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Bio-efficacy of chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC and some sole insecticides against lepidopteran borers in cabbage

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ABSTRACT

The results of bio-efficacy revealed that the treatment, Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC 250mL ha^{-1} was found to be most effective treatment against P. xylostella and S. litura larvae in cabbage on the basis of collected 3,7 and 10 days after both spray during Rabi season of 2021-22. The overall mean larval population recorded after 1st and 2nd spray, treatment Chlorantraniliprole 10%+ Lambda-cyhalothrin 5% ZC 250mL ha^{-1} was most effective (0.61 larvae plant^{-1} and 0.57 larvae plant^{-1}, 0.81 larvae plant^{-1} and 0.71 larvae plant^{-1}, respectively) followed by Chlorantraniliprole 25g a.i. ha^{-1} (0.78 larvae plant^{-1} and 0.66 larvae plant^{-1}, 0.93 larvae plant^{-1} and 0.83 larvae plant^{-1}, respectively) against P. xylostella and S. litura. The treatment, Chlorantraniliprole 10%+ Lambda-cyhalothrin 5% ZC 250mL ha^{-1} (379.33 q ha^{-1}) also produced maximum yield followed by Chlorantraniliprole 25 g a.i. ha^{-1} (360 q ha^{-1}) and Flubendiamide 60g a.i. ha^{-1} (340 q ha^{-1}). The benefit: cost ratio of insecticides indicated that Chlorantraniliprole 10%+ Lambda-cyhalothrin 5% ZC 250mL ha^{-1} (35.09:1) is the most economic insecticide followed by Lambda-cyhalothrin 30g a.i. ha^{-1} (32.22:1). The least cost-effective insecticide was Spinosad 60g a.i. ha^{-1} (1.25:1) followed by Indoxacarb 60g a.i. ha^{-1} (3.07:1).

Keywords: Bio-efficacy, Cabbage, Insecticides, *Plutella xylostella*, *Spodoptera litura*

INTRODUCTION

Cabbage, *Brassica oleracea* var. *capitata* L. is an exotic leafy vegetable from Europe that belongs to the Brassicaceae family (FAO, 2000). Cabbage is a widely grown vegetable crop worldwide; it is one of the most popular food crops; and it grows well in many parts of the world (Legwaila *et al.*, 2014). After China, India is the world's largest producer of vegetables, accounting for approximately 3% of total area and 11.40% of total production. The cabbage fields occupy around 82000 hectares in India, producing 1260 million tons annually (NHB, 2018). Cabbage has tremendous promise in contemporary agriculture as a crop with a short growing season. The world's mild to cool regions are where it grows best (Cabbage, Encyclopedia Britannica, 2010), which is superior in terms of nutrition and capable of producing high-quality food per unit area and time. It is consumed raw as a salad, cooked as a vegetable, boiled, fermented (kimchi), dehydrated or used as pickles sandwiches and hamburgers (Abbey and Manso, 2004; Baidoo *et al.*, 2012). It is important in the diets in the countries, where vegetarianism is widespread (Borkakati *et al.*, 2019). In its raw state, cabbage has high nutritive value it contains in 100g are 93g water, 1.60g protein, 6.0g carbohydrates, 55mg calcium, 0.8mg iron, 0.30mg carotene, 0.06mg thiamine, 0.06mg riboflavin, 0.30mg niacin, 46mg vitamin C and 92kJ energy in a considerable amount (Bediako *et al.*, 2010). In India, poor cabbage yield has several reasons but focusing on the major cause is the loss caused by insect pests from the vegetative to maturity stage. In India, cabbage is damaged by approximately 35 insect pests. Due to cabbage's high nutritional value and succulent nature, it has attracted several insect pests which feed on it (Mochiah *et al.*, 2011). The insect pests associated with cabbage include the Diamondback moth, *Plutella xylostella*; Cabbage webworm, *Hellula undalis*; Cabbage looper, *Trichoplusia ni*; Cabbage aphid, *Brevicoryne brassicae*; Leaf Webber, *Crocidolomia binotalis*; Mustard aphid, *Lipaphis erysimi*; Green peach aphid, *Myzus persicae*; Tobacco Caterpillar, *Spodoptera litura*; Grasshopper, *Zonocerus variegatus*; Flea beetle, *Phyllotreta* spp.; and Whitefly, *Bemisia tabaci*. The *P. xylostella* in cabbage causes yield loss up to a range

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between 50 to 97 per cent transplanting to harvesting (Fenning *et al.*, 2014).

