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The impact of several insecticides against the legume pod borer, *Maruca vitrata* Fab. (Lepidoptera: Crambidae) on cowpea

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ABSTRACT

Cowpea (*Vigna unguiculata*), a widely cultivated grain legume in Nepal and a member of the Fabaceae family, faces significant production challenges due to the legume pod borer (*Maruca vitrata*). This pest is a major threat, limiting both the yield and productivity of cowpea crops. The research was laid out in Randomised Completely Block Design with seven treatments and three replications. The treatments comprise chlorantraniripole 18.5% SC, emamectin benzoate 5% SG, spinotoram 11.7% SC, dimethoate 30% EC, azadiractin 0.07 % EC and BT+ *Saccharopolyspora spinosa* and control. Chlorantraniliprole demonstrated the highest effectiveness, reducing larval populations to just 0.16 after the fourth application, while achieving the maximum fruit yield of 13 t/ha. Emamectin and spinetoram also performed well, both decreasing larval counts to below 1.0 and producing comparable yields of 12.90 t/ha and 12.89 t/ha, respectively. In contrast, biological treatments, such as *Bacillus thuringiensis* var. Kurstaki, exhibited moderate success in pest control, resulting in a lower yield of 10.19 t/ha. Azadirachtin and the untreated control plots experienced the highest infestation rates, leading to significantly lower yields of 8.04 t/ha and 4.70 t/ha, respectively. Chlorantraniliprole also proved superior in reducing fruit damage, limiting it to just 1.55%, compared to the high damage rate of 42.04% observed in the untreated control. These findings highlight the strong efficacy of chemical insecticides, especially chlorantraniliprole, in controlling *Maruca vitrata* infestations and enhancing cowpea productivity. Future studies should focus on integrating biological agents with chemical treatments to minimize environmental impacts and prevent resistance, while maintaining high yields and effective pest control.

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1. Introduction

Pulse crops are prominent source of proteins, carbohydrates, and fats along with vitamins and minerals like phosphorous, calcium, iron, etc. (Kumar, 2005). They are cultivated in most of the tropical or sub-tropical regions of the world (Singh et al., 2020). Among several pulses crop cowpea is also one of the widely grown grain legume crop species in Nepal (Pant et al., 2021; Aryal et al., 2021). The crop flourishes well in areas where the temperature ranges from 27-35 °C, comfortably adapted to a wide range of soil types and various cropping systems but not so in the case of alkaline soil (Kumar, 2005). The botanical name of cowpea is *Vigna unguiculate* pronouncedly also known as black pea or southern pea. It belongs to the family Leguminiaceae and sub-family Fabaceae (Pant et al., 2021). Cowpea contains about 90% of dry matter (DM), 17-18% of crude protein (CP) & 13-15% of an ash (Owade et al., 2020). It can be used in multiple ways such as food, feed, forages, fodder, green manuring, and as a vegetable too (Pant et al., 2021). It enhances soil fertility due to its N2 fixing ability as well as being helpful in preventing soil erosion (Doyle et al., 2013). Emphasizing the uses of cowpea, Nepal has managed to produce around 9186 Mt of cowpea utilizing an area of 6752 hectares (Ha) (Aryal et al., 2021).

However, its production and productivity is confined by some factors like nutritional deficiency, climatic extremities, diseases outbreak, and majorly insect pests of several genera. Some major pests of cowpea include cowpea pod borers, aphids, sucking bugs, and leaf hoppers (Pant et al., 2021). Originating from the Ind-Malaysian region, legume pod borer (LPB), *Maruca vitrata* (Lepidoptera, Crambidae) is one of the most severely damaging pests of cowpea crops (Yule and Srinivasan, 2014), (Yadav and Singh, 2014). It is widely distributed in tropical and sub-tropical regions of the world but the majority of the LPB population is found in Asian and African regions and is polyphagous (Aryal et al., 2021). It feeds on more than 39 host plants belonging to 26 different genera and 6 families extensively on plants from the papilionaceae family. Eggs of LPB are greenish white and are laid singly or in batches of 2-6 on the underside of the leaves, terminal shoots, and floral buds, which hatch in 2-3 days (Ba et al., 2019), (Ashigar and Umar, 2016). They are oval and translucent and measures around 0.65 * 0.45 mm (Ba et al., 2019). Depending on the climatic condition and host plant the five instars larval stage lasts up to 8-10 days (Ashigar and Umar, 2016). The body is tube shaped and measures about 11-12 mm long and 2.1-2.4 mm wide with a slender head and a pair of dark brown spots on each segment (Ba et al., 2019). The pupae are initially red brown but later change their color from red brown to dark brown when fully developed measuring about 13 mm in length (Ba et al., 2019; Ashigar and Umar, 2016). Female pupae of LPB do not have any rings but male pupae bear a small distinct ring on the last abdominal segment (Ba et al., 2019). An adult LPB has a wingspan of 13-25 mm with a dark brown body color (Ba et al., 2019). The forewings are brown with white spots and black edges whereas the hindwings are translucent (Ashigar and Umar, 2016). Mostly the reproductive parts of at least 73 of the host plant species get infected by the pests of these species leading to 20-80% of crop loss (Ekesi, 1999; Srinivasan et al., 2021; Sharma and Franzmann, 2000). The infection is initiated by the larvae in leaves where it feeds inside the rolled and webbed leaves (Sharma and Franzmann, 2000).

