2. Compounds applied

The investigated chemicals were applied topically on March 25th of each season, when the beet beetle's natural population reached the economic injury level (EIL). A calibrated backpack sprayer with a standard nozzle was used to apply the treatments, guaranteeing even and complete coverage of the plant canopy. When applied this chemicals the mean temperature was (17.0 and 18°C), RH% was (55 and 50 %) and wind speed was (16 and 14 Km/h) in 2024 and 2025 season, respectively (data were obtained from the Central Laboratory for Agricultural Climate, Egypt). The cultivated area was 1/8 feddan a fixed sample of 10 plants each replicate (40 plants per treatment) was chosen at random in order to track insect population dynamics. Inspection was conducted after sunset, followed immediately by spraying .An inner diagonal sample pattern was used to thoroughly analyze these plants in order to exclude edge effects. The following schedule was followed in the visual counts of live beet beetle and two natural enemy's larvae and adults:

- Pre-treatment count: Conducted on March 25th just before application in order to determine the baseline population.
- Post-treatment counts: Methodically carried out at intervals of 1, 3, 7, and 10 days following spraying to assess the investigated chemicals' immediate knockdown effect as well as their long-term residual efficacy. Tested compounds, dosages, common name, trade name and chemical source of tested insecticide are presented in Table (1- Design 1).

Table (1): Tested chemical compounds structure during 2023/2024 and 2024/2025 season.

Chemical compounds	Trade Name	Common Name	Chemical Class / Source	Recommended Dose
Emamex	Emamex 5% SG	<i>Emamectin benzoate</i>	Avermectins (Semi-synthetic microbial derivative)	150gm/fedden (120-150L/water)
Dipel 2X	Dipel 2X 6.4%WP	<i>Bacillus thuringiensis</i> subsp. <i>Kurstaki</i>	Microbial (Bacterial endospores/delta-endotoxins)	200gm/feddan (150-200L/water)
Biosect	Biosect WP	<i>Beauveria bassiana</i>	Entomopathogenic Fungus (Biological control agent)	200gm/100 L/ water
Mineral Oil	Mineral Oil	Mineral Oil	Aliphatic Hydrocarbons	1.5L/100 L/ water

3-Statistical analysis

Treatment-related population declines were computed and contrasted with insect populations in untreated plots (control). The **Henderson and Telton (1955)** formula was used to estimate the percentage of infestation reduction in these circumstances.

$$\text{Reduction \%} = 1 - (\text{Cb}/\text{Ca} \times \text{Ta}/\text{Tb}) \times 100$$

Cb = control before spray.

Ca = control after spray.

Ta = treatment after spray

Tb = treatment before spray

Results and discussion

1-Efficacy of tested treatments against *C. vittata*

1.1- Immediate and long-term impact of tested treatments against larvae of *C. vittata* at various post-treatment intervals in 2023/2024 and 2024/2025 seasons.

In both seasons data observed a distinct hierarchy of efficacy, with Mineral Oil continuously being the least effective treatment against the targeted larvae and Emamex achieving the highest initial and peak control (Tables 2 and 3) and (Fig. 1 and 2 a&b) . In particular, Emamex achieved its maximum peak efficacy on Day 7 (88.75% and 90.56%, respectively), and recorded the highest knockdown effect after 1 day in first and second season, respectively (65.24% and 77.73%). This led to the highest overall mean reductions of (77.70% and 83.68%) across the two seasons. Regarding the quick neuromuscular disruption brought on by Eamectin benzoate, **Zalizniak et al. (2023)** clearly support this remarkable achievement. On the other hand, the microbial therapies demonstrated 0% decrease on Day 1 but made significant improvement with time; Dipel 2X achieved its maximal efficacy on Day 10 (81.83% and 83.40%), which is consistent with the delayed, ingestion-dependent nature of bacterial endotoxins, according to **Raymond and Federici (2024)**. According to **Ramanujam et al. (2025)**, Biosect also followed a consistent cumulative course, peaking on Day 10 with 70.00% in first season and an astounding 86.55% in second season. However, Mineral Oil maintained the lowest overall seasonal mean reductions of 44.50% and 57.01%, confirming the consensus, and reported the lowest efficacy throughout the trials, with its lowest reduction falling to 26.40% on Day 1 in first season, and maintained the lowest seasonal mean reductions of 44.50% and 57.01%, confirming **Donga et al. (2022)** conclusion that physical spiracle closure offers little defense against sophisticated, active larvae.