The use of insecticides by cabbage growers has helped them attain a high output. The excessive use of broad-spectrum pesticides by Indian farmers for pest management not only raises the cost of production but also damages natural enemies and pollutes the environment through harmful residue. Because of the over-reliance on chemical control, which has resulted in the development of resistance, every new pesticide is expected to have a maximum potential effectiveness of only two to three years. In many instances, insecticides progressively lose their efficacy, which results in the target pests not being effectively controlled and forcing the development of more insecticides to combat against lepidopteran pests' resistance. Keeping the aforesaid facts, the current research was carried out to test the bio-efficacy of Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC and some sole insecticides against lepidopteran borers in Cabbage.

MATERIALS AND METHODS

The evaluation of bio-efficacy of some selected insecticides against lepidopteran borers was conducted at Students' Instructional Farm (SIF), Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.).The bio-efficacy of some insecticides *viz*., Emamectin benzoate 12g a.i. ha^{-1} (T_1), Indoxacarb 60g a.i. ha^{-1} (T_2), Chlorantraniliprole 25g a.i. ha^{-1} (T_3), Flubendiamide 60g a.i. ha^{-1} (T_4), Lambda-cyhalothrin 30g a.i. ha^{-1} (T_5), Chlorantraniliprole 10%+ Lambda-cyhalothrin 5% ZC 250mL ha^{-1} (T_6), Spinosad 60g a.i. ha^{-1} (T_7) and Control (T_8) was tested. The unit plot size was kept at 5×5 m^2 with a 0.5m field border line to line spacing kept at 45cm and plant to plant spacing kept at 30cm. The experiment was laid out in Randomized Block Design (RBD) with 3 replications. The observations on the Lepidopteran larval population (*Spodoptera litura* and *Plutella xylostella*) were taken on larvae per plant. The population dynamics of *S. litura* and *P. xylostella* on cabbage was recorded from 5 randomly selected plants at weekly intervals. The population was counted a day before the spray and again afterward 3rd, 7th and 10th day after each spraying in each treatment. In each treatment, the head yield was noted separately and then converted into yield for each treatment on a quintal per hectare basis. The net profit was calculated based on the current market price of produce, the cost of insecticides, the cost of labours, and the cost of other inputs. The benefit-cost Ratio for each treatment was calculated using the additional return over control in rupees and the cost of insecticide spray in each treatment.

RESULTS AND DISCUSSION

The field experiment was conducted to investigate the bio-efficacy of various insecticides against *P. xylostella* (Table 1 & Fig. 1). The incidence was recorded a day before the first spray and distributed consistently throughout the experiment and ranged from 6.40-6.67 larvae $plant^{-1}$. The overall mean population of *P. xylostella* was recorded at 3, 7 and 10 DAS after the first spray, the least larval incidence was seen in treatment Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC 250mL ha^{-1} (0.81 larvae $plant^{-1}$) followed by the treatment Chlorantraniliprole 25g a.i. ha^{-1} (0.93 larvae $plant^{-1}$) and the highest larval incidence was noticed in treatment Lambda-cyhalothrin 30g a.i./ha, (1.91 larvae $plant^{-1}$) followed by treatment Indoxacarb 60g a.i. ha^{-1} (1.66 larvae $plant^{-1}$). However, all of the treatments outperformed the control (7.06 larvae $plant^{-1}$).

