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Insecticide-induced mortality and toxicity in two insect pests of sweet gourd

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Abstract

Sweet gourd (*Cucurbita moschata*) is a popular and nutritious vegetable widely grown in tropical and subtropical regions, including Bangladesh during both winter and summer seasons. The insects of red pumpkin beetle (*Aulacophora foveicollis*) and epilachna beetle (*Epilachna dodecastigma*) are potential pests that adversely affect sweet gourd production in Bangladesh. Chemical insecticides are considered as the primary and most widely used tools for managing these pests in sweet gourd production. In this study, the mortality, weight reduction, and toxicity effects of six insecticides-AC Mix 55 EC, Damdama 440 EC, Decis 2.5 EC, Phyphanon 57 EC, Imitaf 20 SL, and Ripcord 10 EC along with an untreated control were evaluated against red pumpkin beetle and epilachna beetle under laboratory conditions. Results showed that among the insecticides, AC Mix 55 EC, Damdama 440 EC, and Decis 2.5 EC caused significant mortality of the beetles at 24, 48, and 72 hours after treatment with their recommended doses. The recommended dose of AC Mix 55 EC caused 100% mortality of red pumpkin beetle and 93.3% mortality of epilachna beetle at 24 h after treatment, while Damdama 440 EC caused 91.0% and 93.3% mortality at 48 h, and Decis 2.5 EC caused 96.7% and 91.7% mortality at 72 h, respectively. AC Mix 55 EC caused the highest weight reduction of red pumpkin beetle (43.1%), followed by Decis 2.5 EC (36.9%) and Damdama 440 EC (29.8%). For epilachna beetle, the highest weight reduction was also caused by AC Mix 55 EC (39.9%), followed by Decis 2.5 EC (33.6%) and Imitaf 20 SL (29.9%). Probit analysis confirmed that Decis 2.5 EC was the most toxic insecticide against the beetles, with the lowest LC_{50} (26.3 ppm, 26.5 ppm) and LC_{95} (70.6 ppm, 62.0 ppm), followed by Ripcord 10 EC (LC_{50} = 104.5 ppm and 98.8 ppm, LC_{95} = 385.4 ppm and 422.3 ppm) and AC Mix 55 EC (LC_{50} = 172.2 ppm and 350.5ppm, LC_{95} = 387.3 ppm and 481.1 ppm).

Keywords: *Aulacophora foveicollis*, *Cucurbita moschata, Epilachna dodecastigma*, mortality, toxicity

Introduction

Sweet gourd (*Cucurbita moschata*) is a nutritionally valuable cucurbit vegetable, rich in vitamins, minerals, and dietary fiber. It is widely cultivated in tropical and subtropical regions, including Bangladesh, in both winter and summer seasons. Sweet gourd is recommended as an anti-diabetic, antioxidant, anti-carcinogenic, anti-inflammatory, and skin disease preventative (Dar *et al*. 2017).The sweet gourd cultivated in winter season revealed significantly shorter durations in production of more than one flower, fruit formation, fruit elongation, fruit maturation for harvest and fruit maturation for seed production compared to summer season (Nancy *et al*. 2018). In both the seasons, eleven insect species infest sweet gourd, with the pumpkin beetle, *Aulacophora foveicollis* (Lucas) and epilachna beetles, *Epilachna dodecastigma* (Wied.) and *E. vigintioctopunctata* (Fab.) being the most destructive, causing severe damage from seedlings to harvest in Bangladesh (Nancy *et al*. 2018, Amin *et al*. 2023).

The adult and grub of red pumpkin beetle attack young plants, leaves, and flowers of sweet gourd, feeding on both leaf surfaces and producing characteristic circular, ring-like injuries, which can result in 30–100% yield loss (Aslam *et al*. 2017). Afroz *et al.* (2022a) reported that leaf infestation by the red pumpkin beetle varied significantly among different sweet gourd genotypes, ranging from 8.5% to 34.6%. Rahaman and Prodhan (2007) reported 35.0% to 75.0% infestation of red pumpkin beetle at the seedling stage of sweet gourd plants. The phytophagous epilachna beetle is a widespread pest of cucurbitaceous crops that causes severe leaf damage and threatens growth and yield of sweet gourd, with reported leaf infestation ranging from 6.2% to 16.4% (Afroz *et al*. 2022b). Both adults and grubs of the epilachna beetle infest cucurbitaceous crops at all growth stages; grubs scrape the leaf epidermis and adults make semicircular cuts, causing up to 80% plant infestation. (Ghule *et al*. 2014).