Table (2): Immediate and long-term impact of tested treatments against the larvae of *C. vittata* at various post-treatment intervals in 2023/2024 season.

Treatments	Pre-spray	After 1 day	After 3 day	After 7 day	After 10 day	% mean Reduction
Emamex	45	17 (65.24%)	10 (77.28%)	5.5 (88.75%)	9 (79.55%)	77.70%
Dipel 2x	45	-	20.5 (61.89%)	10 (79.56%)	8 (81.83%)	74.43%
Biosect	46	-	25 (54.54%)	17.5 (65%)	13.5 (70%)	63.18%
Minteral oil	45	36 (26.4%)	28.5 (47.03%)	20 (59.11%)	24 (45.48%)	44.50%
Control	46	50	55	50	45	000

Table (3): Immediate and long-term impact of tested treatments against the larvae of *C. vittata* at various post-treatment intervals in 2024/2025 season.

Treatments	Pre-spray	After 1 day	After 3 day	After 7 day	After 10 day	% mean Reduction
Emamex	52	12 (77.73%)	8 (85.41%)	5 (90.56%)	9.5 (81.04%)	83.68%
Dipel 2x	50	-	19 (63.96%)	10.5 (79.37%)	8 (83.40%)	72.58%
Biosect	54	-	22 (61.37%)	10 (81.81%)	7 (86.55%)	76.58%
Minteral oil	51	33 (37.56%)	22.5 (58.16%)	14 (73.04%)	20 (59.30%)	57.01
Control	55	57	58	56	53	000

1.2- Immediate and long-term impact of tested treatments against Adult of *C. vittata* in 2023/2024 and 2024/2025 seasons.

The combined field data from first and second seasons showed a consistent efficacy hierarchy against adults with Mineral Oil being the least effective intervention and Emamex producing the best control in Tables (4 and 5) and Fig.(3and 4 a &b). With an instantaneous 1-day reduction (71.95% and 74.32%) in first and second season, respectively and a peak on Day 7 (90.60% and 92.87%, respectively), Emamex (*Emamectin benzoate*) demonstrated a strong effect, resulting in the largest seasonal mean reductions (82.86% and 85.29%). The remarkable vulnerability of adult insects to emamectin benzoate formulations under Egyptian field conditions is firmly supported by **El-Sheikh et al. (2024)**. Microbial treatments, on the other hand, showed a 24-hour lag phase but significant progressive control; Dipel 2X (*B. thuringiensis*) reached its maximum efficacy by Day 10 (77.23% and 78.61%), which is consistent with the findings of **Moussa et al. (2025)** concerning the delayed toxicity and ingestion-dependent nature of bacterial delta-endotoxins in adult insect populations. According to **El-Sadawy et al. (2023)** and **Gadelhak et al. (2025)**, Biosect (*B. bassiana*) also followed an incremental mortality trajectory that peaked on Day 10 (71.18% and 73.42%) in both season, respectively.

Table (4): Immediate and long-term impact of tested treatments against the Adult of *C. vittata* at various post-treatment intervals in 2023/2024 season

Treatments	Pre-spray	After 1 day	After 3 day	After 7 day	After 10 day	% mean Reduction
Emamex	30	9.5 (71.95%)	5 (86.40%)	3 (90.60%)	5 (82.48%)	82.86%
Dipel 2x	30	-	15.5 (57.85%)	7.5 (76.51%)	6.5 (77.23%)	70.53%
Biosect	31	-	19.5 (48.68%)	10.5 (68.18%)	8.5 (71.18%)	62.68%
Minteral oil	30	24 (29.14%)	13 (64.65%)	12 (62.42%)	18.5 (35.20%)	47.85
Control	31	35	38	33	29.5	000

Table (5): Immediate and long-term impact of tested treatments against the Adult of *C. vittata* at various post-treatment intervals in 2024/2025 season

Treatments	Pre-spray	After 1 day	After 3 day	After 7 day	After 10 day	% mean Reduction
Emamex	37	10 (74.32%)	3 (92.66%)	2.5 (92.87%)	6 (81.33%)	85.29%
Dipel 2x	35	-	16.5 (57.35%)	8 (75.87%)	6.5 (78.61%)	70.61%
Biosect	39	-	24.5 (43.16%)	12 (67.52%)	9 (73.42%)	61.37%
Minteral oil	36	28 (26.11%)	21 (47.22%)	13 (61.88%)	18 (42.42%)	44.40%
Control	38	40	42	36	33	000

2-Efficacy of tested treatments against associated natural enemies.

