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Toxicity of insecticides to red pumpkin beetle on sweet gourd leaf

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Abstract

Red pumpkin beetle *Aulacophora foveicollis* Lucas (Coleoptera: Chrysomelidae) is a major devastating insect pest of sweet gourd. The larva and adult stages of this beetle are injurious to sweet gourd plants. Several groups of insecticides are applied by the farmers in Bangladesh to control this insect pest. However, the efficacy of these insecticides in field and laboratory conditions have not been assessed in Bangladesh. In this study, the efficacy of the frequently used insecticides namely, Cyren 20 EC, Marshal 20 EC, Ripcord 10 EC and Orogard 55 EC were evaluated to control adult red pumpkin beetles. The mortality rates of the beetles at 24, 48 and 72 hours after application of the insecticides ranged from 14.4 to 46.7%, 33.3 to 73.3% and 52.4 to 86.7%, respectively, and the results differed significantly. Among the tested insecticides, only Orogard 55 EC with recommended dose revealed statistically higher mortality rate (86.7%) of the beetle at 72 hours after treatment, and the computed toxicity data (LC_{50} and LC_{95}) were 7260 ppm and 8323.4 ppm, respectively. Cyren 20 EC, Marshal 20 EC and Ripcord 10 EC with recommended doses revealed very lower rates of mortality and showed toxicity at very high concentrations, indicating that the beetle has developed resistance to these insecticides.

Keywords: *Aulacophora foveicollis*, sweet gourd, insecticide, mortality, toxicity

Introduction

Sweet gourd, a vegetable crop of Cucurbitaceae is used as a component in the preparation of bread, flour, soup, pies, and other dishes (Guiné *et al*. 2012). The fleshy shell, seeds, leaves, and even the flowers are eaten. In Bangladesh, cucurbits make up roughly 66% of the vegetable fields but only produce 11% of the overall vegetable crop (Nasiruddin *et al*. 2004). Sweet gourd is cultivated year-round in Bangladesh, and the area and total production during the year 2021-22 were 30.1 thousand ha and 145.2 thousand Mt, respectively (BBS 2022). The soil and climate of Bangladesh are ideal for growing this vegetable; however, the main production challenge is the infestation of insect pests. The red pumpkin beetle *Aulacophora foveicollis* (Coleoptera: Chrysomelidae) is one of the major insects that hamper cucurbit production in Bangladesh (Nancy *et al*. 2018).

The red pumpkin beetle is a frequent and serious pest of a variety of cucurbits, including sweet gourd, bottle gourd, bitter gourd, white gourd, water melon, and musk melon. The adult and grubs of the beetle feed on the leaves of cucurbits and they cause 30 to 100% yield loss in *Cucurbita pepo* (Aslam *et al*. 2017). Afroz *et al*. (2022) reported 8.5 to 34.6% leaf infestation of red pumpkin beetle among twelve genotypes of sweet gourd. Occurrence and damage severity of red pumpkin beetle in sweet gourd cultivation stand in need of tactics for controlling. In order to control this insect, farmers of Bangladesh apply chemical insecticides numerous times.

The synthetic insecticides prevent, destroy and repel insect pests or mitigate their damage potential very quickly, and are considered as one of the most effective strategies of pest control. But frequent applications and overuse of synthetic insecticides lead to gene mutation in insect resulting in insecticide resistance (Yuan *et al*. 2017). So, efficacy evaluation should be an integral part to assess the toxicity effect and determining the dose of an insecticide for successful pest management in order to combat pests and boost agricultural productivity. Hence, the objective of this study is to evaluate the laboratory efficacy of some commonly used synthetic insecticides on red pumpkin beetle of sweet gourd.

Material and methods

The study was conducted from July 2022 to September 2023 in the laboratory facilities of the Department of Entomology, Gazipur Agricultural University (GAU), Gazipur, Bangladesh. In this study four synthetic insecticides from four different chemical groups (active ingredient) were selected to evaluate their efficacy on adult red pumpkin beetle. Trade name, active ingredient, mode of action, recommended doses and tested doses of the insecticides are noted in Table 1. The five different concentrations of each synthetic insecticide were generated prior to bioassay using repeated dilutions with distilled water.

