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Research Article

Relative toxicity of commonly used pesticides in mango against *Chrysoperla zastrowi sillemi* (Esben-Peterson) (Neuroptera: Chrysopidae) larvae under laboratory conditions

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ABSTRACT: Chrysopids are biological control agents vulnerable to various broad-spectrum and non-selective pesticides used for pest management. A relative toxicity study was conducted on 2nd instar larvae of *Chrysoperla zastrowi sillemi* (Esben-Peterson) (Neuroptera: Chrysopidae) in the Bio-control laboratory, Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari during 2024. Various pesticides (insecticides and bio-pesticides) used at recommended doses for the management of mango insect-pests were utilised for determination using the thin film method. Amongst eight pesticides tested, buprofezin 25 SC @0.025%, *Lecanicillium (Verticillium) lecanii* 1.15 WP @0.07%, and Azadirachtin 1 EC @0.001% were categorised as harmless with less than 30 per cent mean larval mortality, whereas *Beauveria bassiana* (NAU strain) 1.15 WP @0.07%, deltamethrin 2.8 EC @0.0008%, imidacloprid 17.8 SL @0.005%, lamda cyhalothrin 5 EC @0.003% and thiamethoxam 25 WG @0.0084% were found slightly harmful with mean per cent larval mortality ranging from 30 to 79 per cent. These findings can inform strategies that incorporate *Chrysoperla* sp. as part of an integrated pest management program for mango pests.

KEYWORDS: Bio-pesticides, *Chrysoperla astrowisillemi*, mango, insecticides, relative toxicity

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INTRODUCTION

Mango is cultivated throughout the tropics and subtropics. Among the different mango-producing countries, India occupies first position with a 45 per cent share (NHB, 2016). Mango trees are attacked by various sucking and chewing insect pests, and indiscriminate use of pesticides leads to problems like resurgence and resistance. That's why, to meet the international demand of residue free product, there is great scope in integrated pest management (IPM) for the profitable mango cultivation (Reddy *et al.*, 2018). Biological control has proven to be a sustainable and environmentally friendly IPM approach for insect-pest management using predators and parasitoids.

Chrysopids have a great contribution in the management of soft-bodied insect-pests as their larvae are polyphagous in nature, feeding on aphids and other arthropod pests (Senior and McEwen, 2001). The grubs of *C. zastrowi sillemi* are effective predators of aphids, thrips, spider mites, whiteflies and insect-pest eggs found in varied agricultural ecosystems (McEwen *et al.,*2001). Because of its wide distribution (New, 1975), feasibility in mass multiplication (Araujo and Bichao, 1990) and pesticide tolerance (Hassan *et al.*, 1985), it has gained great focus from researchers and farmers as a potential biocontrol agent.

The correct use of pesticides is less harmful to beneficial insects, and therefore, before spraying pesticides, it is necessary to choose a product that is efficient to pest and selective to natural enemies (Fernandes *et al.,* 2010). Nowadays, with an increase in demand for residue-free food products and organic products, the use of microbial

pesticides, botanicals and bio-pesticides has great potential in pest management. However, the success as an efficient management tactic relies not only on its effectiveness against insect pests, but on its toxic effect on non-target insects (natural enemies). Therefore, considering the importance of chrysopid predators in the mango ecosystem to generate information on the relative toxicity of commonly used pesticides against chrysopid larvae, the present study was carried out. The primary objective of this study was to assess the toxicity of various commonly used insecticides on *Chrysoperla* sp*.,* a beneficial predator against mango sucking pests. Additionally, we evaluated the safety of these insecticides for *Chrysoperla* sp*.,* examining whether the effective dose for pest control is also safe for this generalist predator. Thus, the information generated from this study could be utilised in modernising and modifying current plant protection practices.

