Research article

FIELD EFFICACY OF NEWER INSECTICIDES AGAINST BRINJAL SHOOT AND FRUIT BORER (*Leucinodes orbonalis* Guenee*)* IN PAKLIHAWA RUPANDEHI, NEPAL

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ABSTRACT

Research was conducted to assess the field efficacy of newer insecticides against the Brinjal Shoot Fruit (*Leucinodes orbonalis* Guenee) at IAAS, Paklihawa, Rupandehi, Nepal. *L. orbonalis* is one of the most obnoxious pests which cause significant levels of damage by boring inside the shoot's petioles and fruits. Seven treatments including the control were replicated three times in a Randomized Complete Block Design (RCBD). The Pusa Purple Long (PPL) variety was employed and the treatments used were i) Spinosad 45%SC (0.33ml/L water) ii) Emamectin benzoate 5.7%WDG (0.33gm/L water) (iii) Chlorantraniliprole 18.5%SC (0.5ml/l water) iv) Spinetoram 11.7SC (0.5ml/L water) v) Imidacloprid 20%SL (1ml/L water) vi) Cypermethrin 10%EC (2.5ml/L water) vii) Control (pure water). Treatments were sprayed four times: at 32 Days after Transplanting (DAT), 47 DAT. 62 DAT and 77 DAT. All treatments were found superior to the control. The result revealed that the lowest percentage of infested shoots was 12.67% at 14 days after the first treatment and that of infested fruits was 16.67%, 4.50%, 23.32%, and 5.42% at 14 days after 1st, 2nd, 3rd, and 4th treatment respectively. The marketable yield of plots treated with Spinetoram was the highest i.e.10.42 t/ha followed by Spinosad (8.02t/ha) and Chlorantraniliprole (7.7t/ha) and that of control plots was 4.43t/ha. Furthermore, we found that the Benefit-Cost (BC) ratio of brinjal fruit was the highest under the treatment of Spinetoram followed by Spinosad. Based on our findings, we concluded that Spinetoram was the most effective treatment for the management of *L. orbonalis* while Spinosad and Chlorantraniliprole identified to be the best alternatives. Hence, Spinetoram can be incorporated as an effective tool for Integrated Pest Management (IPM.)

KEYWORDS

Spinetoram, Management, Treatment, Pest, Spinosad

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Introduction

Brinjal is one of the most significant vegetables in South and Southeast Asia (Yousafi et al., 2015), where hot and humid weather is predominant (Hanson et al., 2006). In the major part of Nepal, it is the second-most-grown vegetable in the Solanaceae family, after the tomato, except in very high altitudes (Singh and Bhandari, 2015). It is a non-woody annual plant that reaches a maximum height of 120 cm and has purple to white flowers, big lobed leaves, and bushy foliage(Naeem & Ugur, 2019). It is an adaptable crop that may be produced in both the winter in the Terai region and the summer in mid-hills to high hills (Kassim, 2013). Therefore, it holds great importance as a vegetable crop in Nepal's Terai and Mid-hill regions as it can grow in a variety of soil types and can be grown all year round (Gautam et al., 2019). Despite being a perennial, it is produced as an annual crop in commerce (Kassim, 2013).

In the context of Nepal, the production of eggplant is poor. The lack of cultivars with the necessary field tolerance for numerous pests and diseases is the primary cause of the low yield (Kassim, 2013). According to the fiscal year 2020/2021, the area of production for brinjal is 11,292 ha with production and yield of 149,075 mt and 13.20 mt/ha respectively. Brinjal plant is attacked by about 140 species of insects during its growth (Sharma & Tayde, 2017), several insects, including Fruit and Shoot Borers, White Flies, Leafhoppers, Thrips, Mites, Leaf Rollers, Red Spider Mite, etc., that are responsible for Brinjal loss (Gautam et al., 2019). *Leucinoides orbonalis* is the most harmful of them and the main barrier to both a large-scale and high-quality brinjal crop (Atwal & Dhaliwal, 2002). It damages the crop by 95.8% during the wet season (Abrol & Singh, 2003). Since the insect larvae hide inside the plant tissue, it is challenging to control (Saimandir & Gopal, 2012). The larval phase harms the edible fruit the most (M. S. Rahman et al., 2002). The larvae of *L. orbonalis* hatch from eggs laid on leaves and proceed into the fruits (Saimandir & Gopal,

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2012)and flower buds causing immediate yield losses by making the fruits unfit for consumption and marketing (DWIVEDI et al., 2014). As its larvae penetrate the petiole and midrib of the leaves as well as young shoots it results in dead hearts (Abrol & Singh, 2003). It also results in an 80% fall in vitamin C content and a loss of yield (Gautam et al., 2019) that may reach up to 85 to 90 percent (Misra, 2008). In the early stages, the larva bore into tender shoots, causing drooping shoots that are evident in the infested fields, caterpillars later consume fruit buds and flower buds (DWIVEDI et al., 2014). This pest is a major concern because of its rapid reproductive capacity, rapid generational turnover, and widespread cultivation of brinjal in both the wet and dry seasons (Sharma & Tayde, 2017).