Application of insecticide treatments and observation of mortality of the beetles: A leaf dip approach was used to assess the toxicity of insecticides to red pumpkin beetle. Fresh sweet gourd leaves were collected from the field laboratory of the Department of Entomology, GAU and dipped into the prepared insecticide doses for few seconds. Then the leaves were air dried on filter paper, afterwards transferred to a Petri dish contained five adult beetles and covered with a ventilated wrap. Only fresh leaves were offered in the untreated control. The number of dead insects in each petri dish was counted at 24, 48 and 72 hours after treatment, and the % mortality was calculated. Three repetitions for each dose of the insecticides were performed and the means were used in the probit analysis.

Statistical analysis: For data analysis, IBM SPSS 20.0 statistical software was utilized. A one-way analysis of variance (ANOVA) was conducted to determine variation in the mortality rate of the insecticides. The dose-dependent mortality response was analyzed at a 95% fiducial confidence interval using probit analysis to estimate the LC_{50} and LC_{95} values.

Results and discussion

The mortality effect of Cyren 20 EC, Marshal 20 EC, Ripcord 10 EC and Oroguard 55 EC with different doses on the adult red pumpkin beetle at 24, 48 and 72 hours after treatment (HAT) are presented in Table 2. From the table, it is seen that the doses of Cyren 20 EC ($F_{4,45} = 6.4$, $p < 0.01$) and hours after treatment ($F_{2,45} = 43.4$, $p < 0.001$) showed significant differences but the interaction effect of the doses and hours after treatment ($F_{8,45} = 0.2$, $p = 0.97$) did not show significant difference. The mortality rate of adult red pumpkin beetles treated with Cyren 20 EC at 24, 48 and 72 HAT varied from 14.4±0.0 to 41.7±14.4%, 33.3±8.2 to 58.3±14.3% and 52.4±8.2 to 75.0±0.0%, respectively. The highest mortality rate of the beetle was observed at 72 HAT with 1200 ppm. It was found that the doses of Marshal 20 EC ($F_{4,45} = 2.8$, $p < 0.05$), hours after treatment ($F_{2,45} = 82.4$, $p < 0.001$) and the interaction effect of the dose and hours after treatment ($F_{8,45} = 0.9$, $p < 0.5$) showed significant differences. The mortality effect of Marshal 20 EC at 24, 48 and 72 HAT ranged from 19.1±8.2 to 28.6±14.3%, 47.6±8.2 to 52.4±8.2% and 52.4±8.2 to 81.9±8.3%, respectively. The highest mortality (81.9±8.3%) of the beetle was recorded at 72 HAT with a dose of 3400 ppm.

Table 1. Details of the insecticides used in the experiment

Trade name	Active ingredient	Mode of action	Recommended dose (ppm)	Company
Cyren 20 EC	Chlorpyrifos	Contact and stomach	1000	Shetu Agro Industries Limited
Marshal 20 EC	Carbosulfan	Contact and stomach	3000	FMC Chemical International AG
Ripcord 10 EC	Cypermethrin	Contact and stomach	1000	BASF Bangladesh Limited
Oroguard 55 EC	Chlorpyrifos + Cypermethrin	Contact and stomach	8000	Oroni International Ltd

Table 2. Effect of different insecticides on the mortality rates (%) of red pumpkin beetle adult at different hours after treatment (HAT)

Insecticide	Dose (ppm)	Mortality (%)		
		24 HAT	48 HAT	72 HAT
Cyren 20 EC	1200	41.7±11.5	58.3±11.5	75.0±11.5
	1100	33.3±11.5	53.3±11.5	73.3±11.5
	1000	33.3±14.4	50.0±0.0	66.7±11.5
	900	26.7±11.5	46.7±11.5	66.7±11.5
	800	14.4±0.0	33.3±8.2	52.4±8.2
Marshal 20 EC	3400	28.6±14.3	52.4±8.2	81.9±8.3
	3200	23.8±8.2	47.6±8.2	80.9±8.2
	3000	19.1±8.2	47.6±8.2	76.2±8.2
	2800	19.1±8.2	47.6±16.5	71.4±11.3
	2600	19.1±8.2	47.6±8.2	52.4±8.2
Ripcord 10 EC	1200	46.7±11.5	73.3±11.5	86.7±11.5
	1100	43.7±11.5	60.0±0.0	73.3±11.5
	1000	33.3±11.5	53.3±11.5	73.3±11.5
	900	26.7±11.5	53.3±11.5	66.7±11.5
	800	20.0±0.0	46.7±11.5	53.3±11.5
Oroguard 55 EC	8300	46.7±11.5	73.3±11.5	86.7±11.5
	8000	46.7±11.5	66.7±11.5	86.7±11.5
	7700	43.3±5.8	53.3±11.5	80.0±20.0
	7400	33.3±11.5	53.3±11.5	73.7±11.5
	7100	33.3±11.5	53.3±11.5	60.0±0.0