MATERIALS AND METHODS

A relative toxicity study was conducted on *C. zastrowi sillemi* larvae in the Bio-control laboratory, Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari during 2024. The laboratory rearing and multiplication of field-collected predominant species of *Chrysopid* sp. in the mango ecosystem was not feasible. Therefore, to study the relative toxicity, culture [*Chrysoperla astrowisillemi* (Esben-Peterson) (Neuroptera: Chrysopidae)]was acquired from Bio-Control Laboratory, Department of Entomology, NMCA, NAU, Navsari. Eight pesticides, *viz*. buprofezin 25 SC @ 0.025 per cent concentration; deltamethrin 2.8 EC (0.0008%), imidacloprid 17.8 SL (0.005%), lamda cyhalothrin 5 EC (0.003%), thiomethoxam 25 WG (0.0084%) and three bio-pesticides *viz. L. lecanii* 1.15 WP (0.070%), *B. bassiana* (NAU strain-0.07%) and neem-based botanical azadirachtin



Figure 1. Relative toxicity study of pesticides against *C. zastrowi sillemi* larvae in laboratory; **a.** Stock solution of different treatments; **b.** Preparation of a thin film of treatment; **c.** Experiment set up in the laboratory.

1 EC (0.001%), along with control (water spray), were selected to determine their relative toxicity against second instar larvae of *C. zastrowi sillemi* using the thin film method as suggested by PDBC, Bangalore (Anon, 1994). The concentration of each pesticide was calculated by using the following formula,

$$\text{Concentration (\%)} = \frac{\text{Quantity of insecticide (Dose g or ml) x Formulation}}{\text{Total quantity of spray solution required (ml)}} \times 100$$

Insecticide film was prepared by dipping plastic vials (5 x 2.5 cm) in respective insecticide solutions, followed by drying under a fan for 15 minutes (Figure 1). Ten second instar larvae of *C. zastrowi sillemi* were released to the treated vials in each treatment and exposed to insecticide film for 45 minutes. Larvae were given UV-irradiated *Corcyra cephalonica* eggs as a food after transferring individual larvae to fresh plastic vials (5 x 2.5 cm). The toxicity of pesticides was expressed in terms of mortality of second instar larvae. The data on per cent corrected mortality were transformed using arc-sine transformation for statistical analysis in a Completely Randomised Design (CRD). The observations on larval mortality were recorded at 2, 12, 24, 48 and 72 hours after exposure to insecticide treatments (Figure 1). The per cent corrected mortality (CM) was calculated by using Abbott's formula (Abbott, 1925) as follows.

$$\text{Corrected mortality (\%)} = \frac{\textit{Per cent mortality of treatment} - \textit{per cent mortality of control}}{\textit{100 per cent mortality of control}} \times 100$$

The statistical analysis was done using OPSTAT, an online Agriculture Data Analysis Tool created by O. P. Sheoran, Computer Programmer at CCS HAU, Hisar, India (http://14.139.232.166/opstat/index.asp). Treatment means were compared using the critical difference (CD). Further, a toxicity score was given to each treatment and classification of pesticides based on relative toxicity to *C. zastrowi sillemi* larvae was carried out as per Sterk (1999).

RESULTS AND DISCUSSION

Per cent larval mortality of *C. zastrowi sillemi* at 2 Hrs

The observations recorded after 2 hours of treatment showed the highest mortality in T_3 – imidacloprid 17.8 SL (16.67%), followed by T_5 – thiamethoxam 25 WG (10.00%), which was statistically at par with other insecticides *viz.,* T_2 – deltamethrin 2.8 EC (6.68%) and T_4 – lamda cyhalothrin 5 EC (6.68%) (Table 1, Figure 2). In treatments T_9 – control (water spray), T_1 – buprofezin 25 SC, T_6 - *L. lecanii* 1.15 WP, T_7 - *B. bassiana* (NAU strain) 1.15 WP and T_8 – Azadirachtin 1 EC, no larval mortality was recorded.