Various strategies have been used to control the Borer. Among those various strategies, the application of pesticides is the first line of defense against insect pests(M. W. Rahman et al., 2019). It is the most commonly practiced method in Nepal to control BSFB (Gautam et al., 2019). Chemical pesticides used often and carelessly against BSFB caused a variety of issues, including resistance growth, revival, secondary pest outbreaks, destruction of natural enemies, etc. (Mehrotra,1990). To manage this insect, the traditional pesticides organophosphates, synthetic pyrethroids, and carbamates are typically used (Chandan et al., 2019). The development of significant levels of pesticide resistance to several common insecticides in L. orbonalis is a result of the intensive usage of chemicals (Latif et al., 2010). However, to manage L. orbonalis, produce blemish-free brinjal fruit, and achieve maximum production, farmers solely rely on the application of pesticides (Misra, 2008). This study will evaluate the efficacy of different newer pesticides to select the new promising pesticides that will have less damage to non-targeted organisms and to find the best practice if pesticides have to be applied for the management of the borer. Due to the year-round availability of brinjal produce, this crop is severely harmed by insect and pest damage.

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In various parts of the world, brinjal is attacked by 142 species of insect pests, four species of mites, and three species of nematodes (Prempong and Bauhim 1977). One of the most destructive pests, *Leucinodes orbonalis Guenee* (Lepidoptera, Crambidae), is a key barrier to good brinjal cultivation (Khanal *et al*., 2021). It harms eggplant at every stage of its life, reducing the crop's output (Kalawate and Dethe, 2012). One larva eats between four and six fruits throughout its larval development (Bhadauria *et al*., 2022). Because of its rapid generational turnover and prolific reproductive potential, L. orbonalis drastically reduces brinjal yield (Sharma and Tayde, 2017). It reduces the yields by between 70% and 92% (Mall *et al*., 1992). Synthetic pesticides are the primary method used by farmers to control pests (Mainali*et al*., 2014). According to some research, farmers heavily rely on pesticides to control the pests linked with brinjal (Shetty, 2004). Although insecticidal treatment is one of the major methods used to combat fruit borer infestations, many pesticides that are used are ineffective in providing appropriate pest management (Pratap Singh *et al*., 2018). Nowadays farmers are getting discouraged from growing brinjal due to the significant decrease in productivity and quality of the crop caused by illnesses, insects, and other pests (Mainali et al., 2014)). Thus, *L. orbonalis* is a serious pest for the cultivation of brinjal and farmers have had little success controlling it with conventional pesticides. Synthetic chemical insecticides outperform all other methods of controlling *L. orbonalis* (Duara*et al*., 2003). The new generation of pesticide molecules is said to be more effective while also being safer for non-target organisms (Tohnishi*et al*., 2005). Research must be done to ensure adequate pesticide selection since improper pesticide selection increases pest populations, which encourages the illogical and careless use of insecticides and harms the environment (Paneru *et al*., 2020). So, this study was done to evaluate the efficiency of different newer pesticides to select the new promising pesticides and to find the best practice for pesticides to be applied for the management of the borer.

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Methodology

Site selection

The research was conducted on a horticultural farm situated in Institute of Agriculture and Animal Science which lies 27 30’ latitude and 83 27’E from Bhairahawa. The reason behind the selection of this site for research is a large number of farmers are involved in brinjal cultivation for their livelihood in this district. The agro-ecological condition of this area also favors the production of brinjal.

Materials and design of experiment

For the experiment, a Randomized Completely Block Design (RCBD) model was used. There were seven treatments, each replicated three times. The entire experiment field measured was 29m×13m. It contained 21 experimental plots, each measuring 3m×3m. The distance between the inter-plot and inter-block was kept at 1m.The plant was placed at 60m×60m spacing with 25 plants in each plot. Five sample plants were selected from each plot.

Table 1. Number of treatment application

S.N.	Treatment application	Date
1	1st spray	2022/6/5
2	2nd spray	2022/6/20
3	3rd spray	2022/7/5
4	4th spray	2022/7/20

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Table 2. Treatment details with trade name, generic name and recommended dose			
Notation	Trade name	Generic name	Recommended Dose
T1	Tracer	Spinosad 45% SC	0.33 ml/L Water
T2	Top Killer	Emamectin Benzoate 5.7% WDG	0.33gm/L Water
T3	Allcora	Chlorantraniliprole 18.5% SC	0.5 ml/L Water
T4	Delegate	Spinetoram 11.7% SC	0.5ml/L Water
T5	Tamasa	Imidacloprid 20% SL	1 ml/L Water
T6	Ki-cyper	Cypermethrin 10% EC	2.5 ml/L Water

Cultural Practices

Planting material

The early maturing variety of brinjal i.e. Purple Purple long was selected for experiment. The seed of this variety was collected from certified agro-vet.