2.1- Immediate and long-term impact of tested treatments against *Coccinella undecimpunctata* L in 2023/2024 and 2024/2025 growing season.

Coccinella undecimpunctata larvae and adults found clear stage-specific susceptibility differences in field trials (Tables 6 and 7). Both phases were most suppressed by Emamex; however, data showed more susceptibility, with a mean reduction of 81.96% (peaking at 87.44% on day 7) , while 79.86% (87.18% peak on 7 day),in first and second season , respectively., support this effect **Desneux et al. (2023)**.On the other hand, high safety margins were preserved by bio pesticides. Dipel 2X produced very slight decreases (20.88%) and (28.71%) in both seasons, respectively, also mineral oil which recorded (31.42 and 34 %) in both seasons, respectively. Data supported of **Raza, et al. (2025)**. At the same time, a Biosect caused a delayed suppression that peaked on Day 7 for both larvae and adults (23.37%) and (40.17%) in both season, respectively, confirming the findings of **Sainand et al. (2024)**. Additionally, Mineral Oil had a transient effect, resulting in modest mean reductions of 31.22% and 25.69% in the two seasons, supporting **Stansly and Liu's (2022)** and **Fernandes et al. 2022** assertion that the physical mechanism of petroleum oils guarantees the best possible predator conservation in IPM programs.

Table (6): Immediate and long-term impact of tested treatments against *Coccinella undecimpunctata* in 2023/2024 season.

Treatments	Pre-spray	After 1 day	After 3 day	After 7 day	After 10 day	% mean Reduction
Emamex	14	3.5 (76.56%)	2.2 (86.53%)	1.7 (87.44%)	2.9 (77.32%)	81.96%
Dipel 2x	13	-	12 (20.88%)	-	-	20.88%
Biosect	13.5	-	-	10 (23.37%)	9.8 (22.95%)	23.16%
Minteral oil	14	10.3 (31.03%)	11.2 (31.42%)	-	-	31.22%
Control	15	16	17.5	14.5	13.7	000

Table (7): Immediate and long-term impact of tested treatments against *Coccinella undecimpunctata* in 2024/2025 season.

Treatments	Pre-spray	After 1 day	After 3 day	After 7 day	After 10 day	% mean Reduction
Emamex	11	3 (70%)	2 (84%)	1.5 (87.18%)	2.5 (78.26%)	79.86%
Dipel 2x	10.5	-	9 (24.57%)	7.5 (32.84%)	-	28.71%
Biosect	11	-	9 (28%)	7 (40.17%)	9.2 (20%)	29.39%
Minteral oil	12	8.5 (22.08%)	9 (34%)	10 (21%)	-	25.69%
Control	11	10	12.5	11.7	11.5	000

2.2- Immediate and long-term impact of tested treatments against *Chrysoperla carnea* in 2023/2024 and 2024/2025 growing season

In Tables (8 and 9) Emamex was found to be the most effective and dependable option with an exceptional overall mean reduction (74.36% and 78.73%) in first and second respectively, driven by its immediate knockdown effect and excellent translaminar residual persistence, which strongly aligns with the findings of **El-Naggar et al. (2020)** **El-Heneidy et al. 2023** and **Salama et al. (2023)**. Both biological agents Observed no immediate action on first day but showed little effect with low percentage in 3.7 and

10 days in both season. On the other hand, Mineral Oil recorded a strictly temporary, short-term contact efficacy (18.71% - 26.04% mean reduction) in both seasons respectively, a pattern previously reported by Stansly and Kostyk (2016).

Table (8): Immediate and long-term impact of tested treatments against *Chrysoperla carnea* in 2023/2024 season.

Treatments	Pre-spray	After 1 day	After 3 day	After 7 day	After 10 day	% mean Reduction
Emamex	8.5	2.5 (69.51%)	1.5 (82.76%)	1 (87.65%)	2 (75%)	78.73%
Dipel 2x	8	-	7.5 (7.5%)	6.5 (14.74%)	7.4 (1.72%)	8.29%
Biosect	9	-	8.8 (4.47%)	7.5 (12.55%)	7 (7.03%)	8.02%
Minteral oil	8	4.8 (37.80%)	6.4 (21.84%)	7 (8.18%)	7 (7.03%)	18.71%
Control	8.5	8.2	8.7	8.1	8	000

Table (9): Immediate and long-term impact of tested treatments against *Chrysoperla carnea* in 2024/2025 season.