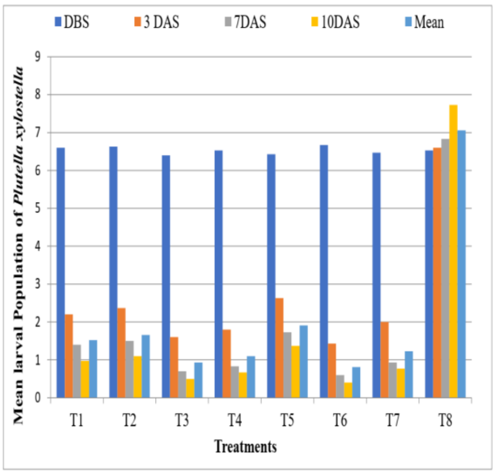
The incidence was noted a day before the second spray throughout the experiment and ranged between 6.13-10.10 larvae $plant^{-1}$. The overall mean data of *P. xylostella* population at 3, 7 and 10 DAS, lowest incidence was found in treatment Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC 250mL ha^{-1} (0.71 larvae $plant^{-1}$ followed by the treatment Chlorantraniliprole 25 g a.i. ha^{-1} (0.81 larvae $plant^{-1}$), and maximum population was noted in treatment Lambda-cyhalothrin 30g a.i. ha^{-1} (1.79 larvae $plant^{-1}$) followed by treatment Indoxacarb 60g a.i. ha^{-1} (1.58 larvae $plant^{-1}$). However, all the treatments were significantly superior to the control (9.63 larvae $plant^{-1}$). Combination insecticides surpass sole insecticides in efficacy due to their multifaceted approach to pest control. By blending active ingredients with complementary modes of action, combination insecticides often exhibit synergistic effects, effectively targeting

Table 1: Bio-efficacy of some selected insecticides against *Plutella xylostella* in cabbage during *Rabi* 2021-22

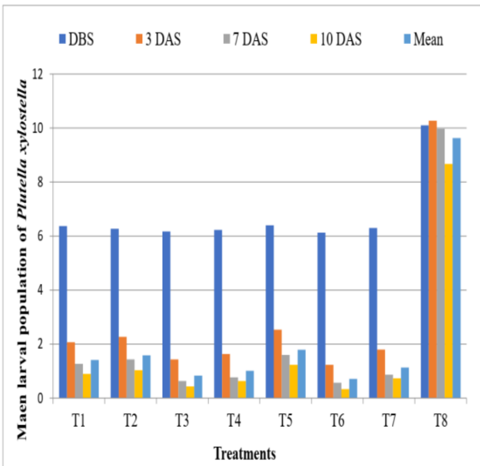
Tr. No.	Treatments	Dose ha^{-1}	*Mean larval population of *P. xylostella* plant^{-1} First Spray DBS	First Spray 3 DAS	First Spray 7 DAS	First Spray 10 DAS	First Spray Mean	Second Spray DBS	Second Spray 3 DAS	Second Spray 7 DAS	Second Spray 10 DAS	Second Spray Mean
T_1	Emamectin benzoate	12g a.i.	6.60 (2.66)	2.20 (1.64)	1.40 (1.38)	0.97 (1.21)	1.52 (1.42)	6.37 (2.62)	2.07 (1.60)	1.27 (1.33)	0.90 (1.18)	1.41 (1.38)
T_2	Indoxacarb	60g a.i.	6.63 (2.67)	2.37 (1.69)	1.50 (1.41)	1.10 (1.26)	1.66 (1.47)	6.27 (2.60)	2.27 (1.66)	1.43 (1.39)	1.03 (1.24)	1.58 (1.44)
T_3	Chlorantraniliprole	25g a.i.	6.40 (2.63)	1.60 (1.45)	0.70 (1.10)	0.50 (1.00)	0.93 (1.20)	6.17 (2.58)	1.43 (1.39)	0.63 (1.06)	0.43 (0.97)	0.83 (1.15)
T_4	Flubendiamide	60g a.i.	6.53 (2.65)	1.80 (1.52)	0.83 (1.15)	0.67 (1.08)	1.10 (1.26)	6.23 (2.59)	1.63 (1.46)	0.77 (1.13)	0.63 (1.06)	1.01 (1.23)
T_5	Lambda-cyhalothrin	30g a.i.	6.43 (2.63)	2.63 (1.77)	1.73 (1.49)	1.37 (1.37)	1.91 (1.55)	6.40 (2.63)	2.53 (1.74)	1.60 (1.45)	1.23 (1.32)	1.79 (1.51)
T_6	Chlorantraniliprole10%+ Lambda-cyhalothrin5%ZC	250mL	6.67 (2.68)	1.43 (1.39)	0.60 (1.05)	0.40 (0.95)	0.81 (0.95)	6.13 (2.58)	1.23 (1.32)	0.57 (1.03)	0.33 (0.91)	0.71 (1.10)
T_7	Spinosad	60g a.i.	6.47 (2.64)	2.00 (1.58)	0.93 (1.20)	0.77 (1.32)	1.23 (1.32)	6.30 (2.61)	1.80 (1.52)	0.87 (1.17)	0.73 (1.11)	1.13 (1.28)
T_8	Control	-	6.53 (2.65)	6.60 (2.66)	6.83 (2.71)	7.73 (2.75)	7.06 (2.75)	10.10 (3.26)	10.27 (3.28)	9.97 (3.24)	8.67 (3.03)	9.63 (3.18)
	S.Em.±		-	(0.05)	(0.06)	(0.07)	(0.07)	(0.01)	(0.06)	(0.07)	(0.08)	(0.03)
	CD @ 5%		(NS)	(0.16)	(0.17)	(0.22)	(0.20)	(0.04)	(0.18)	(0.21)	(0.23)	(0.09)