Bed and seedling preparation

The nursery bed was prepared by mixing 2-2.5 kg of rotten cow dung manure. The length and width of the beds were 2 meters and 1 meter respectively & nursery beds were made 10-15 cm high from the ground. To prevent damping off, drenching of beds was done by Bavistin (2gm/l). The seeds were sown in the seedbed at in April 12, 2022, with a depth of 1-1.5cm in rows at the distance of 10 cm. The beds were lightly irrigated regularly in the morning and evening to ensure proper growth and development of the seedlings.

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Land Preparation

The land was plowed with a tractor-drawn cultivator. All weeds, stubbles, and residues were removed using a rake. Then a good tilth field was made. The experimental field was divided into plots raising them to a certain height from the soil surface following the design of the experiment. Water drains were made around every plot. Well-decomposed FYM was mixed into the soil weighing 36 kg per plot. At the time of final land preparation, a split dose of nitrogen and a full dose of phosphorus and potassium were applied.

Transplanting

The transplantation of seedlings was done on May 6, 2022, into a depth of certain centimeters in the evening. The distance of 60cm row to row and 60 cm plant to plant was maintained in each plot. Then after transplantation, mulching and watering were done.

Manure and fertilizers

The required nitrogen, phosphorus, and potassium were applied in the form of urea, DAP, and MOP respectively. For organic manure sources, well-decomposed FYM was used. The recommended dose of NPK used for Brinjal cultivation is 200:180:80 kg/ha and FYM was 20 mt/ha. Urea as a basal dose and a complete dose of Diammonium Phosphate (DAP) and Muriate of Potash (MOP) were applied after final field preparation. Another split of urea was applied after 30 and 45 days of transplanting as top dressing.

Weeding and intercultural practices

Weeding and hoeing were done after a month of transplantation for the proper growth and development of the plant followed by earthing up. The hoeing was repeated as per the requirement and irrigation was done at the regular interval.

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Harvest

Brinjal were harvested when they have developed a good colour and marketable size. Basically, they were harvested when they were quite immature and have not lost culinary qualities. Tenderness bright colour and glossy appearance of fruit was taken as optimum stage of harvesting of fruits. Six harvests were done as the fruits were ready to harvest.

Table 3. Number and date of harvest

Harvest	Date of harvest
1st Harvest	2022/6/27
2nd Harvest	2022/6/30
3rd Harvest	2022/7/5
4th Harvest	2022/7/12
5th Harvest	2022/7/21
6th Harvest	2022/7/28

Data collection and statistical analysis

Observation parameters included infested and healthy shoots obtained from five sample plants from each plot, as well as each plant from each plot at 3, 7, 10, and 14 days following transplantation. When no contaminated shoots were found after a few treatments, the shoot data

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was not reported. Data on the number of healthy and damaged fruits were collected from each plot of each treatment three, seven, ten, and fourteen days after spray. In addition, the weight of healthy fruits in each harvest was measured in grams (gm) for economic analysis. Microsoft Excel 2017 was used to prepare the data entry analyzed using Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) utilizing data analysis tool R Studio 4.2.1 at a 5% level of probability to compare the significant difference.

Shoot infestation

The shoot infestation was calculated in percent using the following equation no. (1):

$$\text{Percent shoot infestation} = \frac{\text{No of infested shoots}}{\text{Total no of shoots}} \times 100 \qquad \text{…………….. Eq. (1)}$$

Fruit infestation

The following equation no. (2) was used for calculation:

$$\text{Percent fruit infestation} = \frac{\text{No of infested fruits}}{\text{Total no of fruits}} \times 100 \qquad \text{………………. Eq. (2)}$$

Benefit-cost ration (BCR)

The fruit were harvested when they were ready to harvest. Six harvests were done throughout the fruiting season. And at each harvest the data of weight of healthy fruits were recorded for each plot per treatment for the calculation of B/C ratio. B/C ratio was calculated using equation no. (3):

$$\text{Benefit-cost ratio (BCR)} = \frac{\text{Adjusted net return}}{\text{Total cost of production including plant protection cost}} \qquad \text{…………….. Eq. (3)}$$

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Results

Chemical methods in controlling have been the best alternative to overcome the hazardous effects of insects. The data on the effectiveness of different insecticides on shoots against *L. orbonalis* receiving foliar spray of insecticides at 3, 7, 10, and 14 days is presented in Figure 4. It is evident from the results that all the insecticides under investigation exhibited good efficacy over *L. orbonalis* larvae but amongst them, Spinetoram showed the comparatively lowest mean percentage of infestation followed by Emamectin benzoate, Spinosad, Chlorantraniliprole, Imidacloprid, and Cypermethrin. All the treatments were significantly superior to the control. The mean percentage of infestation of shoot was found to be 25.3%. The same kind of observation was made in 7 DAS, 10 DAS, and 14 DAS. Spinetoram excelled over other treatments with the lowest shoot infestation followed by Emamectin benzoate. Untreated plot recorded the highest shoot infestation.

