



RESEARCH ARTICLE

Efficacy of novel insecticides and bio-pesticides for diamond back moth (*Plutella xylostella*) management in cabbage

JK Choudhary¹, Akhilesh Kumar^{1*}, TK Singh², Rajesh Singh³, Manju Shukla³, Smita Singh³, VK Singh² and SK Tripathi⁴

Abstract

The experiment was carried out at the Instructional Farm of JNKVV-College of Agriculture, Rewa (M.P), during the *Rabi* season 2020-2021 on cabbage. The experiment was laid out in a Randomized Block Design with nine treatments, including Chlorantraniliprole 18.5 SC at 10 g a.i./ha, Fipronil 5% SC @ 40 g a.i./ha, Indoxacarb 14.5 SC @ 40 g a.i./ha, Spinosad 45 SC @ 100 g a.i./ha, Novaluron 10 EC @ 75 g a.i./ha, Emamectine benzoate 5 SG @ 10 g a.i./ha, Neem oil 0.15% @ 4.5 g a.i./ha, Bt 5% WP @ 25 g a.i./ha and untreated control and three replications against diamondback moth two sprays of insecticide were done at 15 and 35 days after transplanting of the crop. The effect of insecticide was recorded on 3, 7, 10 and 15 days after the insecticide. The mean population of DBM after two sprays showed that Spinosad 45 SC proved to be the most effective and superior treatment, recording the lowest population of DBM (0.55 larvae/plant). The order of efficacy of insecticides was found in order T4 (Spinosad 45 SC) > T1 (Chlorantraniliprole 18.5 SC) > T6 Emamectin benzoate > T3 (Indoxacarb 14.5 SC) > T2 (Fipronil 5% SC) > T5 (Novaluron 10 EC) > T8 (Bt 5% WP) > T7 (Neem oil 0.15%). The untreated control recorded a maximum DBM larval population (3.35 larvae/plant). Resulting in the head yield 320.00 q/ha Spinosad 45 SC @ 100 g a.i./ha with maximum C:B ratio (1:21.31) was recorded from Chlorantraniliprole 18.5 SC treatment followed by Indoxacarb 14.5 SC (1:18.20).

Keywords: Cabbage, DBM, Insecticides, Biopesticides, Economics.

¹Department of Entomology, JNKVV-College of Agriculture, Rewa, Madhya Pradesh, India.

²Department of Horticulture, JNKVV-College of Agriculture, Rewa, Madhya Pradesh, India.

³JNKVV-KVK, College of Agriculture, Rewa, Madhya Pradesh, India.

⁴Department of Plant Pathology, JNKVV-College of Agriculture, Rewa, Madhya Pradesh, India.

*Corresponding author; Email: akhiliivr@gmail.com

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Introduction

The diamondback moth, *Plutella xylostella* (L.), presents one of the greatest threats to crucifer production in many parts of the world. In recent years, crucifer production in tropical and subtropical regions has been significantly impacted by populations that have developed resistance to a wide range of insecticides (Tabashnik et al. 1990; Shelton et al. 1993). It primarily attacks crops of the cruciferous family, including cabbage, rape, broccoli, cauliflower, and Chinese cabbage. The damage is caused by its larvae, which skeletonize the foliage of the host plant and render it unfit for consumption. Among the pest complex of cabbage, diamondback moth (*P. xylostella* Linn.) is the most destructive insect pest. Kumar et al. (1983) reported 52 percent losses in the marketable yield of cabbage due to infestation by *P. xylostella*. The diamondback moth (DBM), *P. xylostella* (Lepidoptera: Plutellidae), is a serious pest of great economic importance worldwide.

Cabbage, *Brassica oleracea* var. capitata L. is one of the important cruciferous vegetable crops grown in India. The total area under cultivation of cabbage in India is 3.9 lakh hectares, with an annual production of 1.0 million tonnes and a productivity of 9037 metric tons (Anonymous, 2018). The position of Madhya Pradesh in Cabbage production is

3rd. Cabbage area and production are respectively 889.74 ha and 686.91 MT (2017-18) in Madhya Pradesh. Cabbage is a great source of calcium, potassium, and vitamin C (Hasan and Solaiman, 2012). The crop has a cooling effect, aids in reducing constipation, increases appetite, speeds up digestion, and is particularly beneficial for diabetic people (Yadav *et al.*, 2000). The aim of the present study was to investigate the efficacy of novel insecticides and biopesticides against the management of Diamondback moth in cabbage, assessing their economic feasibility.