Treatments	Pre-spray	After 1 day	After 3 day	After 7 day	After 10 day	% mean Reduction
Emamex	6	2 (64.58%)	1.5 (76.39%)	1 (82.72%)	1.5 (73.76%)	74.36%
Dipel 2x	7.5	-	7 (11.35%)	6.5 (10.16%)	7 (2.06%)	8.02%
Biosect	8	-	7.5 (11.45%)	6.5 (15.78%)	7.6 (21.30%)	16.17%
Minteral oil	7	4 (39.28%)	4.5 (39.28%)	5.5 (18.55%)	6.2 (7.05%)	26.04%
Control	8.5	8	9	8.2	8.1	000

The chart in Fig. (6) illustrates the comparative efficacy of four pesticides (Emamex, Dipel 2x, Biosect, and Mineral oil) by evaluating their overall mean reduction effect on different life stages (larvae and adults) of the target pest *C. vittata*, alongside their collateral impact on two types of natural enemies. Emamex consistently shows the highest reduction rates (75% to over 85%) across all categories. This indicates high toxicity and broad-spectrum activity, making it highly effective against the target pest, but equally destructive to beneficial natural enemies. **Dipel 2x** and **Biosect** (which are typically bio-pesticides, such as *Bacillus thuringiensis* and *Beauveria bassiana* respectively) along with **Mineral oil** show a significant drop in toxicity against the natural enemies (the last four groups of bars), with reduction rates dropping well below 30% in most cases. While Mineral oil has the lowest efficacy against the pest (around 45% reduction), it maintains a relatively uniform and low-to-moderate impact on natural enemies, showing less selectivity but lower absolute toxicity compared to synthetic options.

Conclusion

This study showed a clear contrast between natural enemy conservation and pest reduction in sugar beet management. Emamex recorded the greatest insecticidal efficiency against larvae and adults of *Cassida vittata*, but it had negative effects on beneficials (*Coccinella undecimpunctata* and *Chrysoperla carnea*). On the other hand, Mineral Oil recorded in continuously performed worse in the both seasons. Figure (6). The bio-pesticides (Dipel 2X and Biosect) observed a gradual, incremental efficacy over time, providing an environmentally viable substitute. In order to maximize consequently, these compounds should be used in rotational cycles within integrated pest management (IPM) programs, it is advised to combine these biopesticides with strategic Emamex applications, striking a balance between the maintenance of biological control agents and efficient *C. vittata* management.

Declarations

Data availability This article includes all data generated or analyzed during the study.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