From the Table 2, it is seen that the doses of Ripcord 10 EC ($F_{4,45}$ = 9.2, $p < 0.01$) and hours after treatment ($F_{2,45}$ = 43.0, $p < 0.01$) showed significant differences but the interaction effect of the doses and hours after treatment ($F_{8,45}$ = 0.5, p = 0.85) did not show significant variation. The mortality rate of red pumpkin beetle of Ripcord 10 EC at 24, 48 and 72 HAT ranged from 20.0±0.0 to 46.7±11.5%, 53.3±11.5 to 73.3±11.5% and 53.3±11.5 to 86.7±11.5%, respectively. The highest mortality (86.7±11.5%) of the beetle was observed at 72 HAT with 1200 ppm. The doses of Oroguard 55 EC ($F_{4,45}$ = 4.3, $p < 0.01$) and hours after treatment ($F_{2,45}$ = 37.2, $p < 0.001$) showed significant differences but the interaction effect of the dose and hours after treatment ($F_{8,45}$ = 0.71, p = 0.67) show significant difference. The mortality effect of the beetle treated with Oroguard 55 EC at 24, 48 and 72 HAT varied from 33.3±11.5 to 46.7±11.5%, 53.3±11.5 to 73.3±11.5% and 60.0±0.0 to 86.7±11.5%, respectively. The highest mortality (86.7±11.5%) of the beetle was observed at 72 HAT with 8300 ppm.

The study revealed that Oroguard 55 EC and Ripcord 10 EC achieved 86.7% mortality at 72 HAT, which closely aligns with Thomas and Jacob's (1994) findings of an 84.3% reduction in red pumpkin beetle populations using carbofuran over 80 days. In contrast, the considerably lower mortality rates observed for Cyren 20 EC and Marshal 20 EC may indicate the development of resistance. Osman *et al*. (2013) reported that Larvin 75 WP and Diazinon 60 EC achieved significant reductions in beetle populations, with mortality rates of 81.9% and 75.0% at 72 hours after treatment (HAT), respectively. In comparison, the current study found that Cyren 20 EC and Marshal 20 EC were less effective, showing maximum mortality rates of 75.0% and 81.9% only at higher concentrations.

Toxicity effect of the insecticides at 24 hours after treatment is presented in Table 3. Toxicity data revealed that LC_{50} and LC_{95} values ranged from 1139.5 to 8067.9 and 2160 to 9437.5 ppm, respectively. Ripcord 10 EC and Cyren 20 EC showed maximum TR_{50} and TR_{95} (7.0 and 4.4, respectively). The TR_{50} and TR_{95} of Marshal 20 EC were 2.5 and 2.0. Oroguard 55 EC showed the lowest toxicity on red pumpkin beetle. The concentration response curves had the steepest slopes and thus small variations in the concentrations induced greater responses in mortality.

Toxicity data of the insecticides at 48 HAT revealed that LC_{50} and LC_{95} values ranged from 989.9 to 7426.4 and 2160.1 to 9437.5 ppm, respectively (Table 4). Ripcord 10 EC showed maximum TR_{50} and TR_{95} 7.5 and 3.4, respectively. The TR_{50} and TR_{95} of Cyren 20 EC were 6.9 and 3.2. And the TR_{50} and TR_{95} of Marshal 20 EC were 2.4 and 1.7. Oroguard 55 EC showed the lowest toxicity on red pumpkin beetle. The concentration response curves had the steepest slopes and thus small variations in the concentrations induced greater responses in mortality.

Toxicity data at 72 HAT revealed that LC_{50} and LC_{95} values ranged from 662.8 to 7260.0 and 2005.3 to 8323.4 ppm, respectively (Table 5). Ripcord 10 EC showed maximum TR_{50} and TR_{95} 10.9 and 4.2, respectively. The TR_{50} and TR_{95} of Cyren 20 EC were 7.7 and 4.0. And the TR_{50} and TR_{95} of Marshal 20 EC were 3.0 and 2.0. Oroguard 55 EC showed the lowest toxicity on red pumpkin beetle. The concentration response curves had the steepest slopes and thus small variations in the concentrations induced greater responses in mortality.