Further, the infestation proceeds to floral buds, flowers, and pods. The larvae feed on the structures by webbing them which prevents these larvae from adverse factors and natural enemies (Sharma and Franzmann, 2000). Most of the farmers heavily rely on chemical insecticides for the control and management of this pest. However, cultural practices and the employment of biological control agents are being focused on the recent days (Ekesi, 1999; Yule and Srinivasan, 2013). The newly emerged larvae can only be killed via chemical insecticides before they bore into the flowers. Therefore, this leads to frequent spraying of insecticides by the farmers for the control and management of LPB resulting in chemical residue in food stuffs (Aryal et al., 2021; Yule and Srinivasan, 2013). The chemical residue hampers soil health, water condition and, also human health (Pant et al., 2021; Aryal et al., 2021). The application of botanical and biological agents like: Bacillus thuringiensis, parasitoid wasps (which is the classical biological control agent used for the control of LPB), and azadirachtin which is found to have a significant impact in reducing LPB population (Yule and Srinivasan, 2013; Yule and Srinivasan, 2014; Dannon et al., 2012).

The aim of this study is to evaluate the effectiveness of various Insecticides against the legume pod borer (*Maruca vitrata*) in cowpea, assess the damage caused, and identify optimal control methods.

The findings will guide farmers in selecting effective management strategies that enhance yield and quality while ensuring consumer safety by minimizing health risks associated with pesticide use.

2. Materials and methods

2.1. Description of the study area

Between March 2023 and May 2023, the study was conducted in the research field of the Prime Minister Agriculture Modernization Project (PMAMP), Katahari Municipality, Morang, Nepal. The location is at an altitude of 73.74 meters above sea level, with geographic coordinates of latitude 26° 28' 10.4118" N and longitude 87° 21' 3.1431" E. Maximum and Minimum temperatures in the region are 33.9°C and 10.5°C, respectively, with an average annual rainfall of 1891.8 mm. Figure 1 represents the experimental site of the study.

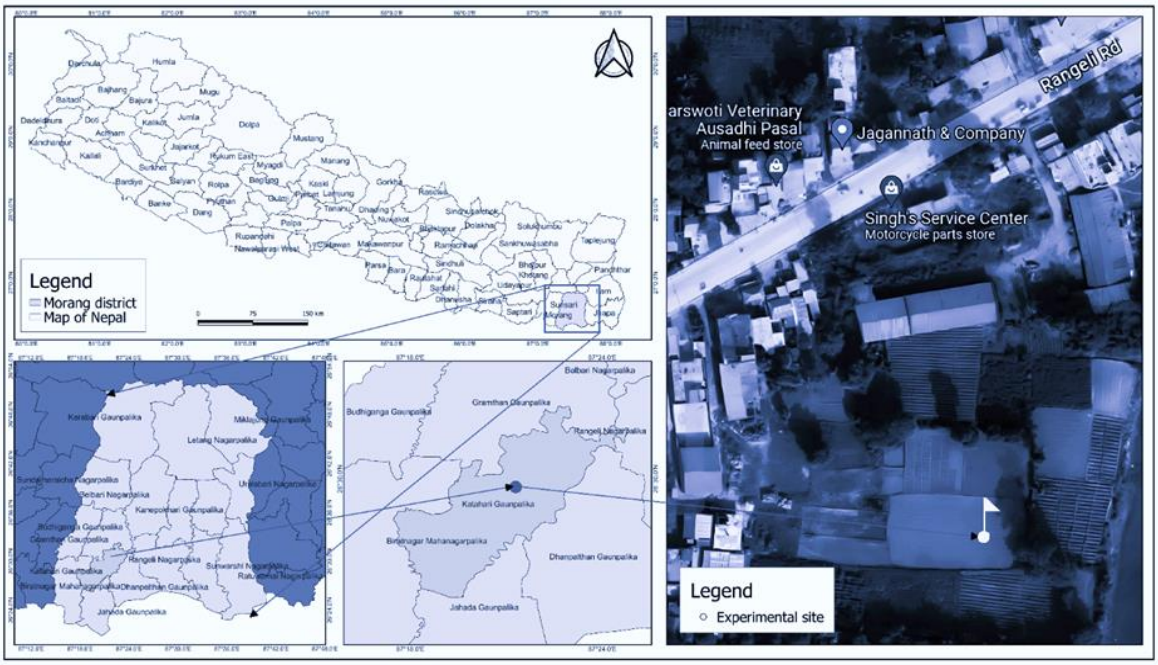

Figure 1. Map illustrating the experimental site of the study

2.2. Trial design

To determine the efficacy of insecticides against LPO (*Maruca vitrata*) in cowpea (*Vigna ungliculata*), the entire research was laid out in Randomized Completely Block Design (RCBD). There were seven treatments and three replications. The treatments were randomly assigned to the experimental plots to get uniform distribution. The experimental units were arranged in a spatial manner, with 1.0 m distance in between the replications and 0.8 m between the treatments. The overall area of the experimental area was 265.1 m^2 which was divided into 21 plots, each with an area of 4.5 m^2. The plants were planted by maintaining a plant-to-plant distance of 30 cm (P-P) and row-to-row distance of 60 cm (R-R).