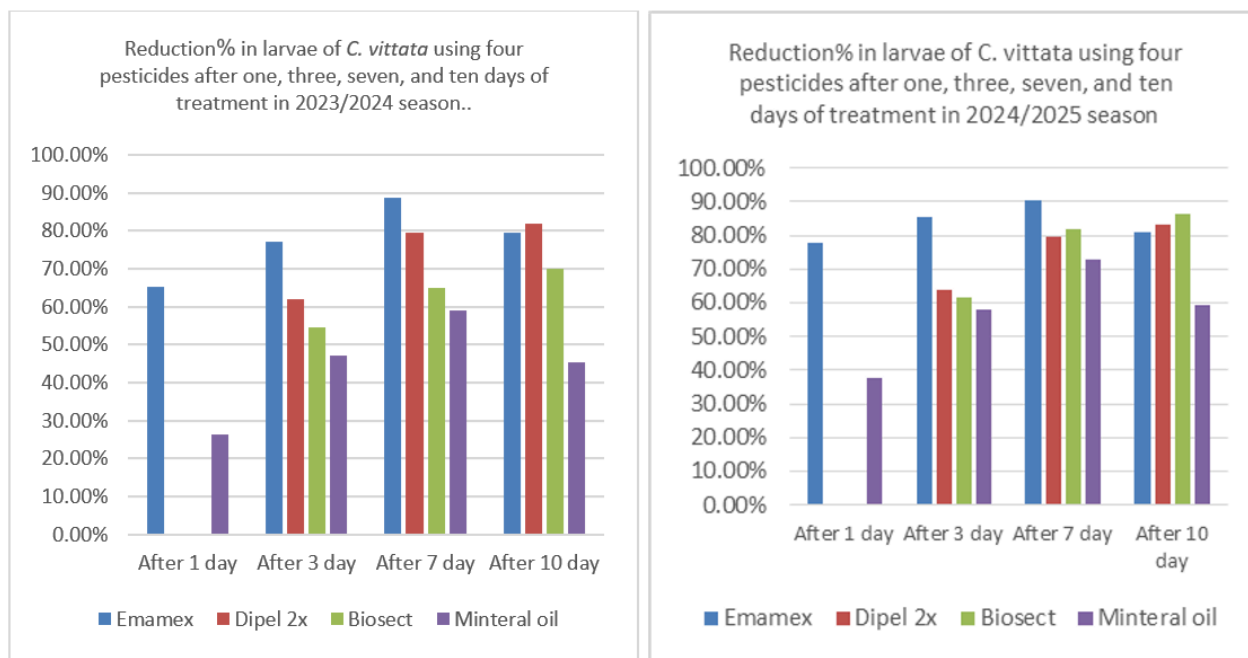
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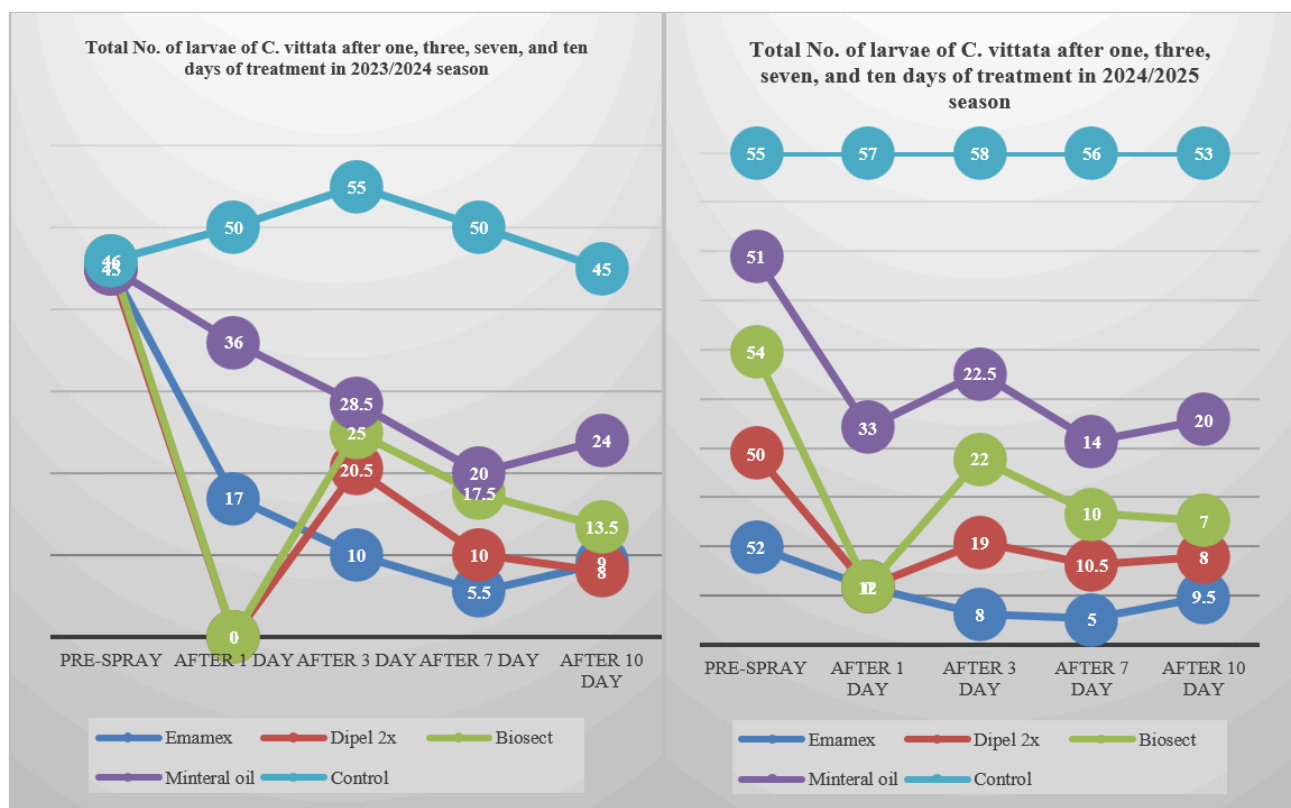
Figures