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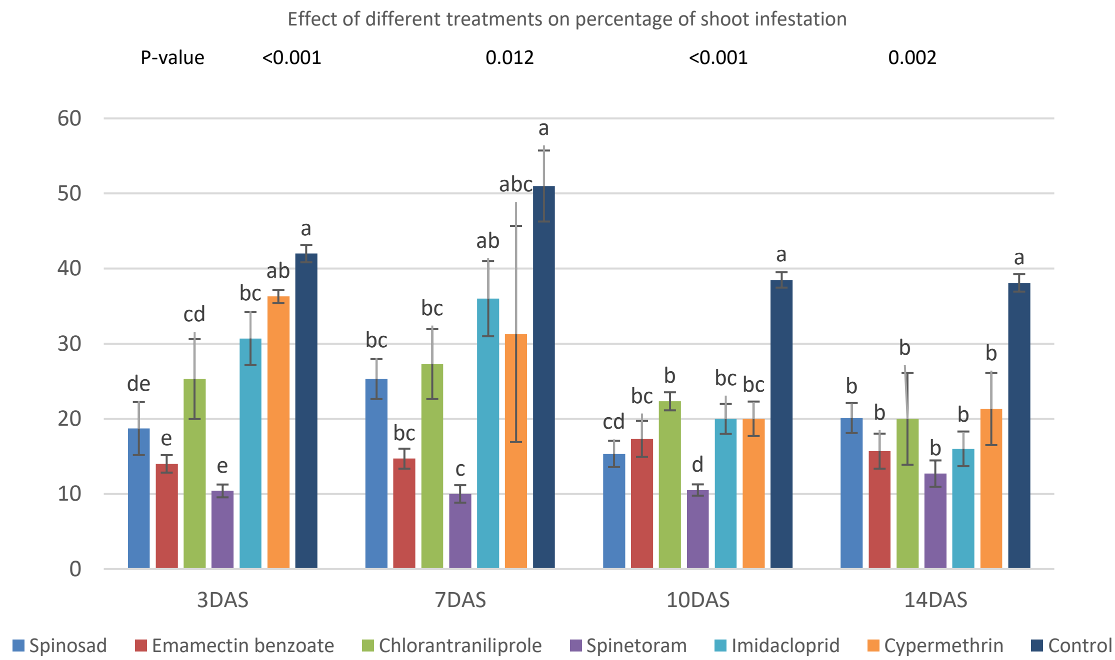

Fig 1. Effect of different treatments on percentage of shoot infestation after 3DAS, 7DAS, 10DAS and 14DAS.

In case of fruit infestation also, same kind of observation was made in 7 DAS, 10 DAS and 14 DAS. Spinetoram was above all other treatments. Untreated plot recorded highest fruit infestation.

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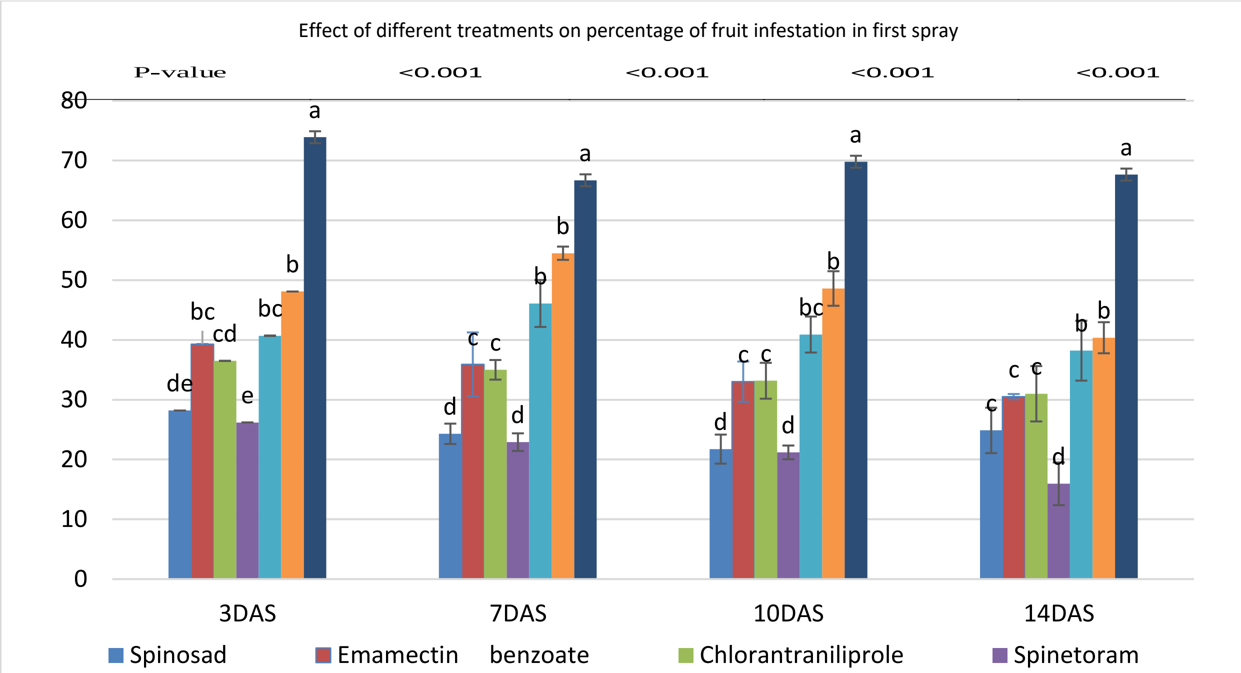

Fig 2. Effect of different treatments on percentage of fruit infestation in first spray.

