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Rishabh Singh
M.Sc. Scholar, Department of Entomology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Ashwani Kumar
Head, Department of Entomology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Rishabh Singh
M.Sc. Scholar, Department of Entomology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Comparative efficacy and economics of selected biopesticides with Chlorantraniliprole against diamondback moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea* L.)

Rishabh Singh and Ashwani Kumar

Abstract
The study entitled "Comparative efficacy and economics of selected biopesticides with Chlorantraniliprole against diamondback moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea* L.) was conducted during the *rabi* season from November 2022 to March 2023 at Crop Research Farm, SHUATS, Prayagraj, U.P. Eight treatments, including Chlorantraniliprole 18.5 SC, 1/2 Dose Chlorantraniliprole + Niscosixer plus, Spinosad 45 SC, Niscosixer plus, NSKE 5%, Azadirachtin 0.15% EC, *Beauveria bassiana* 1.15% WP, and untreated control, were used against *Plutella xylostella* on three replications in randomized block design.

Chlorantraniliprole 18.5 SC showed the highest percentage of population reduction of diamondback moth larvae against control (78.37%), followed by Spinosad 45 SC (73.06%) and 1/2 Dose Chlorantraniliprole + Niscosixer plus (60.41%). The least reduction was observed in Niscosixer plus (41.63%). The mean crop yield ranged between 11.00 t/ha to 25.25 t/ha in the insecticidal treatment, with Chlorantraniliprole 18.5 SC showing the highest yield (25.25 t/ha) followed by Spinosad 45 SC (23.52 t/ha). The C: B ratio varied from 1:1.07 to 1:2.32 in different insecticidal treatments, with Chlorantraniliprole 18.5 SC showing the highest ratio of 1:2.32.

Keywords: Bio-pesticides, chlorantraniliprole, *Plutella xylostella*, cost-benefit ratio

Introduction

Cabbage, scientifically known as Brassica oleracea, belongs to the Cruciferae family and is a member of the Cole group. It has 18 chromosomes, with a chromosome number of 2n=18. The term cole originates from the word Colewort, which means wild cabbage. It is a widely grown vegetable in India and is used in various forms such as salad, boiled vegetables, curries, pickling, and as dehydrated vegetable. (Singh *et al.*, 2021) [19]. Cabbage is a nutrient-rich vegetable with low calories (31 kcal/100g) and high-water content (91.9g/100g), making it hydrating and suitable for low-calorie diets. It contains protein (0.96g), fat (0.23g), and carbohydrates (6.38g) in small amounts. Cabbage is a good source of minerals like calcium, potassium, magnesium, and manganese, important for bone health and energy metabolism. It is also rich in vitamin C (40.3mg/100g) for immune function and antioxidant protection. With vitamin B6 for brain function and dietary fibre for digestive health and blood sugar regulation, cabbage is a valuable addition to a balanced diet. (Anon, 2022) [3]. The cultivated brassicas are believed to have originated in Europe, and it has been proposed (Hardy, 1938) [10] and widely accepted since (Harcourt, 1957) [9] that the diamondback moth also originated in the same region, likely in the Mediterranean area. According to (Glance, 2018) [8], the global production of cabbages in 2016 was 71.26 million tonnes, with China being the leading producer at 33.88 million tonnes, followed by India at 8.76 million tonnes. In India, the estimated cabbage production volume for the fiscal year 2021-2022 was 9.60 million metric tonnes, with around 413 thousand hectares of land utilized for its cultivation. Among the states in India, West Bengal has the highest cabbage production share at 24.38%, followed by Orissa at 11.77%, and Gujarat at 8.29%. Uttar Pradesh ranks eighth in production with 3.63% of total production, producing 348,940 tonnes (Anon, 2021) [2]. Cabbage cultivation is prone to damage from various insect pests throughout the crop cycle, such as the tobacco caterpillar (*Spodoptera litura* F.), diamondback moth (*Plutella xylostella* L.), cabbage leaf webber (*Crocidolomia bionotalis* Zell), aphids (*Brevicoryne brassicae* L. and *Lipaphis erysimi* Kalt), painted bug (*Bagrada cruciferarum* Kirk), and flea beetle (*Phyllotreta cruciferae* Goeze).

These pests attack cabbage plants from sowing until harvest, causing significant yield losses (Shukla and Kumar, 2004) [18]. *Plutella xylostella* Linnaeus, commonly known as the diamondback moth, is a notorious pest of cruciferous vegetables that is found worldwide (Talekar *et al.*, 1993) [20]. This pest can cause significant damage to cabbage plants, with infestations leading to a yield loss of up to 52% (Krishnamoorthy, 2004) [12]. The economic impact of this pest is substantial, with an estimated annual loss of around $16 million (Mohan and Gujar, 2003) [15]. The diamondback moth was first reported in India by Fletcher (1914) [7] and subsequent literature reviews indicate that it is widely distributed throughout the country.