Table 3. Toxicity effect of the studied insecticides on red pumpkin beetle at 24 hours after treatment

Insecticides	Slope (±SE)	LC_{50} (95% fl)	TR_{50}	LC_{95} (95% fl)	TR_{95}	χ^2 (df)	P
Cyren 20 EC	2.5±0.9	1139.5	7.0	2160.1	4.4	5.6 (3)	0.132
Marshal 20 EC	4.5±1.5	3268.5	2.5	5642.2	2.0	8.0 (3)	0.045
Ripcord10 EC	6.3±0.9	1139.5	7.0	2970.3	4.4	5.6 (3)	0.132
Oroguard 55 EC	29.9±3.9	8067.9	-	9437.5	-	6.5 (3)	0.086

Each datum represents the mean of three replicates, each set up with available insects. Concentrations are expressed as ppm. fl stands for fiducial limits.

Table 4. Toxicity effect of the studied insecticides on red pumpkin beetle at 48 hours after treatment

Insecticides	Slope (±SE)	LC_{50} (95% fl)	TR_{50}	LC_{95} (95% fl)	TR_{95}	χ^2 (df)	P
Cyren 20 EC	5.4±0.9	1083.3	6.9	2116.8	3.2	3.2 (3)	0.351
Marshal 20 EC	6.3±1.4	3110.1	2.4	4537.6	1.7	2.3 (3)	0.497
Ripcord10 EC	3.4±0.9	989.9	7.5	2074.7	3.4	1.6 (3)	0.64
Oroguard 55 EC	15.8±2.3	7426.4	-	9154.0	-	5.0 (3)	0.169

Each datum represents the mean of three replicates, each set up with available insects. Concentrations are expressed as ppm. fl stands for fiducial limits.

Table 5. Toxicity effect of the studied insecticides on red pumpkin beetle at 72 hours after treatment

Insecticides	Slope (±SE)	LC_{50} (95% fl)	TR_{50}	LC_{95} (95% fl)	TR_{95}	χ^2 (df)	P
Cyren 20 EC	4.7±0.9	940.2	7.7	2074.7	4.0	3.4 (3)	0.986
Marshal 20 EC	7.8±1.5	2442.5	3.0	3956.3	2.0	2.7 (3)	0.804
Ripcord10 EC	3.4±0.9	662.8	10.9	2005.3	4.2	1.2 (3)	0.743
Oroguard 55 EC	26.1±2.7	7260.0	_	8323.4	_	13.3 (3)	0.789

Each datum represents the mean of three replicates, each set up with available insects. Concentrations are expressed as ppm. fl stands for fiducial limits.

The toxicity data revealed that Ripcord 10 EC consistently exhibited the highest TR_{50} and TR_{95} values, highlighting its strong efficacy against red pumpkin beetles. These findings are consistent with the observations of Khorsheduzzaman *et al*. (2010), who emphasized the effectiveness of integrated pest management strategies, such as combining soil applications with neem-based treatments, to enhance control measures.

The tested insecticides demonstrated limited effectiveness against the red pumpkin beetle, as indicated by the LC_{50} and LC_{95} values, suggesting that the beetle exhibits resistance to these chemicals. Among the tested insecticides, Ripcord 10 EC showed the highest toxicity; however, its recommended dose did not result in substantial efficacy based on mean insect mortality. In contrast, Oroguard 55 EC, which exhibited the lowest toxicity, achieved a significantly higher mortality rate with its recommended dose compared to the other three insecticides.

Khan and Khattak (1992) evaluated five synthetic insecticides—Cropgard (Pyrethroid), Cypergard (Cypermethrin), Sunmerin (Cypermethrin), Stinger (Pyrethroid), and Mavrik (Pyrethroid)—against the red pumpkin beetle and reported resistance to these treatments. Similarly, Bharathi and John (2013) explored control methods for the red pumpkin beetle, using carbaryl, kerosene-mixed ash, and Parthenium hysterophorus extract. Babu *et al*. (2002) found that carbaryl was the most effective insecticide, followed by chlorpyriphos. Later studies by Rathod *et al*. (2009) and Ratnakar *et al*. (2016) also highlighted carbaryl and cypermethrin as effective options for beetle management.

Conclusion

The results revealed that the insecticides did not show any efficacy to control the beetle at their recommended dosages, probably due to the development of resistance to these insecticides. Mortality data showed that the Oroguard 55 EC depicted comparatively higher efficacy in controlling the red pumpkin beetle. Therefore, new chemical groups should be used to replace these insecticides.

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