2.3. Planting material

To determine efficacy of various Insecticides against *Maruca vitrata*, the crop or cowpea variety selected was Anna green F1. The seeds of this variety were obtained from the National Agriculture Research Council (NARC), Tashara, Morang, Nepal. The seed packets had some specifications labelled on them such as the minimum physical purity of the seeds as 98%, which ensures the absence of impurities in the seeds, the genetic purity of the seeds as 96%and the germination percentage was labelled as 97%, ensuring high rate of successful germination of the seeds.

2.4. Cultural practices

Before the start of the experiment, the land was brought to a cultivable condition via various steps. The land was measured and made free of weeds; The land was ploughed with rotavator followed by harrowing to make a land even. The depth of ploughing was adjusted to about 15-20 cm. The seeds of cowpea for the experiment were directly sown in the plots on March 15, 2023. A dibbler was used to make a hole of 2.0 cm for the placement of seeds. Two seeds per hole were placed so as to ensure successful germination in the case of seeds. After two weeks, gap filling and thinning were done to ensure one healthy plant per hill with total of 30 plants per plot. At the time of field preparation, the land was incorporated with well decomposed and rotten Farmyard manure at the rate of 15 tons per hectare. The fertilizers used as sources of nutrients were urea, diammonium phosphate (DAP), and muriate of potash (MOP). At the rate of 40:60:40 Kg NPK/ha. The full dose of potassium (K) and phosphorous (P) along with half dose of nitrogen (N) was applied at the time of field preparation. The remaining half dose of nitrogen was applied in further two split doses i.e., one after gap filling and another during flowering stage to ensure proper nutrient supply at different growth stages for the plants. The irrigation schedule involves watering the plants twice a day, one during the morning time and another during evening depending on the field moisture condition. For the management and control of weeds, an application of pre-emergence herbicide pendimethalin 50% EC was used. In addition to this, two hand weeding was also performed at 25 and 40 DAS respectively. A fungicide named SAAF (carbendain 12 % + mancozeb 63 % WP) at a rate of 2 gm/L of water was sprayed to avoid of any fungal infestation. Staking was done with the help of bamboo and ropes to support the plants and facilitates easy monitoring, spraying and harvesting. Harvesting was done manually by picking the matured pods from the plants in every 3 days. All the cultural practices such as irrigation, weeding, fungicide application, staking and harvesting followed the guidelines of NARC, Tarrahara, Morang.

2.5. Treatments details

The Insecticides used in the experiment were brought from Koshi Agro Traders, Biratnagar. Insecticides selected for this experiment were of different categories including chemical, botanical, and biological agents based on their proven efficacy against LPB. The total of 7 treatments were applied in this experiment, out of which 6 were Insecticides and remaining was water spray or control group. The selection of these treatments was based on recommendation from local agricultural extension services and previous research, also commonly used insecticides of the region were included. To facilitate easy identification and references, each pesticide treatment was assigned a unique code or name. LPB infestation reached a critical level (Economic Threshold Level or ETL) on the 38th day after sowing (DAS). At this point, one live larva was found on average for every six plants. To control the pest, four rounds of insecticide spraying were conducted. Each spraying was done a week apart, starting on the 38th DAS. The insecticides were sprayed using a motorized knapsack sprayer, which was set to a pressure of 40 psi and had a tank capacity of 16 liters. To reduce environmental impact, the spraying was always done in the late evening.

Table 1. Different insecticides used in the experiment including brand name, application rates, and treatment numbers

S.N.	Treatments	Brand Name	Dose/L	Treatment No.
1.	Chlorantraniliprole18.5% SC	Coragen	0.2 ml/l of water	T1
2.	Emamectin Benzoate 5% SG	Indogulf	1.5 ml/l of water	T2
3.	Spinotoram 11.7% SC	Largo	1 ml/l of water	T3
4.	Dimethoate 30% EC	Rogorasa	2 ml//l of water	T4
5.	Azadirachtin 0.03 % EC	Multiplex	2 ml//l of water	T5
6.	*Bacillus thuringiensis var. Kurstaki (BK) + Saccharopolyspora spinosa 15 % SC*	Multiplex	2 ml//l of water	T6
7.	Water spray	N/A	N/A	T7

2.6. Data observation and collection

For data collection and observation, the healthy plants were tagged randomly keeping border plants neglected. The data was collected on number of pods, weight of normal pods, number of damaged pods and weight of damaged pods, number of larvae in damaged pods, No. of Larvae in 12 flowers before treatments and after 7 days of successive treatments.