To minimize insect infestation in sweet gourd, farmers widely use synthetic insecticides with different active ingredients and formulations, applied in combination or rotation with other management tactics, which result in varying levels of effectiveness and cost (Amin *et al*. 2008). Different active ingredients and modes of action of insecticides cause varied levels of toxicity and mortality in insect pests due to differences in their target sites and speed of action (Mandal *et al.* 2024, Moon *et al*. 2024). Pumpkin beetle and epilachna beetle are mainly controlled by chemical pesticides. However, indiscriminate use of synthetic insecticides is a major concern. Overuse or misuse leads to pest resurgence, resistance development, environmental contamination, biodiversity loss, insecticide residues in fruits, health risks to consumers, and disruption of pollinators. Proper selection of insecticides and their judicious application, considering mode of action and recommended doses, are essential for effective management of major sweet gourd pests. Comprehensive information on the comparative effectiveness of commonly used insecticides against these key insect pests remains limited. Therefore, this study evaluated the effectiveness of commonly used insecticides by assessing insect mortality response and toxicity levels against the red pumpkin beetle and epilachna beetle under controlled laboratory conditions, with the aim of identifying comparatively effective insecticides for managing these key pests of sweet gourd.

Materials and methods

The study was conducted from February 2025 to September 2025 in the Laboratory of the Department of Entomology, Gazipur Agricultural University (GAU), Gazipur, Bangladesh. The experiment was conducted following a completely randomized design. Six insecticides namely AC Mix 55 EC (Chlorprifos 50% + Cypermethrin 5%), Damdama 440EC (Profenofos 40% + Cypermethrin 4%), Decis 2.5EC (Deltamethrin 2.5%), Imitaf 20SL (Imadacloprid 20%), Phyphanon 57EC (Malathion), and Ripcord 10EC (Cypermethrin) along with an untreated control treatment were applied on the adult red pumpkin beetle and epilachna beetle under laboratory conditions. Detailed information of the tested insecticides is presented in table 1.

Table 1. Formulation details and applied doses of the tested insecticides

Trade name	Active ingredient	Mode of action	Group	Manufacturer	Applied dose (ppm)		
					Lower	Recommended	Higher
AC Mix 55 EC	Chlorpyrifos 50% + cypermethrin 5%	Contact and stomach action	Organophosphate + synthetic pyrethroid	ACI Crop Care	440	660	880
Damdama 440 EC	Profenofos 40% + Cypermethrin 4%	Do	Organophosphate + synthetic pyrethroid	Infenta	264	440	616
Decis 2.5 EC	Deltamethrin 2.5%	Do	Synthetic pyrethroid	Bayer Cropscience	15	25	35
Imitaf 20 SL	Imidacloprid 20%	Do	Neonicotinoid	Auto Crop Care Limited	200	280	360
Phyphanon 57 EC	Malathion	Do	Organophosphate	FMC Corporation	342	570	798
Ripcord 10 EC	Cypermethrin	Do	Pyrethroid	BASF Bangladesh Limited.	80	120	160

Laboratory bioassay for observation of mortality and analysis of toxicity: The leaf dip method was used to observe the mortality effect of the insecticides and to assess their toxicity levels against the adult red pumpkin beetle and epilachna beetle. Three application rates (lower, recommended, and upper doses) were evaluated for each insecticide to compare their effects across different concentration levels. Fresh and healthy sweet gourd leaves were collected from the experimental field of the Department of Entomology and dipped into the respective insecticide solutions for five seconds to ensure uniform coating. The treated leaves were then air-dried naturally on filter paper and subsequently placed in clean Petri dishes. For each concentration, ten adult beetles for each pest were released into each Petri dish and provided with treated leaves as their food source. In the untreated control, only fresh, pesticide-free leaves were supplied. The experiment was conducted under controlled laboratory conditions, with an average temperature of 25 ± 2 °C and relative humidity of 65 ± 5%. Beetle mortality was recorded at 24, 48, and 72 hours post-treatment. The number of dead beetles in each Petri dish was counted, and the percentage mortality was calculated accordingly. Each concentration was replicated three times, and the mean mortality values obtained were used for probit analysis to estimate the lethal concentrations (LC_{50} and LC_{95}) and to evaluate the relative toxicity of the tested insecticides and mortality percent. Mortality data were corrected using Abbott's formula prior to statistical analysis to account for natural mortality in the control, although control mortality was negligible.