Per cent larval mortality of *C. zastrowi sillemi* at 12 Hrs

The percentage larval mortality recorded at 12 hours after treatment showed that among the different pesticides used lowest per cent larval mortality was recorded in T_1 – buprofezin 25 EC (6.68%), followed by T_6 – *L. lecanii* 1.15 WP and T_8 - Azadirachtin 1 EC (16.67%), which means these are safer pesticides. Whereas higher mortality was recorded in T_3 - imidacloprid 17.8 SL (46.67%), followed by T_5 - thiamethoxam 25 WG (30%), T_2 – deltamethrin 2.8 EC (26.67%), T_4 – lamda cyhalothrin 5 EC (23.33%) and T_7- *B. bassiana* (NAU strain) 1.15 WP (20%)(Table 1, Figure 2).

Per cent larval mortality of *C. zastrowi sillemi* at 24 Hrs

The data recorded after 24 hours of treatment showed that the highest per cent larval mortality was observed in T_3 – imidacloprid 17.8 SL (56.67%), followed by T_5 -thiamethoxam 25 WG, T_4 – lamda cyhalothrin 5 EC and T_2 – deltamethrin 2.8 EC with 36.67, 33.33 and 30.00 per cent mortality, respectively. There was no larval mortality observed in the control (water spray). Lowest per cent mortality was recorded in T_1 – buprofezin 25 EC (13.33%), which was statistically at par with T_6 - *L. lecanii* 1.15 WP (20%) and T_8 – azadirachtin 1 EC (16.67%). Meanwhile, T_7 – *B. bassiana* 1.15 WP with mortality 23.33 per cent was statistically in line with T_2 – deltamethrin 2.8 EC (30%), T_6 - *L. lecanii* 1.15 WP (20%) and T_8 – azadirachtin 1 EC (16.67%) (Table 1, Figure 2).

Per cent larval mortality of *C. zastrowi sillemi* at 48 Hrs

The data noted 48 hours after insecticide treatment showed that in the control (water spray), no larval mortality was observed. *Lecanicillium lecanii* 1.15 WP (20.00 %) recorded significantly the lowest per cent mortality among different treatments, which was at par with T_1 -buprofezin 25 EC (23.33 %) and T_8 - azadirachtin 1 EC (23.33%). Significantly highest larval mortality was noted in T_3 - imidacloprid 17.8 (80.00 %), followed by T_4 - lamda cyhalothrin 5 EC (43.33 %), which was at par with T_2 - deltamethrin 2.8 EC (40.00%) and T_5 - thiamethoxam 25 WG (40.00%). *Beauveria bassiana* 1.15 WP recorded 30.00 per cent larval mortality, which was statistically at par with T_1 and T_8 (Table 1, Figure 2).