Figures in the parenthesis are $\sqrt{x+0.5}$ *transformed values, NS= Non-significant, DBS= A Day before spray, DAS= Days after spray, *Mean of three replications*

pests at various life stages and with diverse feeding habits. This comprehensive strategy not only delays the development of resistance but also broadens the spectrum of activity, providing more thorough pest control. Additionally, combination insecticides enable farmers to minimize pesticide residues and reduce environmental impact while optimizing cost-effectiveness through fewer applications. Their ability to address a wider range of pests with a single treatment underscores their importance in integrated pest management strategies and sustainable agricultural practices. These findings are strongly supported by Kumar (2021) who found that the Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC 250 mL ha^{-1} was recorded as the most effective against management of Tomato fruit borer. The results are also agreed upon Sen *et al.* (2017) found that Ampligo 150 ZC (Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% ZC) 35g a.i. ha^{-1} was the most effective treatment against shoot and fruit borer of Brinjal with the lowest percentage of shoot (1.26%) and fruit (2.49%) infestation. Reddy and Hampaiah (2018) evaluated different insecticide mixtures against the spotted pod borer, *Maruca vitrata* and found that Lambda-cyhalothrin 4.6 % + Chlorantraniliprole 9.3 % ZC @ 0.50 mL L^{-1} was most effective treatment.



First Spray



Second Spray

Fig. 1: Bio-efficacy of some selected insecticides against *P. xylostella* in cabbage during *Rabi* 2021-22

Table 2: Bio-efficacy of some selected insecticides against *Spodoptera litura* in cabbage during *Rabi* 2021-22