(a) Reduction% in larvae of *C. vittata* in 2023/2024 season **(b)** Reduction% in larvae of *C. vittata* in 2024/2025 season

Figure 1

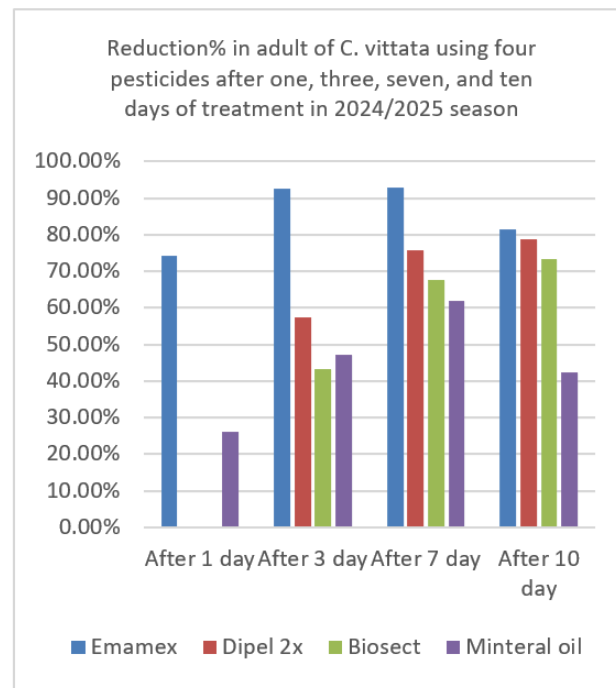
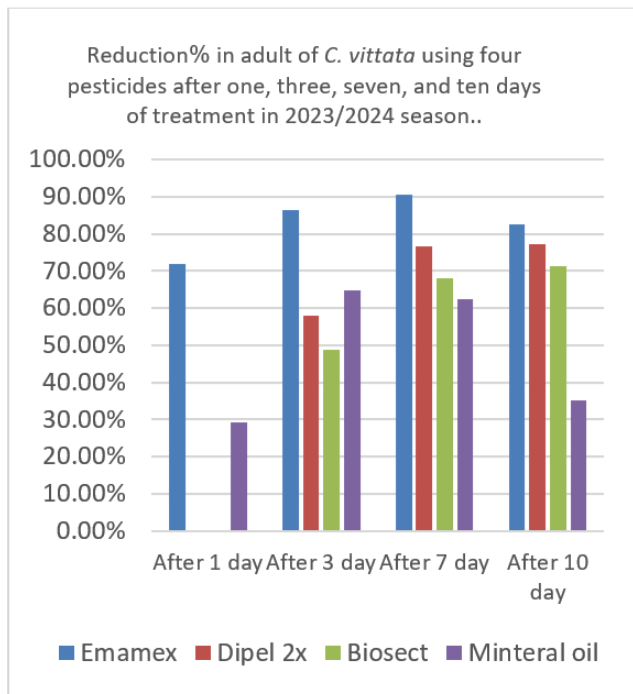
(a&b): Mean reduction percentage larvae of *C. vittata* at various post-treatment intervals in 2023/2024 and 2024/2025 season.



(a) Total No. of larvae of *C. vittata* in 2023/2024 season. (b) Total No. of larvae of *C. vittata* in 2024/2025 season