Materials and Methods

The experiment was conducted at the Instructional Farm, College of Agriculture, Rewa (M.P.) during the Rabi season 2020-2021. The cabbage field was studied on variety CLX 3945 by raising crops following the recommended package of practices with plant spacing of 50 × 50 cm with plot size 3 m × 2.5 m. The incidence of *P. xylostella* was observed from five randomly selected plants from three middle rows of each plot. The spray of insecticides was applied as soon as the pest incidence was noted. The first spray was applied using a knapsack sprayer at the site of insect incidence on the crop and repeated after 15 days. Pre-treatment observation on pest population was undertaken one day before the application of the first spray by direct counting of *P. xylostella* larvae per five randomly pre-selected plants in each plot. A similar procedure was followed for post-treatment observation, which was recorded at 3, 7, 10, and 15 days after both spray operations. The efficacy of new molecule of insecticides viz., Chlorantraniliprole 18.5 SC, Fipronil 5% SC, Indoxacarb 14.5 SC, Spinosad 45 SC, Novaluron 10 EC, Emamectin benzoate 5 SG, Bt and Neem oil, were compared with untreated control plot against the cabbage diamondback moth (*P. xylostella*).

The data were analyzed according to the experimental design to test the significance of the treatment. The data obtained on the number of insects were transformed to square root ($\sqrt{x+0.5}$) for the statistical analysis. Cabbage yields in different treatments were recorded per plot and then converted to yield in q/ha.

Gross return was calculated by multiplying the total yield by the market price of the product. The cost of cultivation and cost of treatment imposition were deducted from the gross returns to find out net returns and cost-benefit ratio by following the formula:

$$B: C = \frac{\text{Gross returns}}{\text{Total cost of cultivation}} \times 100$$

Where, B: C = Benefit Cost Ratio

Grain yield

Yield was calculated under different treatments as per formula.

Yield / ha = Factor x grain yield / plot

Results and Discussion

Efficacy of novel insecticides and biopesticides against the diamondback moth (*P. xylostella*)

All insecticides were found to be very effective and significantly superior to the untreated control. However, T4 and T1 (Spinosad 45 SC and Chlorantraniliprole 18.5 SC, respectively) were the best among them. (Table 1 & 2). Eight insecticides, namely Chlorantraniliprole 18.5 SC, Fipronil 5% SC, Indoxacarb 14.5 SC, Spinosad 45 SC, Novaluron 10 EC, Emamectin benzoate 5 SG, Bt, and Neem oil, were evaluated against DBM following two applications of insecticide spray at 15 days and 35 days after cabbage transplanting. The

Table 1: Efficacy of different insecticide treatments against population of Diamondback moth during Rabi season 2021

Insecticides	Dosage g or ml a.i./ha	DBM larvae per plant First spray After treatment					Mean
		Pre-count	3DAT	7DAT	10DAT	15DAT	
Chlorantraniliprole 18.5 SC	10	2.46 (1.72)	1.06 (1.25)	0.87 (1.17)	0.6 (1.17)	0.93 (1.19)	0.85 (1.16)
Fipronil 5% SC	40	2.2 (1.64)	1.53 (1.42)	1.2 (1.30)	0.8 (1.30)	1.2 (1.30)	1.18 (1.29)
Indoxacarb 14.5 SC	40	2.33 (1.68)	1.27 (1.33)	1.13 (1.28)	0.73 (1.28)	1.06 (1.25)	1.05 (1.24)
Spinosad 45 SC	100	2.6 (1.76)	1 (1.22)	0.67 (1.08)	0.53 (1.08)	0.8 (1.14)	0.75 (1.11)
Novaluron 10 EC	75	2.13 (1.62)	1.53 (1.42)	1.27 (1.33)	0.87 (1.33)	1.27 (1.33)	1.22 (1.31)
Emamectin benzoate 5 SG	10	2.13 (1.62)	1.13 (1.28)	0.93 (1.19)	0.67 (1.08)	1 (1.22)	0.92 (1.19)
Neem oil 0.15%	4.5	2.33 (1.68)	1.73 (1.49)	1.53 (1.42)	1 (1.42)	1.6 (1.45)	1.465 (1.4)
Bacillus thuringiensis 5% WP	25	2.2 (1.64)	1.67 (1.47)	1.33 (1.35)	0.93 (1.35)	1.4 (1.38)	1.33 (1.35)
Untreated check	-	2.4 (1.7)	2.53 (1.74)	2.93 (1.85)	2.93 (1.85)	3 (1.87)	2.85 (1.83)
SEm ± CD at 5%		0.23	0.1	0.07	0.09	0.11	
		NS	0.31	0.22	0.3	0.34	