Tr. No.	Treatments	Dose ha^{-1}	*Mean larval population of *S. litura* plant^{-1}										Marketable yield of cabbage heads (q/ha)
			First Spray					Second Spray					
			DBS	3 DAS	7 DAS	10 DAS	Mean	DBS	3 DAS	7 DAS	10 DAS	Mean	
T_1	Emamectin benzoate	12g a.i.	4.67 (2.27)	1.80 (1.52)	0.97 (1.21)	0.70 (1.10)	1.16 (1.29)	4.60 (2.26)	1.70 (1.48)	0.83 (1.15)	0.57 (1.03)	1.03 (1.24)	300.00
T_2	Indoxacarb	60g a.i.	4.53 (2.24)	2.03 (1.59)	1.13 (1.28)	0.77 (1.13)	1.31 (1.35)	4.53 (2.24)	2.00 (1.58)	1.00 (1.22)	0.67 (1.08)	1.22 (1.31)	280.00
T_3	Chlorantraniliprole	25g a.i.	4.63 (2.27)	1.33 (1.35)	0.60 (1.05)	0.40 (0.95)	0.78 (1.13)	4.23 (2.18)	1.20 (1.30)	0.47 (0.98)	0.30 (0.89)	0.66 (1.07)	360.00
T_4	Flubendiamide	60g a.i.	4.43 (2.22)	1.50 (1.41)	0.73 (1.11)	0.53 (1.02)	0.92 (1.19)	4.40 (2.21)	1.43 (1.39)	0.60 (1.05)	0.40 (0.95)	0.81 (1.15)	340.00
T_5	Lambda-cyhalothrin	30g a.i.	4.60 (2.26)	2.23 (1.65)	1.33 (1.35)	0.97 (1.21)	1.51 (1.42)	4.70 (2.28)	2.13 (1.62)	1.23 (1.32)	0.90 (1.18)	1.42 (1.39)	260.00
T_6	Chlorantraniliprole10%+ Lambda-cyhalothrin5%ZC	250mL	4.57 (2.25)	1.13 (1.28)	0.40 (0.95)	0.30 (0.89)	0.61 (1.05)	4.17 (2.16)	1.10 (1.26)	0.33 (0.91)	0.27 (0.88)	0.57 (1.03)	379.33
T_7	Spinosad	60g a.i.	4.50 (2.24)	1.63 (1.46)	0.87 (1.17)	0.60 (1.05)	1.03 (1.24)	4.47 (2.23)	1.57 (1.44)	0.70 (1.10)	0.47 (0.98)	0.91 (1.19)	321.33
T_8	Control	-	4.67 (2.27)	4.90 (2.32)	5.03 (2.35)	6.20 (2.59)	5.38 (2.42)	8.10 (2.93)	7.83 (2.89)	8.03 (2.92)	7.17 (2.77)	7.68 (2.86)	180.00
	S.Em.±		-	(0.05)	(0.06)	(0.07)	(0.08)	(0.02)	(0.06)	(0.07)	(0.08)	(0.04)	5.69
	CD @ 5%		NS	(0.16)	(0.17)	(0.21)	(0.23)	(0.07)	(0.19)	(0.20)	(0.24)	(0.13)	17.27

Figures in the parenthesis are $\sqrt{x+0.5}$ *transformed values, NS= Non-significant, DBS= A Day before spray, DAS= Days after spray, *Mean of three replications*