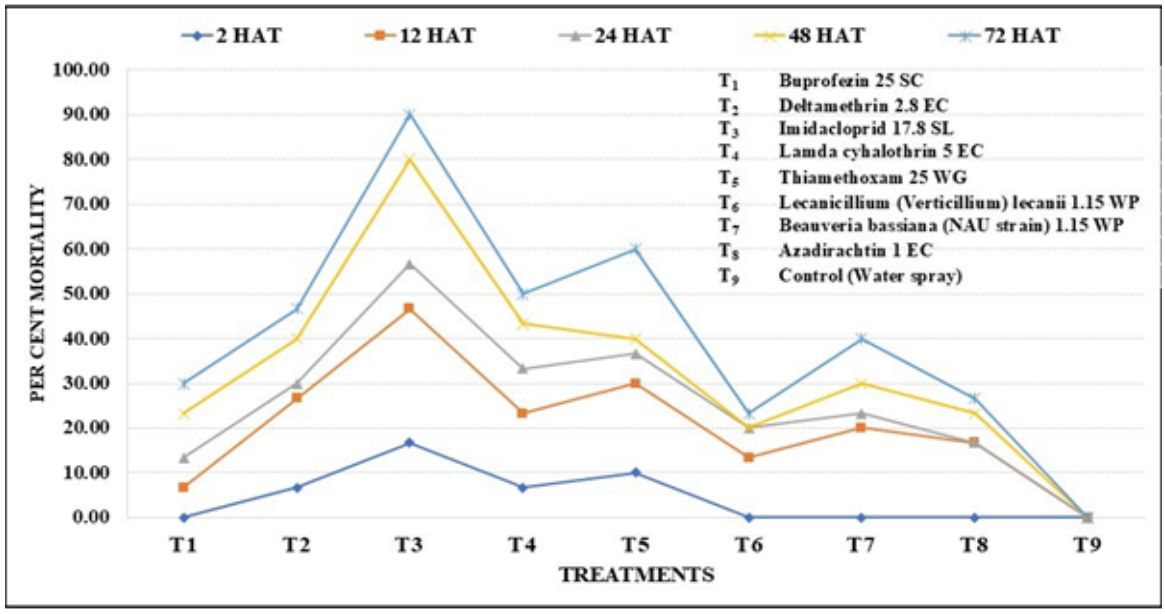


Figure 2. Mean per cent mortality of *C. zastrowi sillemi* larvae from the toxicity of different pesticides under laboratory conditions.

HAT-Hours After Treatment; *Figures in parentheses are original values, and those outside the parentheses are arcsine-transformed values. Treatment means (s) with the same letter (s) do not differ significantly by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance.

Per cent larval mortality of *C. zastrowi sillemi* at 72 Hrs

The data recorded on larval mortality 72 hours after treatment revealed that T_3 - imidacloprid 17.8 SL had the highest larval mortality to the tune of 90 per cent, followed by T_5 - thiamethoxam 25 WG (60%), T_4 - lamda cyhalothrin 5 EC (50%) and T_2 - deltamethrin 2.8 EC (46.67%). Bio-pesticides and botanicals recorded minimum per cent mortality ranging between 26.67 and 40.00 per cent (Table 1). Significantly lower per cent mortality was recorded in T_8 - azadirachtin 1EC (26.67%), which was statistically similar to T1-buprofezin 25 SC (30%). In control (water spray), no larval mortality was observed.

The overall mean data on per cent larval mortality at different intervals revealed that significantly the highest per cent larval mortality was recorded in T_3 - imidacloprid 17.8 SL (58.00 %), followed by T_5 - thiamethoxam 25 WG (35.33%), T_4 - lamda cyhalothrin 5 EC (31.34%) and T_2 - deltamethrin 2.8 EC (30.0%). Moreover, T_4 and T_2 were found to be at par with each other. Bio-pesticidal treatments *viz*., *Beauveria bassiana* 1.15 WP and *Lecanicillium lecanii* 1.15 WP; and botanical-based treatment *viz*., azadirachtin 1EC recorded lower mortality ranging between 15.34 to 22.67 per cent (Table 1). The ANOVA of overall mean data on per cent larval over the period revealed that the interaction of period and treatment was found significant showed inconsistency in performance of various treatments over the period. Further, it was noted that none of the treatments was found moderately harmful or harmful. However, imidacloprid 17.8 SL, thiamethoxam 25 WG, lamda-cyhalothrin 5 EC and deltamethrin 2.8 EC were slightly harmful. Whereas, buprofezin 25 SC, *Lecanicillium lecanii* 1.15 WP, *Beauveria bassiana* 1.15 WP and Azadirachtin 1 EC were found safer or relatively harmless against the larvae of *C. zastrowi sillemi* (Table 2).