Effect of insecticides on the weight of adult beetles: Small pieces of fresh sweet gourd leaves were treated with the selected insecticides at their recommended doses. After dipping into the treatment, the leaves were air-dried and then transferred into Petri dishes. The individual weight of adult beetle was measured using a digital weighing balance before exposure. Each beetle was then placed individually into a Petri dish containing insecticide-treated leaves. After 24 hours of exposure, the weight of each beetle was recorded again to assess the effect of the insecticides on their body weight. This procedure allowed the determination of changes in body weight after exposure to different insecticide treatments. Each insecticide treatment was replicated five times for both the pests.

Statistical analysis: One-way analysis of variance (ANOVA) followed by Tukey HSD posthoc test (at 5% level of significance) was done to determine the effects of insecticides on the mortality rate and weight reduction of the beetles. Probit analysis was employed in analyzing the dose-mortality response at 95% fiducial confidence interval. LC_{50} and LC_{95} values and their fiducial limits were estimated. Toxicity ratios (TR) were calculated using the formula stated by Gusmao *et al*. (2013) where TR = LC_{50} and/or LC_{95} of the insecticide with less toxicity divided by LC_{50} and/or LC_{95} of the other insecticides, individually. The statistical software package IBM SPSS 20.0 was used for data analysis.

Results and discussion

The mortality rate of red pumpkin beetle differed significantly among the tested insecticides, and mortality rate increased with higher doses and longer exposure times ($F_{6,14}$ = 26.76–122.36, $p < 0.05$) (Table 2). AC Mix 55 EC caused the highest mortality across all doses: 94.3 ± 5.6% at 24 hours after treatment (HAT), and 100% at later periods in low doses. Damdama 440 EC also showed strong efficacy (83.0 ± 4.0%) at 72 HAT with low dose. Similarly, in recommended and high doses AC Mix 55 EC, Damdama 440 EC, and Decis 2.5 EC showed more than 90% and 100% mortality, respectively. The mortality percentage of epilachna beetle significantly differed across the insecticides and increased with higher doses and exposure times ($F_{6,14}$ = 17.7–117.3, $p < 0.05$) (Table 3). AC Mix 55 EC caused the highest mortality started from 73.3 ± 8.8% in 24 HAT and reached to 100% at low dose. At recommended and higher doses, it reached to 100%. Damdama 440 EC showed increasing high percentage of mortality with time and doses. Decis 2.5 EC, Imitaf 20 SL, phyphanon 57 EC showed moderated mortality which increased with time.

The insecticides used in this study possess contact and stomach poisons, that caused mortality of the beetles through penetration or ingestion. The tested insecticides in this study likely disrupted the insects' nervous system or metabolic processes, resulting in paralysis and eventual death. The insecticides exhibited varying levels of mortality over time, which may be attributed to differences in their modes of action, with

Table 2. Effect of different insecticides on the mortality rate of red pumpkin beetle