* Figures in parentheses are $x + 0.5$ transformed values

Table 2: Efficacy of different insecticides against population of Diamond back moth during Rabi season 2021

Treatment	Insecticides	Dosage g or ml a.i./ha	Pre- count	DBM larvae per plant Second spray after treatment				Mean
				3DAT	7DAT	10DAT	15DAT	
T ₁	Chlorantraniliprole 18.5 SC	10	1.6 (1.45)	1 (1.22)	0.73 (1.11)	0.47 (0.98)	0.33 (0.91)	0.67 (1.08)
T ₂	Fipronil 5% SC	40	2 (1.58)	1.67 (1.47)	1 1.22	0.73 (1.11)	0.53 (1.01)	0.98 (1.22)
T ₃	Indoxacarb 14.5 SC	40	1.87 (1.54)	1.53 (1.42)	0.93 (1.19)	0.67 (1.08)	0.47 (0.98)	0.9 (1.18)
T ₄	Spinosad 45 SC	100	1.53 (1.42)	0.87 (1.17)	0.67 (1.08)	0.4 (0.94)	0.27 (0.88)	0.55 (1.02)
T ₅	Novaluron 10 EC	75	2.2 (1.64)	1.73 (1.49)	1.06 (1.25)	0.8 (1.14)	0.6 (1.05)	1.05 (1.24)
T ₆	Emamectin benzoate 5 SG	10	1.73 (1.49)	1.06 (1.25)	0.8 (1.14)	0.6 (1.04)	0.4 (0.95)	0.71 (1.1)
T ₇	Neem oil 0.15%	4.5	2.33 (1.68)	1.8 (1.52)	1.2 (1.30)	0.87 (1.17)	0.73 (1.11)	1.15 (1.28)
T ₈	Bacillus thuringiensis 5% WP	25	2.4 (1.70)	1.73 (1.49)	1.13 (1.28)	0.8 (1.14)	0.67 (1.08)	1.08 (1.26)
T ₉	Untreated check	-	3.67 (2.04)	4.33 (2.19)	3.6 (2.02)	2.93 (1.85)	2.53 (1.74)	3.35 (1.96)
	SEm±		0.14	0.08	0.11	0.1	0.11	
	CD at 5%		0.44	0.23	0.34	0.31	0.33	

*Figures in parentheses are transformed values

observations were recorded at 3, 7, 10 and 15 days after each spray, along with the respective pre-count population. The Diamondback moth population count in this treatment was recorded between 1 to 1.73 larvae per plant in all the insecticide treatment plots as against control (2.53 larvae per plant).

However, after 7 and 10 days after treatment again, insecticides were found to be significantly superior over untreated control in reducing the larval population of the pest, with the diamondback moth population range 0.67 to 1.53 larvae per plant noted in all the insecticide-treated plots. In contrast, in the control plot 2.93 larvae per plant were recorded 7 days after. The population of diamondback moth varied between 0.53 and 1 larvae per plant in various insecticide treatments, as compared to the control (2.93 larvae per plant), which was recorded 10 days after treatment. Here, Spinosad 45 SC also proved superior, with a reduction in the diamondback moth population to the extent of 0.53 larvae per five plants. T₄ (Spinosad 45 SC) > T₁(Chlorantraniliprole 18.5 SC) >T₆ (Emamectin benzoate 5 SG) >T₃(Indoxacarb 14.5 SC) >T₂ (Fipronil 5% SC) > T₅(Novaluron 10 EC) >T₈ (Bt 5% WP) > T₇ (Neem oil 0.15%).