2.7. Statistical analysis

For further investigation, the gathered data were imported into MS Excel (2019). Using SPSS, the Kolmogorov-Smirnov and Shapiro-Wilkinson tests of normality were performed to see whether the data were normal (Buragohain et al., 2021). A square root transformation (SQRT) was used to normalize the data when the data did not adhere to the assumptions of normality (Devkota et al., 2016). R-Studio statistical software was then used to do an Analysis of Variance (ANOVA). Using the methods given by Gomez and Gomez (1984), this research sought to identify significant differences between the treatments. At a significance threshold of p 0.05, post-hoc tests like Tukey's HSD were used to detect treatment effects.

3. Results

3.1. Impact of insecticides on pod borer larval count in cowpea flowers before and one week post-each spray

3.1.1. Impact of *Maruca vitrata* infestations on cowpea before treatment spray

Before the spray treatments, *Maruca vitrata* infestations on cowpea plants did not show statistically significant differences across the treatments as presented on table 2. The infestation levels varied slightly, with Spinetoram having the lowest mean infestation at 14.91 ± 3.92, and both emamectin and dimethoate showing the highest mean infestation at 16.02 ± 4.06 and 16.02 ± 3.94, respectively. Chlorantraniliprole, *Bacillus thuringiensis* var. *Kurstaki (BK) + Saccharopolyspora spinosa* 15 % SC, azadirachtin, and water spray had infestation levels between these extremes, all averaging around 15.41 to 15.63. The overall mean infestation level across all treatments was 15.50, with a standard error of ±1.12, and the coefficient of variation (CV%) was 5.46%, indicating low variability among the treatments.

3.1.2. Effect of insecticides on larvae after multiple consecutive sprays:

The effect of insecticides on larval counts in cowpea flowers after consecutive sprays shows a clear trend of decreasing larval populations with each application. Chlorantraniliprole consistently had the most significant reduction, dropping from 2.49 ± 1.728 after the first spray to just 0.16 ± 0.813 after the fourth spray. Similarly, emamectin and spinetoram also showed notable reductions, with larval counts decreasing from around 3.5 to below 1 by the final spray. In contrast, treatments like *Bacillus thuringiensis* var. *Kurstaki (BK) + Saccharopolyspora spinosa* 15 % SC and azadiractin showed moderate effectiveness, with larval counts declining but remaining relatively higher than other insecticides. *Bacillus thuringiensis* var. Kurstaki (BK) + *Saccharopolyspora spinosa* 15 % SC reduced larvae from 7.94 ± 2.903 to 2.27 ± 1.663, while azadiractin reduced from 9.47 ± 3.157 to 3.24 ± 1.934. Dimethoate was less effective compared to the top treatments but still showed a consistent decline over time. Water spray, serving as the control, had the highest larval counts throughout, starting at 20.10 ± 4.532 and only reducing to 6.19 ± 2.580 after four sprays. The grand mean larval counts for each spray dropped steadily from 7.47 to 2.07.

Table 2. Impact of insecticides on pod borer larval count in cowpea flowers before and one week post-each spray

Treatment	Before spray	First spray	Second spray	Third spray	Fourth spray
Chlorantraniliprole	15.63 ± 4.016[a]	2.49 ± 1.728[d]	1.41 ± 1.380[c]	0.80 ± 1.132[d]	0.16 ± 0.813[c]
Emamectin	16.02 ± 3.935[a]	3.44 ± 1.985[cd]	2.05 ± 1.584[c]	1.24 ± 1.306[cd]	0.69 ± 1.088[c]
Spinetoram	14.91 ± 3.924[a]	3.58 ± 2.019[cd]	2.13 ± 1.606[c]	0.99 ± 1.186[cd]	0.83 ± 1.142[c]
Dimethoate	16.02 ± 4.063[a]	5.30 ± 2.409[c]	3.22 ± 1.925[c]	2.11 ± 1.594[c]	1.13 ± 1.225[c]
Bt K + S. spinosa	15.50 ± 3.992[a]	7.94 ± 2.903[b]	5.11 ± 2.363[b]	3.32 ± 1.955[b]	2.27 ± 1.663[b]
Azadiractin	15.02 ± 3.949[a]	9.47 ± 3.157[b]	6.30 ± 2.607[b]	3.83 ± 2.080[b]	3.24 ± 1.934[b]
Water spray	15.41 ± 3.986[a]	20.10 ± 4.532[a]	16.44 ± 4.106[a]	12.19 ± 3.560[a]	6.19 ± 2.580[a]
Grand mean	15.50	7.47	5.23	3.50	2.07
SEM (±)	1.12	0.70	0.56	0.34	0.35
CV%	5.46	5.76	6.53	10.99	14.14
F value	NS	***	***	***	***

Data was transformed by (√(x+0.5)) before statistical analysis, and the parentheses show the transformed value. Mean sharing same letter within column are non-significant. Means followed by different letter within each column are significantly different, DMRT ($p \leq 0.05$). SEM: Standard error of mean. CV: Coefficient of variation. *** Significant at 0.1% level of significance. NS: Non-significant

The F values for all sprays were highly significant at 0.1% level of significance, indicating that insecticide treatments had a strong effect on larval reduction. Overall, chlorantraniliprole emerged as the most effective treatment, with the others also reducing larval counts, albeit to varying degrees.