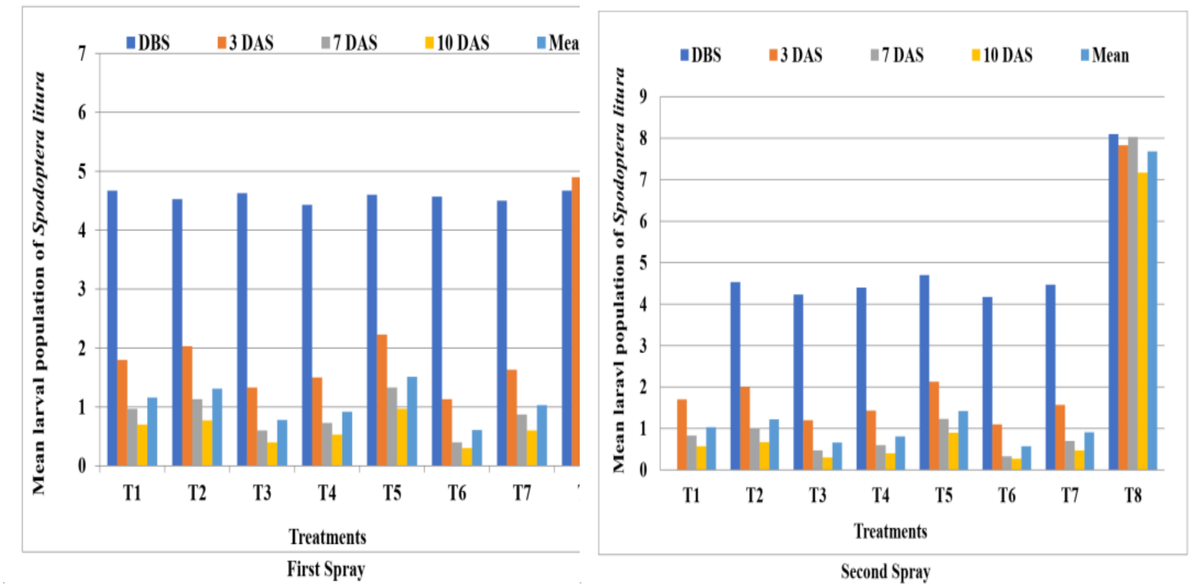


Fig. 2: Bio-efficacy of some selected insecticides against *S. litura* in cabbage during *Rabi* 2021-22

The population of *S. litura* was noted a day before the first spray and distributed uniformly and ranged from 4.43-4.67 larvae plant^{-1} (Table 2 & Fig 2).The overall mean population of *S. litura* data of 3, 7 and 10 DAS at first spray the most effective was found in treatment Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC 250mL ha^{-1} (0.61 larvae plant^{-1}), and statistically superior to overall treatments followed by the treatment Chlorantraniliprole 25g a.i.ha^{-1} (0.78 larvae plant^{-1}), while least promising treatment was Lambda-cyhalothrin30g a.i.ha^{-1} (1.51 larvae plant^{-1}) following that Indoxacarb 60g a.i. ha^{-1} (1.31 larvae plant^{-1}) against *S. litura* in cabbage. However, all of the treatments outperformed the control significantly (5.38 larvae plant^{-1}).

During the experimental period, the population was assessed a day before the second spray and ranged from 4.17-8.10 larvae plant^{-1}. The overall mean data of the *S. litura* population after the second spray at 3, 7 and 10 DAS, the lowest incidence was found in Chlorantraniliprole 10% + Lambda cyhalothrin 5% ZC 250 mL ha^{-1} (0.57 larvae plant^{-1}) followed by the treatment Chlorantraniliprole 25g a.i. ha^{-1} (0.66 larvae plant^{-1}), while highest larval population was recorded under the treatment Lambda-cyhalothrin 30g a.i. ha^{-1} (1.42 larvae plant^{-1}) followed by treatment Indoxacarb 60g a.i. ha^{-1} (1.22 larvae plant^{-1}). However, all the treatments were significantly superior to the control (7.68 larvae plant^{-1}). Combination insecticides demonstrate superior efficacy compared to sole insecticides primarily due to their synergistic action and broader spectrum of activity. By incorporating multiple active ingredients with distinct modes of action, combination insecticides target pests at different developmental stages and with varying susceptibilities, resulting in more comprehensive pest control. This multifaceted approach not only reduces the likelihood of resistance development but also enhances the overall effectiveness of pest management strategies. Furthermore, combination insecticides offer the advantage of minimizing environmental impact and pesticide residues while optimizing cost-effectiveness through reduced application frequency. Their ability to provide holistic pest control solutions makes them indispensable tools in modern agricultural practices, emphasizing the importance of integrated pest management approaches for sustainable crop protection. The present findings are in agreement with Bajya *et al.* (2015) who reported that Chlorantraniliprole 9.3% w/w + Lambda-cyhalothrin 4.6% w/w 150 ZC @ 37.5 g a.i/ha was effective against cotton bollworm. The present findings were also supported by Reddy and Paul (2019) who also found that Lambda-cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC @ 30 g a.i ha^{-1}, Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC @ 27.5 g a.i ha^{-1} and Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC @ 150 g a.i ha^{-1} were effective in management of *S. litura*. Reddy and Hampaiah (2018) evaluated different insecticide mixtures against the spotted pod borer, *Maruca vitrata* and found that Lambda-cyhalothrin 4.6 % + Chlorantraniliprole 9.3 % ZC @ 0.50 mL L^{-1} was most effective treatment.