Materials and Methods

A field trial was conducted at the Central Research Field using a randomized block design with three replications. The study included eight treatments, one of which was an untreated control. The "Golden acre" variety of cabbage was used and recommended agronomic practices were followed to raise a healthy crop. The plot size was 2m x 1.5m with row and plant spacing maintained at 60 X 45 cm, respectively.

The eight treatments tested were T_1 - Chlorantraniliprole 18.5 SC (0.3 ml/litre), T_2 - 1/2 Dose Chlorantraniliprole (0.15 ml/litre) + Niscosixer plus (0.15 ml + 1ml respectively / litre), T_3 - Spinosad 45 SC (0.5 ml/lit), T_4 - Niscosixer plus (2 ml/litre), T_5 - NSKE 5% (50 g/litre), T_6 - Azadirachtin 0.15% EC (5.0 ml/litre), T_7 - *Beauveria bassiana* 1.15% WP (4.0 g/litre), and T0 - an untreated control. The sprays were initiated once the larvae population of the diamondback moth reached the economic threshold level (ETL) of 4-5 larvae per plant, and the crop damage exceeded 10-20 percent. Spraying was repeated twice at 15-day intervals during the crop season. Observations on larvae and plant damage by the diamondback moth were recorded during morning hours one day before spray (pre-count) and 3rd, 7th, 14th days after each spray on 5 randomly selected plants per plot.

Percent reduction over control was worked out by using Abbott's Formula (1925) [1]:

$$P = \frac{(CM\ Control - CM\ Treatment) \times 100}{CM\ Control}$$

Where,
P=Percent reduction over control of a treatment
$CM_{Control}$: Cumulative mean of control
$CM_{Treatment}$: Cumulative mean of treatment

The total yield of marketable cabbage obtained from each treatment was calculated, considering the additional cost of treatment and agricultural practices, and compared to the untreated control. The income from the main product (yield) of cabbage crops is considered for accounting gross return (Zorempuii and Kumar, 2019) [21].

$$Gross\ return\ (₹) = Yield\ (q\ per\ ha) \times Market\ price$$

The benefit-cost ratio was then determined based on the gross income gained from yield over control. (Zorempuii and Kumar, 2019) [21].

$$B{:}C\ ratio = \frac{Gross\ return}{Cost\ of\ Cultivation}$$

Result and Discussion

The results after 1st spray showed that all treatments reduced the larval population compared to the control group, with T_1 (Chlorantraniliprole 18.5 SC) showing the highest reduction of 70.75%. T_3 (Spinosad 45 SC) and T_2 (1/2 Dose Chlorantraniliprole + Niscosixer plus) also showed significant reductions of 66.04% and 50.94% respectively. T_5 (NSKE 5%) and T_6 (Azadirachtin 0.15% EC) exhibited moderate reductions of 37.74% and 35.85%, respectively; while T_7 (*Beauveria bassiana* 1.15% WP) and T_4 (Niscosixer plus) had relatively lower reductions of 33.96% and 30.19%, respectively. After the 2nd spray, it was observed that T_1 (Chlorantraniliprole 18.5 SC) showed the highest reduction of 78.37% in the larval population of diamondback moth, followed by T_3 (Spinosad 45 SC) with 73.06%, and T_2 (1/2 Dose Chlorantraniliprole + Niscosixer plus) with 60.41%. In contrast, T_5 (NSKE 5%) with 47.76%, T_6 (Azadirachtin 0.15% EC) with 46.53%, and T_7 (*Beauveria bassiana* 1.15% WP) with 44.49% exhibited lower percentages of reduction. The treatment with the lowest percentage of reduction was T_4 (Niscosixer plus) with 41.63%, but even this treatment proved to be more effective than the untreated control.

Table 1: Comparative efficacy and economics of selected biopesticides with Chlorantraniliprole against diamondback moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea* L.)

T. No.	Treatments	Larval population of diamondback moth /five plants*							Overall mean	% reduction over control	Yield (q/ha)	C: B ratio
		First Spray				Second Spray						
		DBS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS				
T_0	Control	6.00 (2.45)	6.20 (2.49)	6.80 (2.61)	8.20 (2.86)	8.60 (2.93)	9.00 (3.00)	10.20 (3.19)	8.17	-	110.00	1:1.075
T_1	Chlorantraniliprole 18.5 SC 0.3 ml/lit.	5.80 (2.41)	2.40 (1.55)	1.80 (1.34)	2.00 (1.41)	1.80 (1.34)	1.20 (1.09)	1.40 (1.18)	1.77	78.37	252.51	1:2.328
T_2	1/2 Dose Chlorantraniliprole + Niscosixer plus 0.15 ml + 1ml (resp.)/lit.	5.60 (2.37)	3.80 (1.95)	3.00 (1.73)	3.60 (1.90)	3.40 (1.84)	2.60 (1.61)	3.00 (1.73)	3.23	60.41	202.89	1:1.889
T_3	Spinosad 45 SC 0.5 ml/lit.	5.80 (2.41)	3.00 (1.73)	1.80 (1.34)	2.40 (1.55)	2.20 (1.48)	1.80 (1.34)	2.00 (1.41)	2.20	73.06	235.26	1:2.238
T_4	Niscosixer plus 2.0 ml/litre	5.60 (2.37)	5.20 (2.28)	4.60 (2.14)	5.00 (2.24)	4.80 (2.19)	4.40 (2.10)	4.60 (2.14)	4.77	41.63	151.08	1:1.420
T_5	NSKE 5% 50 g/lit.	5.80 (2.41)	4.80 (2.19)	3.80 (1.95)	4.60 (2.14)	4.40 (2.10)	3.80 (1.95)	4.20 (2.05)	4.27	47.76	166.20	1:1.488
T_6	Azadirachtin 0.15% EC 5.0 ml/lit.	5.80 (2.40)	5.20 (2.28)	3.80 (1.95)	4.60 (2.14)	4.40 (2.10)	4.00 (2.00)	4.20 (2.05)	4.37	46.53	164.04	1:1.514