Earlier, Ullah *et al.* (2017) noted 76 per cent 2nd instar grub mortality at 24 hours after treatment of imidacloprid 17.8 SL. Similarly, Daval *et al.,* (2016) found imidacloprid 17.8 SL as very toxic to 2nd instar larvae of *Chrysoperla* sp. In addition to this, Nasreen *et al.* (2005) concluded that all concentration of imidacloprid was found harmful to the larvae of *C. zastrowi sillemi*. These results more or less confirmed the present findings. In contrast, Haran e*t al.* (2019) and Preetha *et al.* (2009) classified imidacloprid as harmless.Lamda cyhalothrin 5 EC was also found slightly harmful as imidacloprid 17.8 SL in the present findings, which is in confirmation with Amarasekare & Shearer

Table 1. Relative toxicity of different pesticides against *C. zastrowi sillemi* larvae

Treatments		Concentration (%) 2 HAT	Larval mortality (%) at different intervals					Treatment mean
			12 HAT	24 HAT	48 HAT	72 HAT		
T_1	Buprofezin 25 SC	0.025	0.91^{c} (0.00)	12.59^{e} (6.68)	21.14^{e} (13.33)	28.78^{de} (23.33)	33.21^{e} (30.00)	19.33^{e} (14.67)
T_2	Deltamethrin 2.8 EC	0.0008	12.59^{b} (6.68)	31.00^{bc} (26.67)	33.21^{bc} (30.00)	39.15^{bc} (40.00)	43.08^{c} (46.67)	31.80^{c} (30.00)
T_3	Imidacloprid 17.8 SL	0.005	23.86^{a} (16.67)	43.08^{a} (46.67)	48.85^{a} (56.67)	63.43^{a} (80.00)	71.57^{a} (90.00)	50.16^{a} (58.00)
T_4	Lamda cyhalothrin 5 EC	0.003	12.59^{b} (6.68)	28.78^{bcd} (23.33)	35.22^{b} (33.33)	41.15^{b} (43.33)	45.00^{c} (50.00)	32.55^{c} (31.34)
T_5	Thiamethoxam 25 WG	0.0084	18.43^{ab} (10.00)	33.21^{b} (30.00)	37.22^{b} (36.67)	39.15^{bc} (40.00)	50.77^{b} (60.00)	35.76^{b} (35.33)
T_6	*Lecanicillium* (*Verticillium*) *lecanii* 1.15 WP	0.070 (1×10^{8} cfu/g)	0.91^{c} (0.00)	21.14^{d} (13.33)	26.57^{de} (20.00)	26.57^{e} (20.00)	28.78^{f} (23.33)	20.79^{e} (15.34)
T_7	*Beauveria bassiana* (NAU strain) 1.15 WP	0.070 (1×10^{8} cfu/g)	0.91^{c} (0.00)	26.57^{bcd} (20.00)	28.78^{cd} (23.33)	33.21^{cd} (30.00)	39.23^{d} (40.00)	25.74^{d} (22.67)
T_8	Azadirachtin 1 EC	0.0010	0.91^{c} (0.00)	23.86^{cd} (16.67)	23.86^{de} (16.67)	28.78^{de} (23.33)	31.00^{ef} (26.67)	21.68^{e} (16.67)
T_9	Control (Water spray)	-	0.91^{c} (0.00)	0.91^{f} (0.00)	0.91^{f} (0.00)	0.91^{f} (0.00)	0.91^{g} (0.00)	0.91^{f} (0.00)
		Period mean	8.00 (4.46)	24.57 (20.37)	28.42 (25.56)	33.46 (33.34)	38.17 (40.74)	-
	T	S.Em ±	2.90	2.63	1.87	2.02	1.23	0.98
		CD at 5%	8.59	7.80	5.53	5.98	3.63	2.77
		CV %	62.76	18.55	11.38	10.45	5.56	14.38
	P	S.Em ±	-	-	-	-	-	0.73
		CD at 5%	-	-	-	-	-	2.06
	T x P	S.Em ±	-	-	-	-	-	2.2
		CD at 5%	-	-	-	-	-	6.2