Table 3: Economics of Some Selected Insecticides Used for Management of Lepidopteran Borers in Cabbage during *Rabi* 2021-22

Tr. No.	Treatments	Dose /ha	Quantity of insecticides	Cost of one Spray (Rs/ha)	No. of sprays	Total cost of Treat. (Rs/ha)	Marketable Yield (q/ha)	Saved yield (q/ha)	Value of saved yield (Rs/ha)	Net Return (Rs/ha)	Cost Benefit Ratio (C:B)
T_1	Emamectin benzoate	12g a.i.	240.00g	₹2133.00	2	₹4266.00	300.00	120.00	₹120000.00	₹115734.00	27.12
T_2	Indoxacarb	60g a.i.	413.00 mL	₹4252.00	2	₹8,504.00	280.00	100.00	₹100000.00	₹91496.00	10.75
T_3	Chlorantraniliprole	25g a.i.	135.00 mL	₹3215.00	2	₹6430.00	360.00	180.00	₹180000.00	₹173570.00	26.99
T_4	Flubendiamide	60g a.i.	152.00 mL	₹3658.00	2	₹7316.00	340.00	160.00	₹160000.00	₹152684.00	20.86
T_5	Lambda-cyhalothrin	30g a.i.	600.00 mL	₹1204.00	2	₹2408.00	260.00	80.00	₹80000.00	₹77592.00	32.22
T_6	Chlorantraniliprole10%+Lambda-cyhalothrin5%ZC	250mL	250.00 mL	₹2761.00	2	₹5522.00	379.33	199.33	₹199330.00	₹193804.00	35.09
T_7	Spinosad	60g a.i.	133.00 mL	₹3681.00	2	₹8762.00	321.33	141.33	₹141330.00	₹1,32,568.00	15.12
T_8	Control	-	-	-	2	-	180.00	-	-	-	-

Rent of sprayer @ Rs. 100/day = Rs.200/, Labour charge @ Rs. 250/day = Rs. 500/-, Cost of produce Rs. 1000/q

The yield was found to be high in treatment Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC 250mL ha^{-1} (379.33 q ha^{-1}), followed Chlorantraniliprole 25 g a.i. ha^{-1} (360 q ha^{-1}) and treatment Flubendiamide 60g a.i. ha^{-1} (340 q ha^{-1}), while among insecticides a low yield was recorded in plots treated Lambda-cyhalothrin 30g a.i. ha^{-1} (260 q ha^{-1}), followed by treatment Indoxacarb 60g a.i. ha^{-1} (280q ha^{-1}). All treatments produced significantly higher yields than Control (180 q ha^{-1}). Combination insecticides are the mixture of two diverse groups of insecticides with dissimilar modes of action that facilitate better management of insect pests as they target two different sites of insect body to kill them, which results in better crop yield.

The highest net return was observed in treatment Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC 250mL ha^{-1} (₹193804.00) followed by Chlorantraniliprole 25 g a.i. ha^{-1} (₹173570.00) and lowermost net return was observed in the treatments Indoxacarb 60g a.i. ha^{-1} (₹75472.00) followed by Spinosad 60g a.i. ha^{-1} (₹78522.00). The benefit-to-cost ratio of various insecticides revealed that Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC 250mL ha^{-1} (35.09:1) is the most economical insecticide followed by treatment Lambda-cyhalothrin 30g a.i. ha^{-1} (32.22:1) are the highly cost-effective insecticides and the least cost-effective insecticide treatment Spinosad 60g a.i. ha^{-1} (1.25:1) followed by treatment Indoxacarb 60g a.i. ha^{-1} (3.07:1). All of the insecticides were found to be effective at controlling insects; however, the net return is dependent on yield as well as insecticide cost. Insecticides that are less expensive have a higher benefit-cost ratio.