3.2. Effect of Insecticides on total number of fruits, total damaged number of pods and total weight of damaged pods per eight plants in cowpea against legumes pod borer

3.2.1. Total fruit number per eight plants

There was a significant difference in the total fruit number per eight plants across the treatments, with a grand mean of 251.38 fruit which is shown in Table 3. Chlorantraniliprole produced the highest fruit number (310.33), closely matched by spinetoram (308.00) and emamectin (307.66). These three treatments dramatically increased fruit production, significantly outperforming dimethoate (286.00), which fell into the same statistical group as the top treatments but still trailed behind them. Biological treatments, such as *Bacillus thuringiensis* var. Kurstaki (BK) + *Saccharopolyspora spinosa* 15 % SC (243.33) and azadiractin (192.00), showed considerably lower fruit numbers, suggesting weaker pest control. At the bottom end, the water spray control (112.33) yielded the fewest fruit, illustrating the impact of heavy pest pressure without protection. In summary, chlorantraniliprole was the most effective in maximizing fruit production, with spinetoram and emamectin providing almost equal results.

3.2.2. Total fruit weight per eight plants (g)

Table 3, illustrates the results of total fruit weight per eight plants displayed significant differences, with an average weight of 4184.78 g. The heaviest fruit production was achieved with chlorantraniliprole (5128.90 g), with emamectin (5125.86 g) and spinetoram (5115.50 g) close behind, demonstrating their effectiveness in enhancing fruit size and overall yield. In contrast, dimethoate (4776.51 g) was less effective but still provided considerable improvement over biological treatments like *Bacillus thuringiensis* var. Kurstaki (BK) + *Saccharopolyspora spinosa* 15 % SC (4018.59 g) and azadiractin (3217.66 g), which lagged significantly. The untreated water spray group yielded the lowest fruit weight (1910.42 g), underscoring the importance of pest control in maintaining fruit quality and quantity. Among the treatments, chlorantraniliprole slightly outperformed the others, but all three top chemical treatments were highly successful in increasing fruit weight.

3.2.3. Total damaged fruit per eight plants

The number of damaged fruits per eight plants varied widely among the treatments presented in Table 3, with a grand mean of 21.90 damaged fruit. Chlorantraniliprole led with the fewest damaged fruit (4.66), clearly surpassing all other treatments in its ability to control pest damage. Both emamectin (9.66) and spinetoram (10.00) were also highly effective but allowed slightly more damage compared to chlorantraniliprole. Dimethoate (19.33) performed moderately, showing its lower effectiveness in damage control. Biological treatments fared worse, with *Bacillus thuringiensis* var. Kurstaki (BK) + *Saccharopolyspora spinosa* 15 % SC (26.33) and azadiractin (37.33) allowing significantly more damaged fruits. The water spray treatment had the highest number of damaged fruit (46.00), highlighting the severe damage caused in the absence of any pest control. Clearly, chlorantraniliprole was the most potent in minimizing fruit damage, followed by emamectin and spinetoram.

3.2.4. Total damaged fruit weight per eight plants (g)

Table 3, shows the total weight of damaged fruit also showed significant differences across treatments, with a grand mean of 262.98 g. Chlorantraniliprole resulted in the lightest damaged fruit weight (58.62 g), indicating its effectiveness in not only reducing the number of damaged fruits but also limiting the extent of damage. emamectin (116.10 g) and spinetoram (118.77 g) also performed well, though they allowed more damage than chlorantraniliprole. Dimethoate (232.92 g) provided only moderate protection, allowing substantially higher damage. Biological treatments were far less effective, with *Bacillus thuringiensis* var. Kurstaki (BK) + *Saccharopolyspora spinosa* 15 % SC (322.54 g) and azadiractin (444.80 g) recording significantly heavier damage.

The untreated water spray treatment had the highest damaged fruit weight (547.11 g), underscoring the necessity of effective pest control. Overall, chlorantraniliprole provided the strongest reduction in damaged fruit weight, proving its superiority over other treatments.

3.2.5. Percentage of fruit damage

The percentage of fruit damage varied significantly presented in Table 3, with a grand mean of 12.40%. Chlorantraniliprole provided exceptional protection, reducing fruit damage to just 1.55%, the lowest among all treatments. Emamectin (3.12%) and spinetoram (3.22%) were also highly effective, though their damage percentages were approximately double that of chlorantraniliprole. Dimethoate allowed a higher damage percentage (6.75%), while biological treatments performed poorly, with *Bacillus thuringiensis* var. Kurstaki (BK) + *Saccharopolyspora spinosa* 15 % SC (10.78%) and azadiractin (19.38%) showing much higher levels of fruit damage. Unsurprisingly, the untreated water spray group had the highest damage percentage (42.04%), indicating severe crop loss without intervention. Among all treatments, chlorantraniliprole was clearly the most efficient at minimizing fruit damage, followed by emamectin and spinetoram.