Table 4. Effects of different treatments on percentage of fruit infestation in second spray

Treatment	3DAS	7DAS	10DAS	14DAS
Spinosad	$19.6^{bc}\pm1.73$	$17.1^{cd}\pm2.54$	$20^{cd}\pm5.71$	$7.6^{c}\pm3.20$
Emamectin benzoate	$20.8^{bc}\pm7.52$	$26.1^{bc}\pm2.62$	$25.4^{cd}\pm2.72$	$19.1^{b}\pm2.97$
Chlorantraniliprole	$25.6^{bc}\pm2.25$	$19.8^{cd}\pm4.64$	$20^{cd}\pm2.14$	$5^{c}\pm1.26$
Spinetoram	$16.4^{c}\pm1.93$	$15.6^{d}\pm1.58$	$14.7^{d}\pm2.71$	$4.5^{c}\pm0.90$
Imidachloprid	$28.7^{b}\pm1.53$	$29.4^{b}\pm3.57$	$31.4^{bc}\pm5.55$	$22.6^{b}\pm6.76$
Cypermethrin	$31.3^{b}\pm1.91$	$34.2^{b}\pm2.07$	$39.7^{ab}\pm5.16$	$20.7^{b}\pm2.97$
Control	$43.1^{a}\pm1.03$	$53^{a}\pm4.27$	$46.3^{a}\pm2.89$	$38.1^{a}\pm1.32$
Grand mean	26.5	27.9	28.2	16.8
LSD	10.76	8.85	11.9	10.33
CV%	3.6	11.3	12.3	12.5
P value	0.003	<0.001	<0.001	0.001

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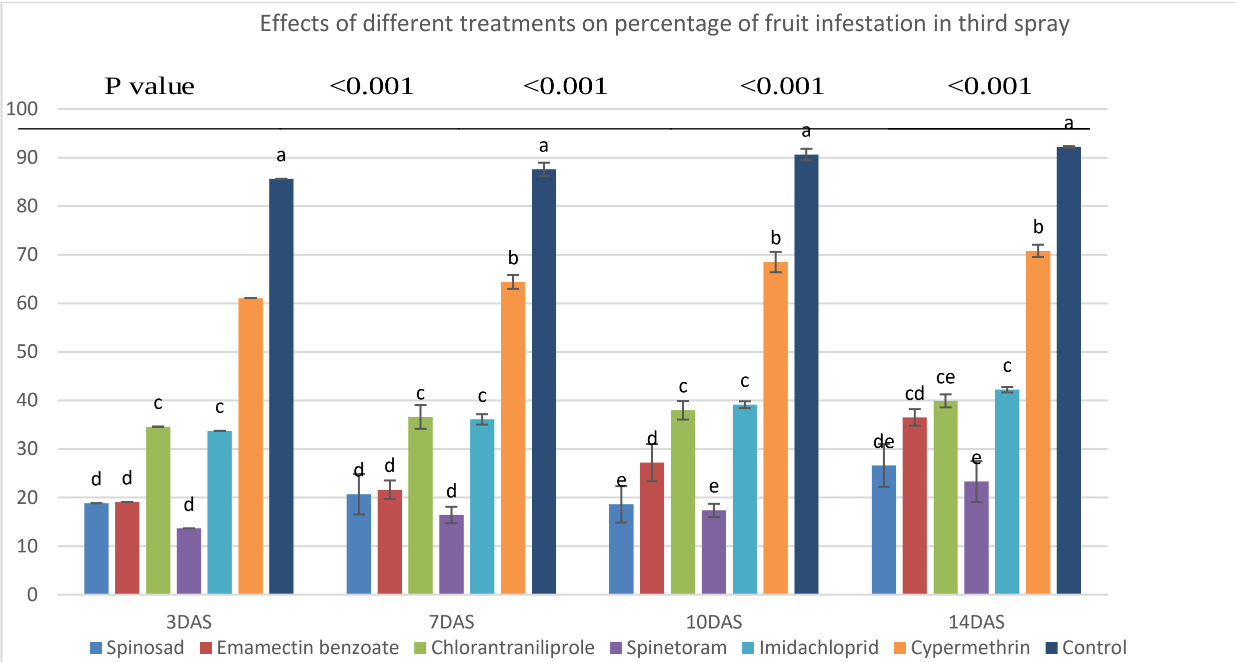

Fig 3. Effect of different treatments on percentage of fruit infestation in third spray.