Treatment	Mortality (%)								
	Low dose			Recommended dose			High dose		
	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT
Decis 2.5 EC	22.1 ± 5.7ab	44.3 ± 5.7b	68.9 ± 5.9bc	71.7 ± 2.5b	80.0 ± 0.0b	96.7 ± 3.3a	79.9 ± 6.9ab	100.0 ± 0.0a	100.0 ± 0.0a
Damdama 440 EC	22.2 ± 5.3ab	52.3 ± 3.9b	83.0 ± 4.0ab	44.3 ± 5.7c	91.0 ± 4.9ab	100.0 ± 0.0a	88.7 ± 5.7ab	100.0 ± 0.0a	100.0 ± 0.0a
AC Mix 55 EC	94.3 ± 5.6a	100.0 ± 0.0a	100.0 ± 0.0a	100.0 ± 0.0a	100.0 ± 0.0a	100.0 ± 0.0a	100.0 ± 0.0a	100.0 ± 0.0a	100.0 ± 0.0a
Imitaf 20 SL	36.3 ± 3.3b	46.3 ± 3.7b	52.2 ± 2.2c	42.2 ± 5.0c	54.3 ± 4.3c	64.3 ± 7.7b	66.7 ± 9.6b	79.3 ± 4.9b	88.4 ± 2.6a
Phyphanon 57 EC	25.3 ± 5.0bc	40.0 ± 5.8b	60.7 ± 5.3c	44.3 ± 5.7c	56.3 ± 2.0c	76.7 ± 2.4ab	74.0 ± 4.9ab	84.0 ± 8.2ab	91.1 ± 4.9a
Ripcord 10 EC	38.6 ± 5.6b	48.3 ± 6.0b	72.3 ± 6.2bc	52.3 ± 6.9bc	62.0 ± 4.2c	85.3 ± 8.7ab	73.0 ± 6.8ab	85.0 ± 3.2ab	96.7 ± 3.3a
Control	3.3 ± 3.3c	6.7 ± 3.3c	8.7 ± 4.7d	3.3 ± 3.3d	6.7 ± 3.3d	8.7 ± 4.7c	3.3 ± 3.3c	6.7 ± 3.3c	8.7 ± 4.7b

Data expressed as mean ± SE. Means within a column followed by same letter(s) are not significantly different by Tukey HSD posthoc statistic at $p < 0.05$

Table 3. Effect of different insecticides on the mortality rate of epilachna beetle

Treatment	Mortality (%)								
	Low dose			Recommended dose			High dose		
	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT
Decis 2.5 EC	15.0 ± 2.9bc	38.3 ± 4.4c	70.0 ± 5.8bc	53.3 ± 6.7b	66.7 ± 3.3c	91.7 ± 6.0a	72.7 ± 6.4b	96.7 ± 3.3a	100.0 ± 0.0a
Damdama 440 EC	35.0 ± 2.9b	43.3 ± 6.7bc	61.7 ± 4.4bc	60.0 ± 5.8b	93.3 ± 6.7ab	96.7 ± 3.3a	83.3 ± 3.3ab	90.0 ± 5.8ab	100.0 ± 0.0a
AC Mix 55 EC	73.3 ± 8.8a	91.7 ± 4.4a	100.0 ± 0.0a	93.3 ± 3.3a	100.0 ± 0.0a	100.0 ± 0.0a	100.0 ± 0.0a	100.0 ± 0.0a	100.0 ± 0.0a
Imitaf 20 SL	23.3 ± 6.7bc	38.3 ± 9.3c	55.0 ± 8.7c	48.0 ± 4.7b	60.0 ± 5.8c	90.0 ± 5.8a	83.3 ± 8.8ab	95.0 ± 5.0ab	100.0 ± 0.0a
Phyphanon 57 EC	20.0 ± 5.8bc	45.0 ± 2.9bc	68.3 ± 6.0bc	70.0 ± 5.8ab	76.7 ± 3.3bc	83.3 ± 3.3a	76.7 ± 3.3ab	90.0 ± 5.8ab	90.0 ± 5.8a
Ripcord 10 EC	40.0 ± 5.8b	70.0 ± 5.8ab	80.0 ± 0.0ab	60.0 ± 5.8b	76.7 ± 3.3bc	83.3 ± 3.3a	70.0 ± 5.8b	76.7 ± 3.3b	90.0 ± 5.8a
Control	1.7 ± 1.7c	3.3 ± 1.7d	5.0 ± 2.5d	1.7 ± 1.7c	3.3 ± 1.7d	5.0 ± 2.5b	1.7 ± 1.7c	3.3 ± 1.7c	5.0 ± 2.5b

Data expressed as mean ± SE. Means within a column followed by same letter(s) are not significantly different by Tukey HSD posthoc statistic at $p < 0.05$

some causing rapid knockdown while others acted more slowly by interfering with physiological or metabolic functions. In addition, variations in insect absorption rates, detoxification capacity, and environmental factors may have contributed to increased mortality with longer exposure periods. Prolonged exposure periods resulted in progressively higher mortality rates, with the most pronounced and statistically significant effects observed 72 hours after treatment, indicating the time-dependent action of the applied insecticides. Our findings are in accordance with Maliha *et al.* (2025) who studied the mortality effects of chemical insecticides with contact and stomach modes of action on red pumpkin beetles on sweet gourd under laboratory conditions and reported mortality rates of 14.4%-46.7%, 33.3%-73.3%, and 52.4%-86.7% at 24, 48, and 72 hours after application, respectively. Ratnakar *et al*. (2016) reported that chlorpyriphos and cypermethrin caused effective mortality of red pumpkin beetle. Prolonged exposure periods resulted in higher mortality rates, with significant impacts seen 72 hours after treatment (Mishra and Regmi 2022).