3.2.6. Yield (t/ha)

There were significant differences in yield among treatments at 0.1% level of significnace, with a grand mean of 10.53 t/ha as given in table 3. Chlorantraniliprole produced the highest yield (13.00 t/ha), slightly ahead of emamectin (12.90 t/ha) and spinetoram (12.89 t/ha), demonstrating its superior pest control and productivity benefits. Dimethoate (11.98 t/ha) provided reasonable yield improvement but remained less effective than the top three treatments. The biological treatments performed poorly, with *Bacillus thuringiensis* var. Kurstaki (BK) + *Saccharopolyspora spinosa* 15 % SC (10.19 t/ha) and azadiractin (8.04 t/ha) delivering significantly lower yields. The lowest yield was recorded in the untreated water spray group (4.70 t/ha), confirming the devastating impact of uncontrolled pest pressure on overall crop production. Chlorantraniliprole was the most successful treatment in maximizing yield, closely followed by emamectin and spinetoram, all of which substantially outperformed biological treatments and the control.

Table 3. Efficacy of Insecticides on total fruit number, damage, and yield performance in cowpea infested by pod borer

Treatment	Total fruit number/eight plants	Total fruit weight/eight plants (g)	Total damaged fruit/eight plants	Total damaged fruit weight/eight plants (g)	Percentage of fruit damage	Yield (t/ha)
Chlorantraniliprole	310.33^{a}	5128.90^{a}	4.66^{f}	58.62^{d}	1.55^{f}	13.00^{a}
Emamectin	307.66^{a}	5125.86^{a}	9.66^{e}	116.10^{c}	3.12^{e}	12.90^{b}
Spinetoram	308.00^{a}	5115.50^{a}	10.00^{e}	118.77^{c}	3.22^{e}	12.89^{b}
Dimethoate	286.00^{ab}	4776.51^{ab}	19.33^{d}	232.92^{b}	6.75^{d}	11.98^{c}
Btk + S. spinosa	243.33^{b}	4018.59^{bc}	26.33^{c}	322.54^{b}	10.78^{c}	10.19^{c}
Azadiractin	192.00^{c}	3217.66^{c}	37.33^{b}	444.80^{a}	19.38^{b}	8.04^{d}
Water spray	112.33^{d}	1910.42^{d}	46.00^{a}	547.11^{a}	42.04^{a}	4.70^{e}
Grand mean	251.38	4184.78	21.90	262.98	12.40	10.53
SEM (±)	15.43	278.7	1.22	15.88	2.32	0.64
CV%	10.63	11.53	9.66	10.46	32.49	10.48
F value	***	***	***	***	***	***

Means followed by different letter within each column are significantly different, DMRT ($p \leq 0.05$). SEM: Standard error of mean. CV: Coefficient of variation, *** Significant at 0.1% level of significance. NS: Non-significant

4. Discussion

The experiments revealed that chemical insecticides were highly effective in controlling *Maruca vitrata* larvae in cowpea, with chlorantraniliprole 18.5% SC being the most effective. This aligns with findings by Aktar et al. (2020), who also reported Chlorantraniliprole's superior performance compared to other chemicals. However, the percentage reduction over control plots was lower in Katahari, Morang, possibly due to climatic factors or *Maruca vitrata* tolerance.

Emamectin benzoate and spinetoram followed in efficacy, consistent with research by Anusha et al. (2014), though their reduction rates in Katahari were lower, likely due to higher infestations or host susceptibility. Dimethoate 30% EC was the least effective, possibly due to resistance, as it's an older insecticide. Biocontrol with *Bacillus thuringiensis* (B.T.) was less effective than chemical insecticides, as its slow toxin release likely delayed suppression. Azadirachtin-treated plots had higher larval counts, which may be due to the decomposition of active ingredients or slower larval suppression, as reported by Aryal et al. (2021). In reducing damaged pods, chlorantraniliprole was again most effective, like Aryal et al. (2021). Emamectin benzoate and spinetoram showed statistically similar results in pod protection, possibly due to their being of the same generation of insecticides, with findings comparable to Ashigar and Umar (2016). Dimethoate was less effective due to its older formulation, and B.T. had an intermediate effect, likely due to slower action, like findings by Ba et al. (2019). Azadirachtin was the least effective, comparable to results by Anusha et al. (2014), while control plots experienced the highest infestation levels. In the experiments conducted in Katahari, Morang, chlorantraniliprole 18.5% EC resulted in the highest yield per hectare. This yield surpassed the findings of Aryal et al. (2021), likely due to the higher genetic potential of the cowpea variety used, favorable soil, climatic conditions, and superior management practices. Emamectin benzoate and spinetoram produced statistically similar yields, with emamectin benzoate yielding more than that reported by Priyadarshini et al. (2013), again attributed to better conditions in Katahari. Dimethoate-treated plots recorded lower yields compared to other chemical insecticides, though still higher than Priyadarshini et al. (2013), possibly due to similar factors. The biocontrol agent *Bacillus thuringiensis* (B.T.) resulted in moderate yields, aligning with the findings of Yule and Srinivasan (2013), although yields in Katahari were higher than those reported by Swathi et al. (2019) due to favorable conditions. Azadirachtin was the least effective, leading to the lowest yield among the treatments, consistent with the findings of Srinivasan et al. (2021). Control plots, as expected, produced the lowest yields due to the lack of pest management interventions.