T_7	*Beauveria bassiana* 1.15% WP 4.0 g/lit.	5.20 (2.28)	5.00 (2.24)	4.20 (2.05)	4.80 (2.19)	4.60 (2.14)	4.20 (2.05)	4.40 (2.10)	4.53	44.49	157.56	1:1.497
F-test		NS	S	S	S	S	S	S				
S. Ed (+/-)		0.413	0.156	0.186	0.165	0.151	0.156	0.170				
C. D. (P=0.05)			0.334	0.400	0.353	0.324	0.334	0.366				

DBS-day before spray
DAS-day after spray
NS-non- significant s-significant
*figures in parentheses are square root transformed value

The experimental findings showed that (T1) Chlorantraniliprole 18.5 SC (1.77 mean larval population/ plant) was the most effective. This result is consistent with previous studies by Sawant and Patil (2018) [17] (1.02), Kommoji and Tayde (2022) [13] (80.35% reduction over control), and Dotasara *et al.* (2017) [6] (0.68). (T_3) Spinosad 45 SC (2.20) was the second most effective treatment, consistent with previous studies by Sawant and Patil (2018) [17] (1.53), Kommoji and Tayde (2022) [13] (77.06% reduction over control), and Dotasara *et al.* (2017) [6] (0.58). The next best treatment was found to be (T_2) ½ Dose Chlorantraniliprole + Niscosixer plus with a mean larval population of 3.23 consistent with previous studies by Sawant and Patil (2018) [17] and Kumar and Kumar, (2020) [14]. (T_5) NSKE 5% showed an efficiency of 4.27 mean larval population per plant, which aligned with earlier investigations conducted by Prakashrao and Kumar (2022) [16] (3.80) and Chandraker *et al.* (2022) [4] (3.97). Similarly, (T_6) Azadirachtin 0.15% EC with a mean larval population of 4.37, consistent with Chandraker *et al.* (2022) [4] (3.39). Beauveria bassiana 1.15% WP (T_7) also performed well, yielding a mean larval population of 4.40, consistent with Chandraker *et al.* (2022) [4] (3.49). On the other hand, Niscosixer plus (T_4) was found to be the least effective with a mean larval population of 4.77, in line with Kumar and Kumar (2020) [14].

Among the treatments tested, T_1 had the highest yield of 252.51 q/ha, followed by T_3 with a yield of 235.26 q/ha and T_2 202.89 q/ha. These treatments were found to be the most profitable. Despite showing lower larval population reduction percentages, T_5, T_6, and T_7 still provided considerable benefits and higher returns compared to the control group, with yields of 166.20 q/ha, 164.04 q/ha, and 157.56 q/ha, respectively. T_4 had the lowest larval population reduction percentage but still showed a decent return on investment, with a yield of 151.08 q/ha. This result is consistent with previous studies by Kommoji and Tayde (2022) [13], Prakashrao and Kumar (2022) [16], Harika *et al.*, (2019) [11], Sawant and Patil (2018) [17], Kumar and Kumar (2020) [16], and Devi and Tayde (2017) [5].

Conclusion

From the findings, it can be concluded that the use of chemical treatments, particularly T1 (Chlorantraniliprole 18.5 SC), T3 (Spinosad 45 SC) and T2 (1/2 Dose Chlorantraniliprole + Niscosixer plus) showed the highest reduction in the larval population and resulted in higher gross and net returns compared to the control and other treatments. They had a favourable cost-benefit ratio of 1:2.328, 1:2.238, and 1:1.889, respectively, indicating higher profitability. Although T_5 (NSKE 5%), T_6 (Azadirachtin 0.15% EC), and T_7 (*Beauveria bassiana* 1.15% WP) showed lower percentages of reduction, they still provided considerable benefits and higher returns compared to the control i.e., they had a cost-benefit ratio of 1:1.488, 1:1.514, and 1:1.497, respectively. T_4 (Niscosixer plus) exhibited the lowest percentage of reduction but was still more effective than the untreated control. Its cost-benefit ratio was 1:1.420, indicating a decent return on investment.

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