In the case of the second spray of insecticides, Spinosad 45 SC was again superior to the rest of the treatments, and all insecticides were found to be very effective and significantly superior to the control. A diamondback moth population range of 0.87 to 1.8 larvae per plant was noted in all insecticide-treated plots. In contrast, in the control plot 4.33 larvae per plant were recorded 3 days after. The population of diamondback moths varied between 0.67 and 1.2 larvae per plant in various insecticide treatments,

as compared to the control (3.60 per plant), which was recorded 7 days after treatment. After 15 days of treatments, the population of diamondback moths varied between 0.27 and 0.73 larvae per plant. The effectiveness of these treatments application was found in order T₄ (Spinosad 45 SC) > T₁ (Chlorantraniliprole 18.5 SC) >T₆ (Emamectin benzoate 5 SG)>T₃ (Indoxacarb 14.5 SC) >T₂ (Fipronil 5% SC) > T₅ (Novaluron 10 EC) >T₈ (Bt 5% WP) > T₇ (Neem oil 0.15%). Dotsara et al. (2017), Nikam et al. (2014), and Shivalingaswamy et al. (2006) also reported the effectiveness of Spinosad against this pest, observing better efficacy of Spinosad against DBM. Some workers also observed the effectiveness of Indoxacarb, Chlorantraniliprole, Bt, and Emamectin benzoate to be better than that of the untreated plot (Kumar et al., 2007; Rai et al., 2007; Shivalingaswamy et al., 2008; Kumar et al., 2014; Kumar et al., 2017).

Effect on cabbage yield

Yield data presented in Table 3, indicates an increase in the yield of cabbage after the spray of insecticides. The highest yield of 320 Q/ha was recorded in the plot treated with Spinosad 45 SC (T₄), which was significantly similar to the at-par treatments, viz. T₁ (Chlorantraniliprole 18.5 SC) and T₆ (Emamectin benzoate 5 SG) recorded a yield of 298 and 293.06 Q/ha, respectively. While the lowest yield of 200.93 Q/ha was recorded from the control plot. Among the treatments, Neem oil 0.15% (T₇) recorded the lowest yield of 220.93 Q/ha. The order of yield (kg/ha) in various treatments was found as: T₄ (Spinosad 45 SC) > T₁ (Chlorantraniliprole 18.5 SC) > T₆ (Emamectin benzoate 5 SG) > T₃(Indoxacarb 14.5 SC) > T₂ (Fipronil 5% SC) > T₅ (Novaluron 10 EC) > T₈

Table 3: Effect of different insecticide sprays on the economics of the cabbage diamondback moth

S. No	Treatments	Insecticides	Dosage mL/g a. i./ha	Average Yield (Q/ha)	Additional yield over control (Q/ ha)	% yield increased	Gross monetary return due to treatment** (Rs./ ha)	Protection cost for 2 sprays* (Rs./ha)	Net return due to treatments (Rs./ha)	C:B ratio
1	T ₁	Chlorantraniliprole 18.5 SC	10	298	97.07	48.31	97067.00	2960	94107.00	1:21.31
2	T ₂	Fipronil 5% SC	40	252.4	51.47	25.61	51467.00	3875	47592.00	1:8.86
3	T ₃	Indoxacarb 14.5 SC	40	284.933	84.00	41.80	84000.00	3850	80150.00	1:18.20
4	T ₄	Spinosad 45 SC	100	320	119.07	59.26	119067.00	5470	113597.00	1:12.23
5	T ₅	Novaluron 10 EC	75	248.933	48.00	23.89	48000.00	4721	43279.20	1:5.40
6	T ₆	Emamectin benzoate 5 SG	10	293.067	92.13	45.85	92134.00	8501	83633.25	1:17.43
7	T ₇	Neem oil 0.15%	4.5	220.933	20.00	9.95	20000.00	4500	15500.00	1:2.51
8	T ₈	Bacillus thuringiensis 5% WP	25	230	29.07	14.47	29067.00	7000	22067.00	1:7.32
9	T ₉	Untreated check	-	200.933						-
	SEm±			0.03	-	-	-	-	-	-
	CD at 5%			0.10	-	-	-	-	-	-

*Protection cost for 2 sprays: Labour charge = Rs 2500; Knapsack hiring = Rs 500

Cost of insecticides used for treatment: Chlorantraniliprole 18.5 SC = Rs 13500 /lit, Fipronil 5% SC = Rs 1388 /Kg, Indoxacarb 14.5 SC = Rs 2500 /lit, Spinosad 45 SC = Rs 13335 /lit, Novaluron 10 EC = Rs 3000 /lit, Emamectin benzoate 5 SG = Rs 5000 /lit, Neem oil 0.15% = Rs450 /lit, Bacillus thuringiensis 5% WP = Rs 495 /lit.