(2013); Abd-Ella *et al.,* (2022), wherein they noted that lamda cyhalothrin 5 EC were toxic to the larvae of *C. zastrowi sillemi.* Similarly, Sabry & EI-Sayed (2011) and Haran *et al.* (2019) classified lamda-cyhalothrin 5 EC as moderately harmful. Thiamethoxam was classified as slightly harmful, which is in confirmation with Shah *et al.* (2012) and Daval *et al.* (2016). Whereas, Preetha *et al.* (2009) and Haran *et al.* (2019) found thiamethoxam 25 WG moderately toxic with larval mortality ranging from 78 to 80 per cent. Similarly, Nasreen *et al.* (2005) classified it as a moderately harmful insecticide after 24 and 48 hours of exposure. Deltamethrin 2.8 EC was found slightly harmful

Table 2. Classification of pesticides based on relative toxicity to *C. zastrowi sillemi* larvae (as per Sterk, 1999)

No.	Categories	Per cent mortality	Toxicity score	Pesticides
1	Harmless	<30	1	Buprofezin 25 SC *Lecanicillum lecanii* 1.15 WP Azadirachtin 1 EC
2	Slightly harmful	30–79%	2	*Beauveria bassiana* 1.15 WP Deltamethrin 2.8 EC Imidacloprid 17.8 SL Lamda cyhalothrin 5 EC Thiamethoxam 25 WG
3	Moderately harmful	80–99%	3	Nil
4	Harmful	>99%	4	Nil

to the larvae of *C. zastrowi sillemi,* which is in confirmation with Garzon *et al.* (2015), who classified it as slightly harmful.

In the present findings, some of the insecticides proved harmless. According to Nasreen *et al.,* (2005) and Sabry & EI-Sayed (2011), buprofezin was found harmless. Similarly, Shankarganesh *et al.* (2016) and Shah *et al.* (2012) found it less toxic to green lacewing, and Bhojani *et al.* (2018) also categorised it as harmless. Botanical pesticide, *viz*., azadirachtin 1 EC found safer against *C. zastrowi sillemi,* which is in line with Shankarganesh *et al.* (2016) and Daval *et al.* (2016), wherein they reported the lowest mortality in azadirachtin in comparison with other chemical insecticides. In the case of microbial bio-pesticides *viz*., *L. lecanii* 1.15 WP and *B. bassiana* 1.15 WP, both were found harmless, which is in confirmation with the previous finding of Devi & Mukherjee (2024) who recorded lower larval mortality in both the microbial bio-pesticides. Haran *et al.* (2019) recorded the highest larval mortality in *B. bassiana,* followed by *L. lecanii* among different microbial bio-pesticides, but it was considered less toxic than that of chemical insecticides. Youssif and Ramadan 2020) found *B. Bassiana* safest among the tested active ingredients with the highest LC_{50} values. Morsy (2017) found comparatively lower larval mortality recorded in the case of *B. bassiana*.

CONCLUSION

Imidacloprid 17.8 SL consistently produced the highest larval death of *C. zastrowi sillemi* (90%) at 72 hours of exposure. Within the same time period, thiamethoxam 25 WG, lamda- cyhalothrin 5 EC, and deltamethrin 2.8 EC also showed significant toxicity. On the other hand, biopesticide, *B. bassiana,* gave 40.00 per cent larval mortality, demonstrating a slightly harmful effect. Similarly, botanical pesticides azadirachtin 1 EC and buprofezin 25 SC, as well as bio-pesticides *L. lecanii,* demonstrated much lower mortality rates, often below 25 per cent, indicating their relative safety for use in IPM strategies. These findings highlight the need for careful selection of pesticides to minimise the harmful effect against beneficial insects like chrysopids while managing pests effectively in mango ecosystems.

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AUTHOR CONTRIBUTION

JMC - Designing and implementation of the experiments and MS preparation implementation of the experiments; SMC - planning, supervising and formal analysis and MS finalisation. All authors have read and agreed to the published version of the manuscript.