The influence of various insecticidal treatments on the weight reduction of red pumpkin beetle is presented in figure 1. Analysis of variance indicated a highly significant difference among treatments ($F_{5,12}$= 15.9; $p < 0.05$). The highest weight reduction was obtained from beetles treated with AC Mix 55 EC (43.1 ± 1.9%), followed by Decis 2.5 EC (36.9 ± 1.6%) and Damdama 440 EC (29.8 ± 4.6%). A moderate effect was noted in Imitaf 20 SL, while the lowest reductions were recorded in Phyphanon 57 EC (12.7 ± 4.9%) and Ripcord 10 EC (13.3 ± 2.1%). The effect of different insecticidal treatments on the weight reduction of epilachna beetle is shown in figure 2. Results showed a highly significant variation among the treatments ($F_{5,12}$= 10.6; $p < 0.01$). The highest weight reduction was recorded in beetles treated with AC Mix 55 EC (40.0 ± 5.0%), followed by Decis 2.5 EC (33.6 ± 3.4%), Imitaf 20 SL (29.9 ± 3.5%) and Damdama 440 EC (26.1 ± 1.9%). In contrast, the lowest reductions were observed in Phyphanon 57 EC (9.3 ± 0.9%) and Ripcord 10 EC (9.6 ± 2.2%). In summary, AC Mix 55 EC proved to be the most effective treatment in reducing the weight of red pumpkin beetle and epilachna beetle, suggesting a pronounced inhibitory effect on feeding and metabolism. Conversely, Ripcord 10 EC exhibited minimal weight reduction, indicating limited efficacy against the beetles.

Weight loss in beetles resulted from the contact and stomach poison effects of insecticides that suppressed