Figure 2

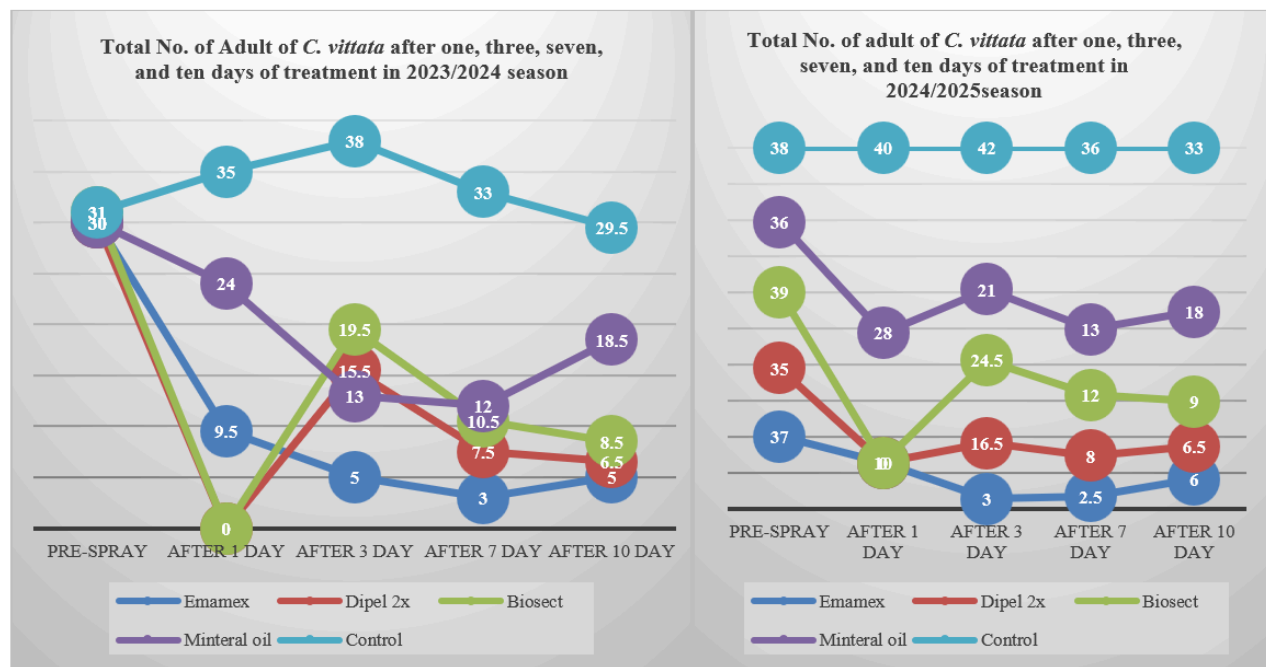
(a&b): Total number of larvae *C. vittata* in 2023/2024 and 2024/2025 seasons.



(a) Reduction% in adult of *C. vittata* in 2023/2024 season **(b)** Reduction% in adult of *C. vittata* in 2024/2025 season

Figure 3

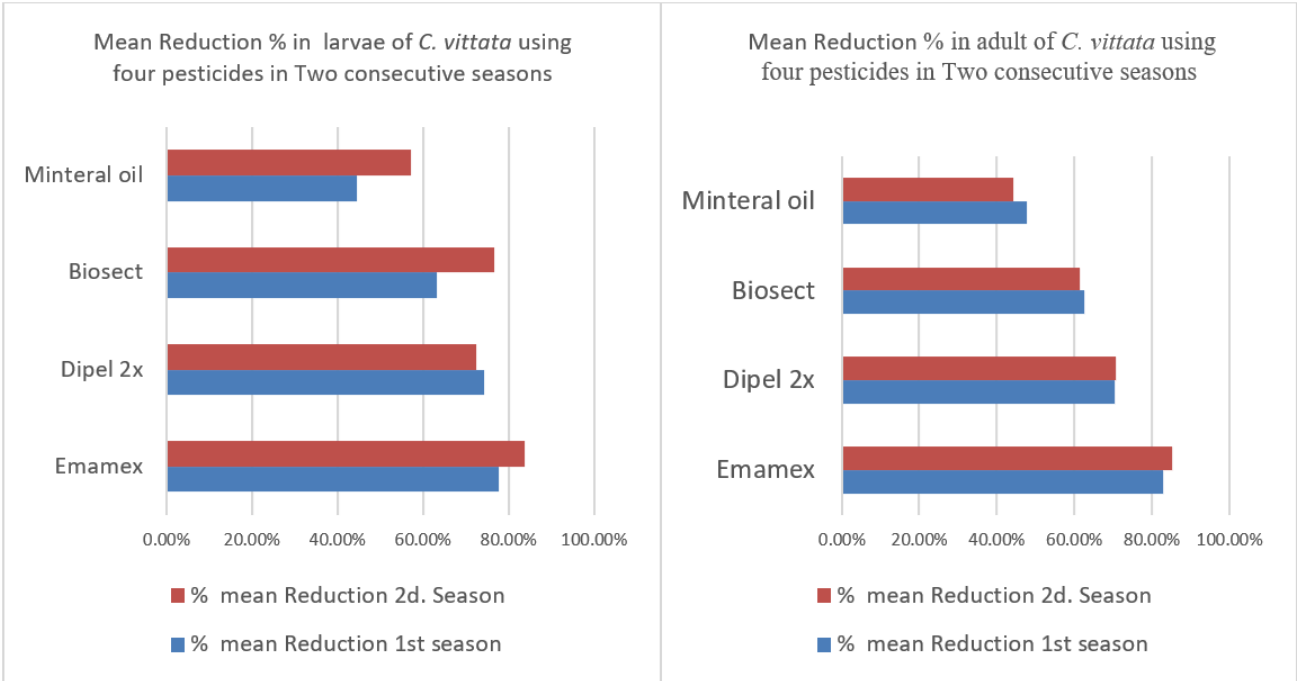
(a&b):Mean reduction percentage of Adult of *C. vittata* at various post-treatment intervals in 2023/2024 and 2024/2025 season