Table 5. Effects of different treatments on percentage of fruit infestation in fourth spray

Treatment	3DAS	7DAS	10DAS	14DAS
Spinosad	13.1^{bc}±1.13	15.71^{bc}±1.56	20.5^{bc}±4.75	13.35^{cd}±0.879
Emamectin benzoate	11.2^{bc}±2.31	16.97^{bc}±1.8	13.8^{bcd}±2.55	16.12^{c}±1.87
Chlorantraniliprole	11.1^{bc}±0.898	11.89^{c}±1.5	10.9^{cd}±2.69	12.87^{cd}±3.87
Spinetoram	6.4^{c}±1.31	11.3^{c}±0.439	7.9^{d}±0.7	5.42^{d}±0.712
Imidachloprid	18.4^{b}±7.31	17.31^{bc}±3.95	22.7^{b}±3.67	20.83^{bc}±5.07
Cypermethrin	19.1^{b}±3.90	19.34^{b}±2.24	19.6^{bc}±5.44	28.55^{b}±0.97
Control	36.5^{a}±1.76	43.37^{a}±1.81	44.8^{a}±1.76	44^{a}±1.07
Grand mean	16.6	19.41	20	20.16
LSD	10.25	6.75	10.48	8.06
CV%	15.1	6	12.1	8.3

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P-value	<0.001	<0.001	<0.001	<0.001

The result actually is compared the mean percentage of infested fruit per sample plant at different DAS and the marketable yield harvested from tested plots. The maximum infestation was reported in fruits taken from control plots, whereas the least infestation was seen in fruits harvested from Spinetoram-treated plots, followed by Spinosad and Chlorantraniliprole. When compared to control plots, fruits harvested from plots treated with Spinetoram had the lowest damage percentage, followed by Spinosad. After three days of spraying, data revealed that control had the maximum infection, while Spinetoram and Spinosad had the lowest infestation rates both of which were significantly lower than Chlorantraniliprole and Emamectin benzoate then followed by Imidachloprid and Cypermethrin. Similarly, after 7 and 10 DAS highest infestation was recorded in control and the lowest in Spinetoram followed by Spinosad and Chlorantraniliprole which is significantly similar with Emamectin benzoate while significantly different from Imidachloprid and Cypermethrin. Similarly, after 14 DAS, infestation of fruit was reduced in all treatments.

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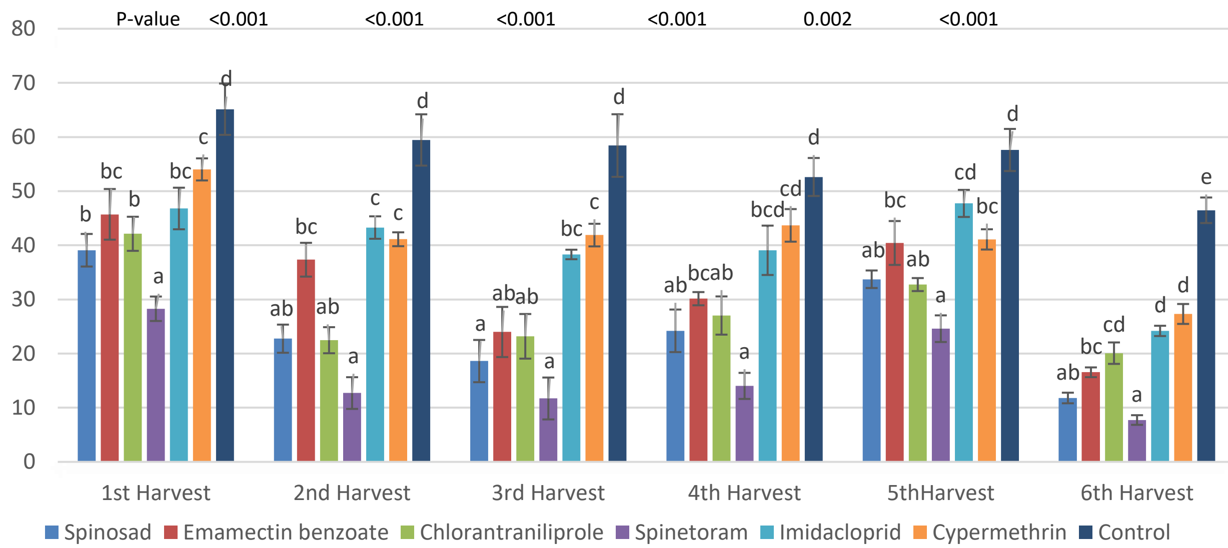

Fig 4. Effect of different treatments on percentage of fruit damage in 1st, 2nd, 3rd, 4th, 5th and 6th harvest.

Table 6. Effects of different treatments on total marketable yield and BC ratio of brinjal fruit.