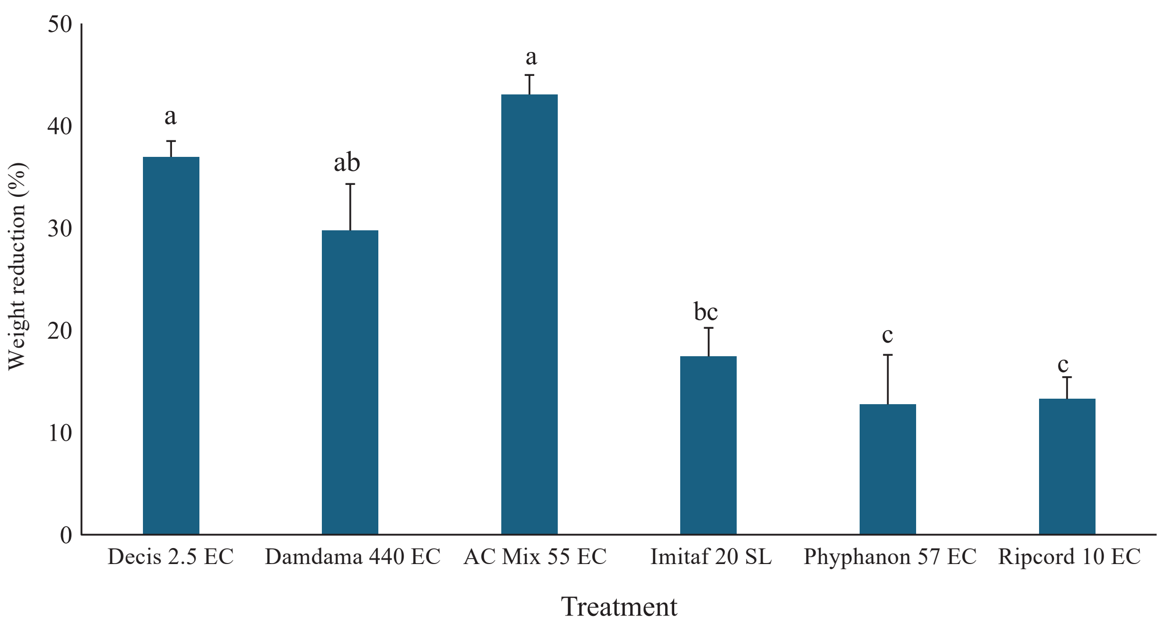

Figure 1. Weight reduction (%) of red pumpkin beetle under different insecticide treatments. Data expressed as mean ± SE. Bars with same letter(s) are not significantly different by Tukey HSD posthoc statistic at p< 0.05.

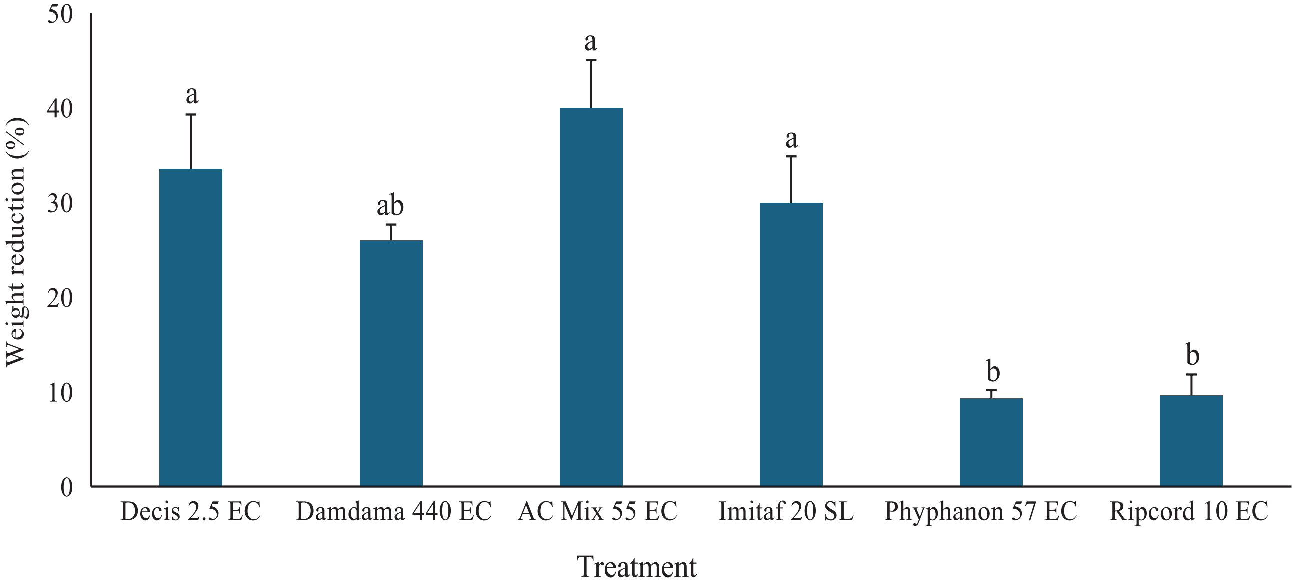

Figure 2. Weight reduction (%) of epilachna beetle under different insecticide treatments. Data expressed as mean ± SE. Bars with same letter(s) are not significantly different by Tukey HSD posthoc statistic at $p < 0.05$.

feeding and disrupted nervous and metabolic functions, leading to physiological damage, paralysis, and reduced body weight. The present findings are consistent with Ahmed *et al.* (2024) who observed that insecticides with different modes of action caused variable weight reduction in cucurbit fruit fly larvae, with Ripcord 10 EC, Karate 2.5 EC, and Shobicron 425 EC reducing larval weight by 18.3%, 24.8%, and 28.4%, respectively, compared to the control. Rajagopal and Trivedi (2000) reported that chemical insecticides, including chlorpyrifos and deltamethrin, markedly suppressed feeding activity and caused significant reductions in body mass of beetles infesting cucurbit crops, indicating strong physiological and toxic effects of these compounds on insect growth and survival.