5. Conclusion

LPB is one of the significant pests that reduces cowpea crop production yield and productivity. Insecticides have a far greater overall effectiveness and yield than bio-control agents and botanical pesticides. However, as advised in IPM tools, these pesticides should only be used as the final option for pest management and should be applied at the prescribed dose or less if possible. Particularly for sustainable cowpea agriculture, safer options such as the use of bio-control agents (*B. thrungiensis*) or botanical pesticides (azadiractin) should be promoted because they are safe to the environment and human health.

Compliance with Ethical Standards

Conflict of interest

The authors declare that they have no conflict of interest.

Authors' contributions

Vivek LAHUTIYA: Conceptualization, funding acquisition, investigation, Data curation,methodology. **Dipesh Kumar MEHATA:** Conceptualization, funding acquisition, investigation,methodology, resources, software, supervision,writing–review & editing, validation, visualization. **Akshita SINGH:** Data curation,methodology, Revision. **Bishnu YADAV:** Data curation,methodology. All authors have read and agreed to the published version of the manuscript.

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References

Aktar, S., Uddin, M., & Ahmed, K. (2020). Bioefficacy of certain novel insecticides and some bioinsecticides for managing bean pod borer, *Maruca Vitrata* Geyer. *Journal of Bangladesh Agricultural University, 18*(0), 1. https://doi.org/10.5455/jbau.96967

Anusha, C., Balikai, R. A., & Patil, R. H. (2014). Management of cowpea pests through newer and conventional insecticides. *International Journal of Agricultural and Statistical Sciences, 10*(1), 157–160.

Aryal, L. N., Regmi, R., Lohani, S., & Bhusal, Y. (2021). Efficacy of commercial insecticides for cowpea pod borer (*Maruca vitrata* F.) management in Pokhara, Nepal. *Journal of Agriculture and Natural Resources, 4*(1), 165–175. https://doi.org/10.3126/janr.v4i1.33250

Ashigar, M. A., & Umar, K. M. (2016). Annals of experimental biology biology of *Maruca vitrata* (Lepidoptera: Crambidae), a serous pest of cowpea and other legume crops : A review. *Annals of Experimental Biology, 4*(2), 33–37.

Ba, N. M., Huesing, J. E., Dabiré-Binso, C. L., Tamò, M., Pittendrigh, B. R., & Murdock, L. L. (2019). The legume pod borer, *Maruca vitrata* Fabricius (Lepidoptera: Crambidae), an important insect pest of cowpea: a review emphasizing West Africa. *International Journal of Tropical Insect Science, 39*(2), 93–106. https://doi.org/10.1007/s42690-019-00024-7

Dannon, E. A., Tamò, M., van Huis, A., & Dicke, M. (2012). Assessing non-target effects and host feeding of the exotic parasitoid *Apanteles taragamae*, a potential biological control agent of the cowpea pod borer *Maruca vitrata*. BioControl, 57(3), 415–425. https://doi.org/10.1007/s10526-011-9415-1

Dunn, L., Latty, T., Van Ogtrop, F. F., & Tan, D. K. Y. (2023). Cambodian rice farmers' knowledge, attitudes, and practices (KAPs) regarding insect pest management and pesticide use. *International Journal of Agricultural Sustainability, 21*(1). https://doi.org/10.1080/14735903.2023.2178804

Ekesi, S. (1999). Insecticide resistance in field populations of the legume pod-borer, *Maruca vitrata* Fabricius (Lepidoptera: Pyralidae), on cowpea, Vigna unguiculata (L.), Walp in Nigeria. *International Journal of Pest Management, 45*(1), 57–59. https://doi.org/10.1080/096708799228058

Indiati, S. W., Hapsari, R. T., Prayogo, Y., Sholihin, Sundari, T., & Mejaya, M. J. (2021). Resistance level of mung bean genotypes to pod borer *Maruca testulalis* Geyer. *Legume Research, 44*(5), 602–607. https://doi.org/10.18805/LR-590

Kendra, K. V. (2020). Ecofriendly Pest Management Approach in Pulse Crops. July. https://doi.org/10.13140/RG.2.2.21497.08807

Kumar, D. (2005). Production Technology for Cowpea Not to Be Issued. 003.

Owade, J. O., Abong', G., Okoth, M., & Mwang'ombe, A. W. (2020). A review of the contribution of cowpea leaves to food and nutrition security in East Africa. *Food Science and Nutrition, 8*(1), 36–47. https://doi.org/10.1002/fsn3.1337

Pandit, T. R., & Dwivedi, S. A. (2021). A study on biology and management of spotted pod borer, *Maruca vitrata* (Geyer) in legumes. *Biological Forum-An International Journal, 13*(2), 220.