Treatments	First harvest (kg/ha)	Second harvest (kg/ha)	Third harvest (kg/ha)	Fourth harvest (kg/ha)	Fifth harvest (kg/ha)	Sixth harvest (kg/ha)	Total marketable yield (t/ha)	Total benefit stream (NRS.)	Total cost stream (NRS.)	B/C ratio
Spinosad	954.89	1994.4	1957.78	1410.7	776.96	932.92	8.02	160400	93696	1.71
Emamectin Benzoate	641.02	918.51	879.25	1090.9	563.85	815.29	4.9	98000	79237	1.24
Chlorantraniliprole	1472.7	1952.1	1668.88	887.29	825.29	904.92	7.71	154200	92828	1.66
Spinetoram	1407.8	2298.3	3811.11	1338	780.07	785.22	10.42	208400	87912	2.37
Imidacloprid	738.55	1072.7	626.66	869.74	705.14	637.18	4.65	90000	77791	1.16

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Cypermethrin	695.22	492.85	1131.85	1173.3	648	433.37	4.57	91400	80393	1.14
Control	274.59	329.49	429.7	556.67	527.26	364.82	2.48	49650.6	73453	0.68

The effect of the treatments on brinjal yield is exhibited in Table. Total six harvests were done where Chlorantraniliprole was with the highest yield of 1472.7 t/ha in the first harvest followed by Spinetoram (1407.8t/ha) and Spinosad (954.89t/ha). Similar trend was seen in 2nd harvest as well. While in the 3rd harvest ,Spinetoram came out as the high yielding treatment with 3811.11 t/ha followed by Chlorantraniliprole and Spinosad. Later the yield was decreasing in all the treatment from 3rd harvest to 6th harvest which is represented in the table. In the sixth harvest, the highest yield obtained was found in Spinosad with 935.32 t/ha followed by Chlorantraniliprole (904.92t/ha), Emamectin Benzoate (815.29t/ha), Spinetoram (785.22t/ha), Imidacloprid (637.18t/ha) and Cypermethrin (433.37t/ha). The control was with the lowest yield in all the harvest with 533.85t/ha, 761.85t/ha, 613.7t/ha, 749.49t/ha, 749.48t/ha and 712.4 t/ha in 1st, 2nd, 3rd, 4th, 5th and 6th harvest respectively. From this we can say that the highest fruit damage was recorded in untreated control .In terms of B/C ratio, Spinetoram got the highest value followed by Spinosad and Chlorantraniliprole. Emamectin Benzoate, Imidacloprid and cypermethrin almost showed same result whereas control got the lowest value of 1.12 t/ha.

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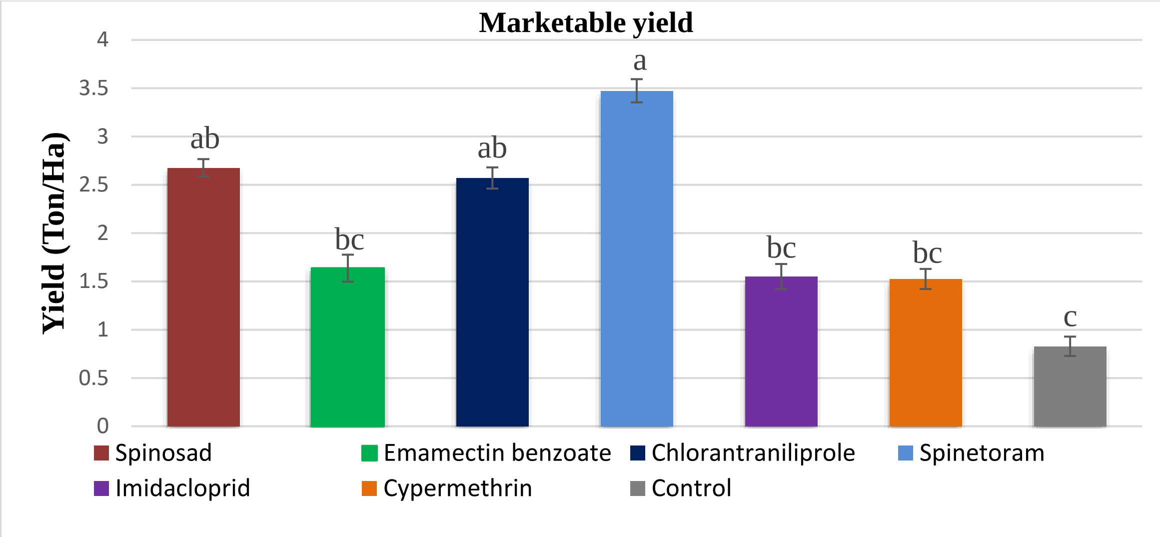

Fig 5. Effect of different treatments on marketable yield of brinjal fruit.

Discussion

Research initiatives, such as the one under consideration, can give farmers and pest managers crucial information regarding the costs and benefits of monitoring insect pests and the application of new insecticides. They serve as a basis for assessing the monetary implications of decisions and help with decision-making related to the production of vegetables. The present study contributes to the literature on Brinjal Shoot and Fruit Borer management by adding empirical evidence about the economic viability of monitoring insect pests. The study focused on quantifying the relative efficacy of these pesticides by analyzing the percentage of fruit infestation observed in damaged fruits and buds, as detailed in the results section.