The probit analysis showed variations in toxicity of the tested insecticides against red pumpkin beetle at 24 hours after treatment (Table 4). Decis 2.5 EC showed the highest relative toxicity (21.3 and 23.8) with very low LC_{50} and LC_{95} doses (26.3 and 70.6 ppm). Ripcord 10 EC (5.4) and AC Mix 55 EC (3.3) exhibited moderate toxicity in both LC_{50} and LC_{90} values than other tested insecticides. The probit analysis also indicated significant variation in insecticidal toxicity against epilachna beetle. Decis 2.5 EC was the most toxic with the lowest LC_{50} (26.5 ppm) and LC_{95} (62.0 ppm) values and the highest relative toxicity (18.8 and 18.8) (Table 5). Ripcord 10 EC and Imitaf 20 SL showed moderate toxicity, while AC Mix 55 EC, Damdama 440 EC and Phyphanon 57 EC were the least toxic, with much higher LC_{50} and LC_{95} values. The findings of this study demonstrated that only small doses of Decis 2.5 EC are needed to achieve high mortality of red pumpkin beetle and epilachna beetle.

Nabti *et al*. (2015) observed toxic effect of Decis 2.5 EC on honeybee with very low dose (LC_{50} 10.4 ppm). Combination of Chlorpyrifos and Cypermethrin was reported higher toxic to *Epilachna dodecastigma* followed by Spinosad, Derisom, and Margosom (Mishra and Regmi 2022). Highly toxic insecticides are applied at lower doses because small amounts of the active ingredient are sufficient to disrupt critical physiological processes of insects, causing rapid mortality, while higher doses could increase risks to non-target organisms and the environment. In contrast, insecticides with lower toxicity require higher doses to achieve effective control, as larger quantities are needed to ensure adequate uptake, overcome insect detoxification mechanisms, and produce lethal effects.

Table 4. Toxicity effect of the studied insecticides on red pumpkin beetle at 24 hours after treatment

Treatment	LD_{50}(ppm)	Relative toxicity	LD_{95}(ppm)	Relative toxicity	Slope ± SE	χ^2 (p)
Decis 2.5 EC	26.3	21.3	70.6	23.8	4.8±1.0	4.0 (p=0.7)
Damdama 440 EC	405.3	1.4	867.1	1.9	4.9±1.0	6.6(p=0.4)
AC Mix 55 EC	172.2	3.3	387.3	4.3	4.7±0.8	7.9(p=0.3)
Imitaf 20 SL	281.2	2.0	1018.9	1.6	2.9±1.3	4.3(p=0.7)
Ripcord 10 EC	104.5	5.4	385.4	4.4	2.9±1.1	3.7(p=0.8)
Phyphanon 57 EC	561.0	1.0	1678.8	1.0	3.5±1.0	3.2 (p=0.8)

Table 5. Toxicity effect of the studied insecticides on epilachna beetle at 24 hours after treatment

Treatment	LD_{50}(ppm)	Relative toxicity	LD_{95}(ppm)	Relative toxicity	Slope ± SE	χ^2 (p)
Decis 2.5 EC	26.5	18.8	62.0	18.8	4.4±1.0	3.4(p=0.8)
Damdama 440 EC	348.5	1.3	1010.0	1.2	3.6±0.9	1.9 (p=0.9)
AC Mix 55 EC	350.5	1.4	481.1	2.4	46.0±2.0	4.2(p=0.7)
Imitaf 20 SL	267.8	1.9	656.6	1.8	6.5±1.4	6.0(p=0.5)
Ripcord 10 EC	98.8	5.0	422.3	2.8	2.6±1.1	2.7 (p=0.9)
Phyphanon 57 EC	497.0	1.0	1167.7	1.0	4.4±1.0	4.3(p=0.7)

Conclusion

The mortality and toxicity effects of the tested insecticides against red pumpkin beetle, and epilachna beetle revealed significant differences. The mortality of the insect pests increased with both dose and exposure time. AC Mix 55 EC, Damdama 440 EC, and Decis 2.5 EC caused over 90% mortality with recommended doses at 72 hours after treatment. Probit analysis revealed that Decis 2.5 EC had the lowest LC_{50} and LC_{95} values, indicating the highest inherent toxicity against the test insects. On the basis of the results, AC Mix 55 EC, Damdama 440 EC, and Decis 2.5 EC can be recommended for the effective management of epilachna beetle, red pumpkin beetle with their recommended doses.

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