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Comparative Efficacy and Economics of Chemicals Insecticides and Bioagents against Diamondback Moth (*Plutella xylostella*) on Cabbage (*Brassica oleracea* var. Capitata L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Field trial was conducted during *rabi* season 2021-2022 at Central Research Farm (CRF), SHUATS. The experiment was laid out in Randomised Block Design with eight treatments each replicated thrice using a variety Green Soccer (546). The treatments are were Chlorantraniliprole 18.5% SC -T_1, Indoxacarb 14.5%SC-T_2, Emamectin benzoate 5% SG-T_3, Spinosad 45% SC-T_4, *Beaveria bassaina* ($1x10^8$CFU/ml)-T_5, *Metarhizium anisopilae* ($1x10^8$ CFU/ml)-T_6, *Bacillus thuringiensis* ($1x10^8$CFU/ml)-T_7 and untreated control -T_8. Mean reduction in the larval population per plant revealed that all the treatments were significantly superior over the control (6.51). Chlorantraniliprole 18.5% SC recorded lowest mean larval population of *P xylostella* (1.52), followed by Spinosad 45% SC (1.75),Indoxacarb 14.SC (2.00), Emamectin Benzoate 5% SG (2.28), *B thuringiensis* (2.68), *B bassiana* (2.87), *M anisopilae* (3.02). Highest yield (280 q/ha) as well as B:C ratio (1:6.37) was obtained from the treatment Chlorantraniliprole 18.5% SC followed by Indoxacarb 14.5 SC (1:6.33), Emamectin Benzoate 5%SG (1:6.25), *B thuringiensis* (1:5.97), Spinosad 45% SC (1:5.75), *B bassiana* (1:5.72), *M anisopilae* (1:5.50) as compared to control (1:3.34).

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1. INTRODUCTION

Cabbage (*Brassica oleracea* var. capitata) is one of the most popular Cole vegetables grown in India. It is originated in Europe and in the Mediterranean region after cauliflower.

Cabbage is also used in herbal medicine. "Cabbage juice can reduce constipation and has also been used as a laxative, as an antidote to mushroom poisoning, or a treatment for hangovers and headaches. In fact, cabbage has historically been used to stop sunstroke, or to relieve fevers. The leaves were also used to soothe swollen feet and to treat childhood croup. Brassica vegetables have also anti-inflammatory activity and have been used to different irritations of the human body" [1].

Regular consumption of dark green leafy vegetables is highly recommended because of their potential in reducing chronic diseases [2] and glucosinolates in cabbage reduced risk of cancer induction and development [3]. It is known to possess medicinal properties and its enlarged terminal buds is a rich source of Ca, P, Na, K, S, Vitamin A, Vitamin C and dietary fibre. It is said to be good for person suffering from diabetes. It may be used to prepare soup, stew, as stuffing for cake [4].

In India, West Bengal accounts highest production of cabbage in the world which is 2288.50 tonnes, which has the share of 25.32 percent followed by Orissa 1058.78, tonnes, