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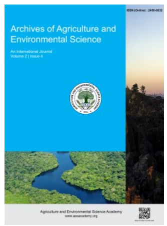

ORIGINAL RESEARCH ARTICLE

CrossMark

Comparative study of various botanical and chemical pesticides against red pumpkin beetle (*Aulacophora foveicollis*) in summer squash at Bhojpur, Nepal

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ABSTRACT

The red pumpkin beetle (*Aulacophora foveicollis*) is an invasive pest of summer squash (*Cucurbita pepo*) that damages seedlings, skeletonize leaves and flower buds, ultimately reducing yield. This study, conducted in Bhojpur, Nepal, examined the effectiveness of selected pesticides for the control of Red Pumpkin Beetle (RPB). A Randomized Complete Block Design (RCBD) was used with seven treatments; each replicated three times. It assessed the effectiveness of Deltamethrin, Profenofos, Malathion, Emmamectin benzoate, Neem oil, Tobacco extract, and water spray. Data on beetle population and leaf damage severity were collected before spray and at 1, 3, 6, and 10 days after spray (DAS), then analyzed using ANOVA and DMRT. Results indicated that Deltamethrin emerged as the most effective, reducing beetle population to 0.71 beetles/plant and leaf damage to 9.46%. Profenofos demonstrated similar efficacy with 0.90 beetles/plant and 13.06% damage. Malathion and Emmamectin benzoate were moderately effective, while Neem oil and Tobacco extract were least effective but better than water spray, which recorded 3.96 beetles/plant and 48.91% damage. All pesticides reduced beetle populations compared to control, but Deltamethrin and Profenofos were most effective and statistically similar. These findings emphasize the importance of selecting appropriate pesticides and applying correct dosages for effective management of Red Pumpkin Beetle.

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INTRODUCTION

Summer squash (*Cucurbita pepo* L.) is commercially important horticultural crops belonging to Cucurbitaceae family, grown in both open-field and protected cultivation, across a diverse range of warm climate and temperate zone globally (Parajuli *et al*., 2020; Rouphael & Colla, 2005). Due to its fast growth and early output, summer squash, often known as Zucchini, has been a valuable source of cash creation for farmers (Parajuli *et al*., 2020). Summer squash not only delights the taste buds but also provides essential nourishment for a healthy diet. In addition to being an excellent source of protein, minerals, and vitamins, it also possesses pharmacological qualities like antifungal, anti-diabetic, anti-inflammatory, and antioxidant characteristics (Rehan Aslam *et al*., 2017). Despite these benefits, the production of summer squash is severely constrained by seasonal insect pests, among which the polyphagous Red Pumpkin Beetle is the most destructive, feeding on the crop at every developmental stage and consequently restricting its growth, yield potential, and quality (Nath & Ray, 2012; Parajuli *et al*., 2020). It is a vibrant orange-red pest whose adults voraciously feeds on leaves and create irregular holes, while larvae inflict further damage by boring into roots and subterranean stem sections, including the lower portions of the plant (Sharma *et al*., 2016).

Moreover, fruits and leaves in contact with soil become susceptible to damage (Diver & Hinman, 2008; Sharma *et al.*, 2016). From the seedling stage to blooming and fruiting, it targets every stage conceivable, generating a tremendous production uproar that results in a 30–100% loss (Rashid *et al.*, 2014). The cotyledonary stage of the crop is when the red pumpkin beetle most frequently attacks it, where the adults skeletonize the young leaves (Rai *et al.*, 2008) Being strong fliers and highly active in warm conditions, they can cause severe damage if unmanaged, often necessitating repeated resowing (Sarker *et al.*, 2022; Sharma *et al.*, 2016). It is crucial to effectively manage such damage to enhance the quality and productivity of summer squash.

A range of control methods, such as physical, chemical, botanical and mechanical, have been used for efficient pest management (Regmi & Paudel, 2020) but farmers mostly rely on synthetic pesticides. These pesticides are often used indiscriminately by farmers, raising serious economic, health, and environmental concerns (Atreya *et al.*, 2022). While some studies have investigated chemical control, there is limited research on the comparative efficacy of different pesticides and their optimum doses against red pumpkin beetle in a meaningful way (Parajuli *et al.*, 2020; Rahman, 2018; Vodnala, 2016). Moreover, farmers are largely unaware of the efficacy of locally available pesticides and their appropriate doses, as well as the potential role of botanical pesticides in pest management. Therefore, this study was conducted to address these significant challenges by generating evidence-based insights to improve pest management strategies. It focuses on evaluating both chemical and botanical pesticides under local field conditions, thereby bridging existing knowledge gaps and contributing to safer and more sustainable crop protection practices.

MATERIALS AND METHODS

Experimental site

The experiment was carried out in Pokhare, Bhojpur municipality-8, Bhojpur. The research site is geographically situated at North latitude 27°10’28” and East longitude 87°3’24” with an elevation of 1520 m above sea level. The soil composition of the research area is identified as sandy loam.

Experimental design

The research study was performed in Randomized Complete Block Design (RCBD) with 7 treatments, each replicated 3 times. Each plot comprised 15 plants, and the sample plant was selected at random from the center 3 plants. Three different colors of ribbon were used to indicate those plants.

Treatment details

The research was conducted using the following 7 treatments including one untreated control.

T_1- Malathion @ 2ml/l

T_2- Immamectin Benzoate @ 0.5gm/l

T_3- Deltamethrin @ 1ml/l

T_4- Profenofos @ 1ml/l

T_5- Neem Oil @ 2ml/l

T_6- Tobacco extract @ 1:5 concentration

T_7- Control (Water spray)

Planting material

Summer squash variety Anna-303 was sown in 4×5-inch plastic bags under protected condition. After reaching the 5-leaf stage, seedlings were transplanted at spacing of 80 cm × 80 cm Plant-Plant × Row-Row (P-P×R-R). Regular watering and appropriate intercultural operation were provided accordingly.

Method of recording observations

To record observations on plant morphology and insect damage in the field, three sample plants were selected from each plot, tagged with ribbons for indication, and the data were collected from these plants. The following parameters were measured in the field to evaluate the effectiveness of different treatments against the Red Pumpkin Beetle in summer squash.

Number of red pumpkin beetle population per plant

The number of Red Pumpkin Beetle per plant was counted manually after the population of RPB meets the Economic Thresh hold Level in the field. The population was counted before the spray, as well as 24 hours, 3 days, 6 days, and 10 days after the spray.

Damage severity percentage in leaf

The number of damaged leaves per plant was manually counted before the spray, as well as 24 hours, 3 days, 6 days, and 10 days after the spray. Damage percentage was calculated by using formula.

Damage percentage=Total number of damaged leaves/Total number of leaves in plant× 100%

Statistical analysis

All the data collected was first documented in Microsoft Excel and subsequently analyzed using R-Studio software. Duncan's Multiple Range Test (DMRT) was applied to determine statistically significant differences among the mean values at a 5% significance level. The significance was evaluated using the standard ANOVA table format.

RESULTS AND DISCUSSION

Number of red pumpkin beetles per plant

The number of red pumpkin beetles (RPB) per plant was recorded both a day before and after the first spray on different days, as shown in Table 1. On average, there were 3.27 RPB per plant before the first spray, with no significant differences among the treatments. After the spray, the average RPB counts per plant were 0.84 at 1 DAS, 1.24 at 3 DAS, 1.99 at 6 DAS, and 2.38 at 10 DAS. At 1 DAS and 3 DAS, the Deltamethrin-treated plots had the lowest RPB, while Neem oil and Tobacco extract treatments were the highest, with no significant difference between the two. By 6 DAS, Deltamethrin and Profenofos treatments showed significantly lower RPB counts compared to the others, with both treatments being statistically similar. Meanwhile, RPB counts were notably higher in the Tobacco extract treatment, followed by Neem oil. At 10 DAS, the number of RPB was significantly higher in the Tobacco extract and Neem oil treatments, which were also statistically like each other. These were followed by Emmamectin Benzoate, Malathion, Profenofos, and Deltamethrin. The highest RPB population was found in the control plots, where no chemicals were applied. Interestingly, the RPB counts in the Profenofos and Deltamethrin treatments were statistically similar.

Leaf damage severity percentage per plant

The leaf damage severity percentage per plant is shown in Table 2. The average leaf damage severity percentage before spraying was 29.51%, which showed no significant differences among treatments as no insecticides were applied. However, after the treatments, insecticide applications were highly significant at each observation point following the sprays. At 1 day after the first spray (1DAS), the least leaf damage was observed in the Deltamethrin-treated plots (12.29%), followed by Profenofos (14.67%), Emmamectin Benzoate (19.58%), Malathion (20.67%), Neem Oil (23.90%), Tobacco Extract (25.47%), and the control plots (43.29%). Malathion exhibited a statistically similar result to Emmamectin Benzoate at 1DAS, while neem oil and tobacco extract-treated plots showed similar levels of damage. At 3 days after the first spray (3DAS), the Deltamethrin-treated plots again had the least leaf damage (11.50%), followed by Profenofos (14.67%), Emmamectin Benzoate (17.96%), Malathion (20.14%), Neem Oil (23.13%), Tobacco Extract (25.80%), and the control (44.97%). Similarly, at 6DAS of the first spray, the leaf damage severity on Malathion and Emmamectin Benzoate-treated plots was found to be statistically similar. At 10 days after the first spray (10DAS), the Deltamethrin-treated plots again recorded significantly lower leaf damage (9.58%) compared to other treatments, with Profenofos (13.06%) following. These results were consistent across all spray timings. Overall, the pooled data showed the lowest leaf damage in Deltamethrin-treated plots (9.46%), followed by Profenofos (13.06%), Emmamectin Benzoate (18.52%), and Malathion (18.79%). The highest leaf damage was observed in the control plots where no chemical was applied.

Table 1. Effect of pesticide on number of red pumpkin beetles per plant of summer squash.

Treatment	Before spray	First spray					Second spray				Mean	
	DBS	1DAS	3DAS	6DAS	10DAS	POOL	1DAS	3DAS	6DAS	10DAS	Pool	Overall
Deltamethrin	3.33	0.14^{d}	0.39^{f}	1.12^{d}	1.26^{d}	0.73^{e}	0.14^{d}	0.67^{d}	0.78^{e}	1.22^{d}	0.70^{f}	0.71^{e}
Profenofos	3.44	0.16^{d}	0.50^{e}	1.23^{d}	1.42^{d}	0.83^{e}	0.16^{d}	1.0^{cd}	1.22^{d}	1.56^{d}	0.99^{ef}	0.90^{e}
Emmamectin	3.22	0.33^{c}	0.69^{d}	1.52^{c}	2.07^{c}	1.15^{d}	0.33^{c}	1.33^{bc}	1.67^{c}	2.06^{c}	1.35^{de}	1.25^{d}
Malathion	3.56	0.35^{c}	0.67^{d}	1.56^{c}	2.11^{c}	1.17^{d}	0.35^{c}	1.33^{bc}	1.69^{c}	2.14^{c}	1.38^{d}	1.27^{d}
Neem oil	2.99	0.68^{b}	1.33^{c}	1.71^{c}	2.20^{c}	1.48^{c}	0.68^{b}	1.59^{b}	2.25^{b}	3.22^{b}	1.94^{c}	1.70^{c}
Tobacco extract	3.22	0.69^{b}	1.45^{b}	2.89^{b}	3.29^{b}	2.08^{b}	0.69^{b}	1.68^{b}	2.43^{b}	3.19^{b}	2.33^{b}	2.20^{b}
Control	3.11	3.55^{a}	3.64^{a}	3.94^{a}	4.33^{a}	3.87^{a}	3.55^{a}	3.86^{a}	3.99^{a}	4.01^{a}	4.07^{a}	3.96^{a}
Grand Mean	3.27	0.84	1.24	1.99	2.38	1.62	0.84	1.64	2	2.48	1.82	1.72
CV (%)	13.06	5.43	4.63	6.16	8.65	5.43	11.84	9.35	11.22	11.44	3.76	7.49
SEM (±)	0.09	0.01	0.012	0.026	0.05	0.013	0.01	0.042	0.041	0.061	0.045	0.0281
F Value	NS	***	***	***	***	***	***	***	***	***	***	***

SEM: Standard error of means. CV: Coefficient of Variation. Means followed by the same letter in a column are not significantly different by DMRT at 5% level of significance. NS= Non-Significant, *=Significant at 5% probability level, **= Significant at 1% probability, ***=Significant at 0.1% probability, DAS= Days After spray, DBS= Days Before Spray.

Table 2. Effects of pesticides on average of leaf damage severity percentage.

Treatments	Before spray	First spray					Second spray				Mean	
	DBS	1DAS	3DAS	6DAS	10DAS	POOL	1DAS	3DAS	6DAS	10DAS	Pool	Overall Pool
Deltamethrin	29.83	12.29^{d}	11.50^{e}	10.73^{e}	9.58^{e}	11.03^{e}	9.11^{e}	8.37^{d}	7.92^{e}	6.23^{e}	7.91^{d}	9.46^{e}
Profenofos	26.24	14.67^{cd}	13.97^{de}	13.37^{de}	13.06^{de}	13.77^{de}	14.01^{de}	12.51^{d}	12.27_{de}	10.65^{de}	12.36^{d}	13.06^{de}
Emmamectin benzoate	30.11	19.58^{bc}	17.96^{cd}	18.30^{cd}	18.76^{cd}	18.65^{cd}	19.28^{cd}	18.71^{c}	18.42^{cd}	17.11^{cd}	18.38^{c}	18.52^{cd}
Malathion	29.26	20.67^{bc}	20.14^{bc}	19.15^{cd}	18.03^{cd}	19.50^{cd}	19.23^{cd}	18.47^{c}	17.77^{cd}	16.89^{cd}	18.09^{c}	18.79^{cd}
Neem oil	30.61	23.90^{b}	23.13^{bc}	23.06^{bc}	22.71^{bc}	23.2^{bc}	24.25^{c}	23.42^{c}	24.32^{bc}	22.57^{bc}	23.64^{c}	23.43^{bc}
Tobacco extract	27.69	25.47^{b}	25.80^{b}	25.78^{b}	27.79^{b}	26.56^{b}	32.00^{b}	30.48^{b}	30.45^{b}	28.67^{b}	30.40^{b}	23.43^{bc}
Control	32.78	43.29^{a}	44.97^{a}	46.19^{a}	48.23^{a}	45.67^{a}	49.95^{a}	51.24^{a}	52.63^{a}	54.75^{a}	52.14^{a}	48.91^{a}
Grand Mean	29.51	22.85	22.49	22.57	22.59	22.63	23.98	23.31	23.39	22.41	22.28	22.95
CV (%)	14.64	15.43	14.2	14.78	15.04	14.58	12.12	12.15	15.6	15.75	13.66	13.89
SEM (±)	0.943	0.769	0.697	0.720	0.740	0.720	0.630	0.610	0.790	0.770	0.694	0.696
F Value	Ns	***	***	***	***	***	***	***	***	***	***	***

SEM: Standard Error of Means. CV: Coefficient of Variation. Means followed by the same letter in a column are not significantly different by DMRT at 5% level of significance. NS= Non-Significant, *=Significant at 5% probability level, **= Significant at 1% probability, ***=Significant at 0.1% probability, DAS= Days After spray, DBS= Days Before Spray.

The present findings showed that synthetic pyrethroid pesticide was successful in suppressing RPB, which corresponds with (Ullah *et al.*, 2022) who reported in their study on *Aulacophora foveicollis* in cucumber cultivars that synthetic pyrethroids consistently outperformed other control methods across all concentration levels, particularly on ridge gourd. Because it interferes with the normal function of insect neurons, deltamethrin may have a unique mechanism of action that contributes to its increased potency. The results were also similar with (Yaligar *et al.*, 2022) who reported that deltamethrin reduce pest population and damage in cucumber plant. Likewise, the organophosphate insecticide Profenofos has been shown to effectively lower RPB populations and minimize damage to summer squash. Profenofos demonstrated results that were nearly identical to those of deltamethrin at all relevant spray dates, leading experts to conclude that it is just as efficacious as deltamethrin against RPB. Although relatively little research has been done to determine Profenofos effectiveness against cucurbit pests, there are studies on other vegetables that provide excellent results in controlling comparable pests. According to (Kallathuru *et al.*, 2023) organophosphates effectively suppressed beetle populations under both field and laboratory conditions, demonstrating consistent efficacy across environments. Research conducted by (Ullah *et al.*, 2022) also showed that malathion has been another effective pesticide to control RPB in cucurbitaceous crop. Damage against RPB has been shown to be effectively controlled using malathion and Emmamectin benzoate. Both chemical pesticides produced results that were almost identical, indicating that they can be employed equally well to reduce the RPB population and the damage that it causes. Neem oil and tobacco extract used in the experiment were found to be the least effective insecticides as they show minimum reduction of pest population. The damage severity (48.91) and beetle's population (3.96) were seen maximum in plot without any treatment. All pesticides effectiveness was observed to increase just a few days after being sprayed, and it steadily decreased as the day progressed.

Conclusion

This study demonstrated that all the pesticides reduced Red Pumpkin Beetle (RPB) infestation and leaf damage in summer squash compared to the untreated control, but their efficacy varied significantly. Among the treatments, Deltamethrin and Profenofos consistently outperformed the other pesticides, showing the lowest beetle populations (0.71 and 0.90 beetles/plant) and minimal leaf damage (9.46% and 13.06%). Malathion and Emmamectin benzoate provided moderate suppression of RPB, whereas Neem oil and Tobacco extract, though less effective, still reduced pest population and damage compared to water spray. The findings confirm that synthetic pyrethroid (Deltamethrin) and organophosphate (Profenofos) insecticides are the most reliable options for effective RPB management under local field conditions in Bhojpur, Nepal. Importantly, this research fills a critical knowledge gap by providing comparative evidence on the performance of both chemical and botanical pesticides, guiding farmers toward more effective and informed pest management decisions. Thus, Deltamethrin is recommended as the most effective control option for Red Pumpkin Beetle in summer squash. However, future research should explore the integration of these chemical options with safer botanical approaches to promote sustainable pest management.

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DECLARATIONS

Authors contribution: Conceptualization, Methodology: S.B. and B.S.; Software, validation: S.B.; Investigation: S.B. and S.K.; Data curation: S.B.; Writing -original draft preparation: S.B., B.S., H.D.; Writing-review and editing: S.B., S.K.; Supervision: A.K., N.G. All authors have read and agreed to the published version of the manuscript.

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