(b) Total No. of adult of *C. vittata* in 2023/2024 season. **(b)** Total No. of adult of *C. vittata* in 2024/2025 season

Figure 4

(a&b): Total number of Adult of *C. vittata* in 2023/2024 and 2024/2025 season.



(a) Mean Reduction % in larvae of *C. vittata* in Two consecutive seasons (b) Mean Reduction % in adult of *C. vittata* in Two consecutive seasons

Figure 5

(a&b): Reduction % of pesticides on larvae and Adult of *C. vittata* in both seasons.

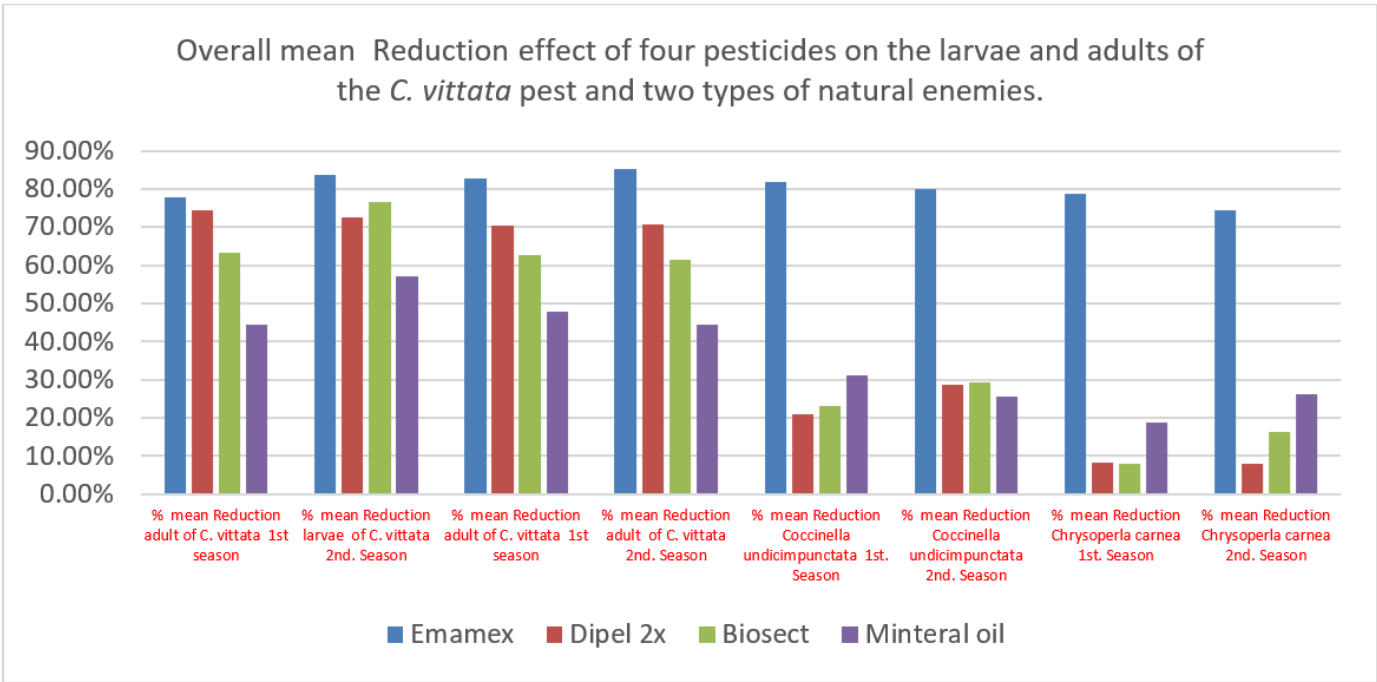


Figure 6

Overall mean Reduction effect of four pesticides on the larvae and adults of the *C. vittata* pest and two associated of natural enemies.