In conclusion, the bio-efficacy results from the study demonstrated that the treatment Chlorantraniliprole 10%+ Lambda-cyhalothrin 5% ZC at 250mL ha^{-1} exhibited significant effectiveness against both *P. xylostella* and *S. litura* larvae in cabbage. This compound is highly effective for the control of lepidopteran borers in cabbage.

AUTHORS' CONTRIBUTION

RKV: Data curation, investigation, and original drafts preparation, SKS: Supervision, Formal analysis, review editing, KRS: review editing UC: Supervision, Formal analysis, review editing, PKY: Drafts preparation and editing.

DECLARATION

The authors have stated that there are no competing interests.

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REFERENCES

Abbey, L. and Manso, F. (2004) Correlation studies on yield and yield components of two cultivars of cabbage (*Brassica oleracea* var. *capitata* L.). *Ghana Journal of Science*, 44:3-9.

Baidoo, P.K., Mochiah, M.B. and Apusiga, K. (2012) Onion as a pest control intercrop in organic cabbage (*Brassica oleracea*) production system in Ghana. *Sustainable Agriculture Research*, 1(1):36-41.

Bajya, D.R., Baheti, H.S. and Raza, S.K. (2015) Bio-efficacy of Chlorantraniliprole 4.6% + Lambda-cyhalothrin 9.3% against *Helicoverpa armigera* in Cotton. *Journal of Cotton Research*, 29(1):94-98.

Borkakati, R.N. Saikia, D.K. and Sarma, D. (2019) Manipulation of crop habitat to encourage natural enemies against key pests of cabbage ecosystem. *Journal of Entomology and Zoology* Studies,7(3):151-154.

Cabbage (2010) Encyclopedia Britannica. Ultimate Reference Suite, Chicago.

FAO (2000) Regional vegetable IPM programme in South and South-east Asia: http://www.vegetableipmasia.org/CropsSites.html.

Fenning, K.O., MacCarthy, D.S. and Tegbe, R.E. (2014) Effect of intercropping and soil amendment on the population dynamics of major pests and natural enemies of white cabbage. *West African Journal of Applied Ecology*, 28(1): 96 –112.

Kumar, S. (2021) Management of insect pest complex of Tomato with combination insecticides. M.Sc. (Ag.) Entomology, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya - 224 229, Uttar Pradesh, India, pp. 25-38.

Legwaila, M.M., Munthali, D.C., Kwerepe, B.C. and Motshwari, O. (2014) Effectiveness of cypermethrin against diamondback moth (*Plutellaxylostella* L.) eggs and larvae on cabbage under Botswana conditions. *African Journal of Agricultural Research*, 9 (51):3704- 3710.

Mochiah. M.B., Baidoo, P.K. and Owusu-Akyaw, M. (2011) Influence of different nutrient applications on insect populations and damage to cabbage. *Journal of Applied Biosciences*, 38: 2564-2572.

Müller, F.P. (1986) The role of subspecies in aphids for affairs of applied entomology. *Journal of Applied Entomology,*101:295–303.

NHB (2018) National Horticulture Board, India. http: nhb.gov.in/vegetable /cabbage/pdf.

Reddy, B.K.K. and Hampaiah, J. (2018) Evaluation of Insecticide Mixtures against Larval Population of Spotted Pod Borer, *Maruca vitrata* in Cowpea. *International Journal of Current Microbiology and Applied Sciences*, 7(7):1820-1826

Reddy, B.K.R. and Paul, A. (2019) Field efficacy of insecticide mixtures against the pod borer and leaf eating caterpillar in cowpea. *Journal of Pharmacognosy and Phytochemistry,* 8(5):1224-1227.

Sen, S., Samanta, A., Alam, S.K.F., Dhar, P.P. and Samanta, A. (2017) Field Evaluation of a New Ready-Mix Formulation Ampligo 150 ZC (Chlorantraniliprole 9.3%+ Lambda-cyhalothrin 4.6% ZC) against Shoot and Fruit Borer (*Leucinodes orbonalis* Guen.) infestation in Brinjal. *Journal of Pharmacognosy and Phytochemistry*, 6(5):1674-1678.