(*Bacillus thuringiensis* 5% WP) > T7 (Neem oil 0.15%) > T9 (Control).

The cost-benefit ratio

The C:B ratio of various insecticidal treatments against cabbage diamondback moth was calculated and presented in Table 3, which divulge that maximum C:B ratio (1:21.31) was recorded from Chlorantraniliprole 18.5 SC (T1) treatment followed by Indoxacarb 14.5 SC (T3) (1:18.20), Emamectin benzoate 5 SG (T6) (1:17.43), Spinosad 45 SC (T4) (1:12.23), Fipronil 5% SC (T2) (1:8.26), Bt 5% WP (T8) (1:7.32), Novaluron 10 EC (T5) (1:5.40) and Neem oil 0.15% (T7) (1:2.51).

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सारांश

यह प्रयोग जेएनकेवीवी-कृषि महाविद्यालय, रीवा (म.प्र.) के इंस्ट्रक्शनल फार्म में रबी सीजन 2020-2021 के दौरान गोभी पर किया गया था। यह प्रयोग 09 उपचारों के साथ रैंडमाइज्ड ब्लॉक डिजाइन में किया गया था, क्लोरेंट्रानिलिप्रोल 18.5 एस सी / 10 ग्राम ए. आई. ध्वेक्टेयर, फिप्रोनिल 5: एससी / 40 ग्राम ए. आई. ध्वेक्टेयर, इंडोक्साकार्ब 14.5 एस सी / 40 ग्राम ए. आई. ध्वेक्टेयर, स्पिनोसैड 45 एस सी / 100 ग्राम ए. आई. ध्वेक्टेयर, नोवलूरॉन 10 ईसी / 75 ग्राम ए. आई. ध्वेक्टेयर, इमामेक्टिन बेंजोएट 5 एस जी / 10 ग्राम ए. आई. ध्वेक्टेयर, नीम तेल 0.15: / 4.5 ग्राम ए. आई. ध्वेक्टेयर, बीटी 5: डब्ल्यूपी / 25 ग्राम ए. आई. ध्वेक्टेयर, और अनुपचारित नियंत्रण और डायमंड बैक मॉथ के विरुद्ध तीन प्रतिकृतियां फसल की रोपाई के 15 और 35 दिन बाद कीटनाशक के दो छिड़काव किए गए। कीटनाशक का प्रभाव कीटनाशक के 3, 7, 10 और 15 दिन बाद दर्ज किया गया। दो स्त्रों के डीबीएम की औसत जनसंख्या से पता चला कि स्पिनोसैड 45 एस सी बाकी उपचारों की तुलना में सबसे प्रभावी और बेहतर साबित हुआ और डीबीएम (0.55 लार्वा धू पौधा) की सबसे कम संख्या दर्ज की गई। कीटनाशकों की प्रभावकारिता का क्रम टी4 (स्पिनोसैड 45 एससी) झा टी1 (क्लोरेंट्रानिलिप्रोल 18.5 एससी) झा टी6 इमामेक्टिन बेंजोएट झा टी3 (इंडोक्साकार्ब 18.5 एससी) झा टी2 (फिप्रोनिल 5: एससी) झा टी5 (नोवलूरॉन 10 ईसी) झा टी8 (बैसिलस थुरिंगिएन्सिस 5: डब्ल्यूपी) झा टी7 (नीम तेल) 0.15:। अनुपचारित नियंत्रण में अधिकतम डीबीएम लार्वा जनसंख्या (3.35 लार्वा/पौधा) दर्ज की गई। अधिकतम सी:बी अनुपात (1:21.31) के साथ क्लोरेंट्रानिलिप्रोल 18.5 एससी उपचार के बाद इंडोक्साकार्ब 14.5 एससी (1:18.20) के साथ हेड उपज 320.00 किलो धू ध्वेक्टेयर स्पिनोसैड 45 एससी / 100 ग्राम एआई धू ध्वेक्टेयर दर्ज की गई।