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Notably, Spinetoram resulted to be the most effective, with the highest percentage of infested shoot reduction and fruit reduction (i.e. after the first, second, third, and fourth spray respectively at 14DAS). The results of (Bade et al., 2017) have been used to corroborate our findings, showing that Spinetoram 12 SC (0.01%) is the most effective treatment for reducing the prevalence of brinjal shoot and fruit borer. Also, according to the results of (Latif et al., 2018), among all the treatments, Spinetoram 120 SC (70 ml) had the greatest reduction of L. orbonalis or 85.60%. Spinetoram and Emamectin benzoate, according to Hanafy and EI-Sayed (2013), demonstrated the greatest reduction in *Helicoverpa armigera* infestation on tomatoes. Spinetoram had the highest acute toxicity against *H. armigera*, followed by indoxacarb, spinosad, and methomyl, which can be used to assess *H. armigera* susceptibility(da Silva et al., 2020).

Additionally, Spinetoram was successful as a grain protectant in the trial done by(Vassilakos et al., 2012), however, its performance varies depending on the target species, concentration, and exposure amount. Spinetoram 12 SC w/v, a novel class insecticide molecule discovered by Visnupriya and Muthukrishnan (2017), proved effective in eliminating third instar larvae of Brinjal Shoot and Fruit Borer The study conducted by (Sammani et al., 2020) concluded that both Spinosad and Spinetoram were effective at varied pesticide concentrations on larval mortality as well as the emergence of adults and progeny. Endosulfan + deltamethrin (0.07%, 0.0025%) and endosulfan + fenvalerate (0.07% + 0.005%) were found to be highly efficient against fruit borer (Abrol& Singh, 2003). However, their usage is forbidden due to the negative effects on the environment and human health. Spinetoram is a semi-synthetic Spinosyn (an analog of Spinosad) that is derived from biologically active substances (Spinosyns) produced by the soil actinomycete *Saccharopolyspora spinosa* (Shimokawatoko et al., 2012). Hence, this might be the reason that Spinetoram might be more effective.

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The trial of (Kumar Khare Krishi Vigyan Kendra et al., 2021) discovered that Spinosad-treated fields had a lower infestation and higher production than other treatments. This may be due to its high stability compared to other novel insecticides used(Huang et al., 2017). Spinosad 0.45 mL/L had the lowest shoot and fruit infestation and the maximum marketable fruit output (Sontakke et al., 2007). Likewise, Spinosad was found to be the most effective with lowest fecundity (19.3), hatchability (6.05%) and seed weight reduction (11.2%) (Jui & Jannat, 2020). This can be supported by the findings which suggest that the insecticidal efficacy of Spinosad is comparatively higher in lepidopterans than that observed for aphids and other insects (Sparks et al., 2021).

These comprehensive results and discussion offer valuable insights into the efficacy of eco-friendly pesticides in controlling Brinjal Fruit and Shoot Borer. We acknowledge that further empirical work is needed to prove whether the findings remain valid in other cases of monitoring of Brinjal Shoot and Fruit Borer.

Conclusion

The field experiment was carried out to know the best alternatives for the management of brinjal shoots and fruit borer (BSFB). *L. orbonalis* larvae feed inside leaves, stems, shoots, and fruits, making it a significant pest of *Solanum melongena* (eggplant) and is first ranked pest in South Asia. Although *L. orbonalis* is typically not recorded as a pest of crops other than *S. melongena*, larvae can also feed on a variety of other plants, primarily within the Solanaceae family. *L. orbonalis* has, however, recently become a pest of *Solanum tuberosum* in south-west India. Numerous studies have suggested that this insect may penetrate both protected and open fields, spread swiftly, and significantly harm agricultural productivity and quality. Different treatments were utilized in this study, and each one significantly differed from the control by 5%. Spinetoram, Chlorantraniliprole, Emamectin Benzoate, Imidacloprid, and Cypermethrin were found to be the

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most effective, with the highest percentage of infested shoot reduction (i.e. 12.7% after first spray at 14DAS) and fruit reduction (i.e. 15.94%, 4.5%, 23.3%, and 5.42% after first, second, third, and fourth spray respectively at 14DAS). The control, however, showed the highest levels of fruit and shoot infestation. Additionally, the highest total marketable yield of eggplant, 10.42 tons/ha, was produced in the Spinetoram-treated plots. We deduced from this investigation that Spinetoram was the most successful treatment, whereas Spinosad and Chlorantraniliprole were shown to be the best alternatives. Spinetoram can therefore be used as an efficient IPM tool along with Spinosad and Chlorantraniliprole. However, the increasing resistance of pests to existing insecticides, as well as concerns over their environmental impact, highlights the need for continued research and innovation in this field.

Declarations

Author contribution statement

Prakriti Paudel; Suvash Chaudhary: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Dipak Khanal: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

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Data will be made available on request.

Declaration of interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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