Pant, C., Regmi, R., Bhusal, S., Yadav, S., Tiwari, S., Wagle, P., & Bhandari, M. (2021). Efficacy of commercial insecticide for the management of cowpea pod borer (*Maruca vitrata*) on cowpea (*Vigna unguiculata* (L.) Walp) under field condition in Chitwan, Nepal. *Food & Agribusiness Management, 2*(2), 92–95. https://doi.org/10.26480/fabm.02.2021.92.95

Patel, S., & Yadav, S. K. (2017). Short communication two parasitoid associated with legume pod borer (*Maruca vitrata* F.) on pigeon pea (*Cajanus cajan* L . Millsp.) at Pantnagar. *SKUAST Journal of Research, 19*(2), 261–264.

Periasamy, M., Schafleitner, R., Muthukalingan, K., & Ramasamy, S. (2015). Phylogeographical structure in mitochondrial DNA of legume pod borer (*Maruca vitrata*) population in tropical Asia and sub-Saharan Africa. *PLoS ONE, 10*(4), 1-24. https://doi.org/10.1371/journal.pone.0124057

Preethi, S., Ragumoorthi, K. N., Vinothkumar, B., Balasubramani, V., & Kumaresan, D. (2022). Development and validation of integrated pest management modules against spotted pod borer *Maruca vitrata* Fabricius on garden bean *Lablab purpureus* var. *typicus* (L.). *Journal of Applied and Natural Science, 14*(4), 1308–1319. https://doi.org/10.31018/jans.v14i4.3905

Priyadarshini, G., Reddy, N., & Reddy, J. (2013). Bioefficacy of selective insecticides against lepidopteran pod borers in pigeonpea. *Indian Journal of Plant Protection, 41*(1), 6–10.

Rahman, M. M., Dash, C. K., Rahman, M. M., Hasan, M. M., Hannan, A., Dev, S., & Mondal, M. F. (2022). Farmers' perceptions and knowledge of country bean (*Lablab purpureus* l.) insect pests, and diseases, and their management practices, in Bangladesh. *Sustainability, 14*(20), 1–19. https://doi.org/10.3390/su142013591

Sharma, H. C., & Franzmann, B. A. (2000). Biology of the legume pod borer, *Maruca vjtrata* (fabricius) and its damage to pigeonpea and adzuki bean. *Insect Science and Its Application, 20*(2), 99–108. https://doi.org/10.1017/s1742758400018737

Singh, B. K., Pandey, R., Singh, A. K., Mishra, M. K., Singh, S. K., & Gupta, R. P. (2020). Field efficacy of new generation insecticides for the management of spotted pod borer, *Maruca vitrata* (Fab.) in cowpea. *International Journal of Plant Protection, 13*(1), 36–39. https://doi.org/10.15740/has/ijpp/13.1/36-39

Srinivasan, R., Tamò, M., & Malini, P. (2021). Emergence of *Maruca vitrata* as a major pest of food legumes and evolution of management practices in Asia and Africa. *Annual Review of Entomology, 66*, 141–161. https://doi.org/10.1146/annurev-ento-021220-084539

Sujayanand, G. K., Datta, D., & Chandra, A. (2023). Assessing pigeonpea genotypes for resistance against Maruca vitrata fabricius and its sustainable management through biorationals. Legume Research- An International Journal, August. https://doi.org/10.18805/LR-5132

Swathi, K., Ramu, P. S., Dhurua, S., & Suresh, M. (2019). Field evaluation of newer insecticides against spotted pod borer [*Maruca vitrata* (Geyer)], on blackgram (*Vigna mungo* L.) in North Coastal Andhra Pradesh. International Research Journal of Pure and Applied Chemistry, *18*(2), 1–9. https://doi.org/10.9734/irjpac/2019/v18i230083

Toper Kaygin, A., & Tasdeler, C. (2019). Geographic distribution, lifecycle and damage of *Cydalima perspectalis* (Walker) (Lepidoptera: Crambidae, Spilomelinae) in Turkey. *Journal of Bartin Faculty of Forestry, 21*(3), 833–847. https://doi.org/10.24011/barofd.578294

Yadav, N. K., & Singh, P. S. (2014). Bio-efficacy of chemical Insecticides against spotted pod borer, *Maruca testulalis* (Geyer) on Cowpea. *International Journal of Agriculture, Environment and Biotechnology, 7*(1), 187. https://doi.org/10.5958/j.2230-732x.7.1.025

Yule, S., & Srinivasan, R. (2013). Evaluation of bio-Insecticides against legume pod borer, *Maruca vitrata* Fabricius (Lepidoptera: Pyralidae), in laboratory and field conditions in Thailand. *Journal of Asia-Pacific Entomology, 16*(4), 357–360. https://doi.org/10.1016/j.aspen.2013.05.001

Yule, S., & Srinivasan, R. (2014). Combining bio-Insecticides with chemical Insecticides to manage legume pod borer (*Maruca vitrata*) on yard-long bean in Thailand. *International Journal of Pest Management, 60*(1), 67–72. https://doi.org/10.1080/09670874.2014.900707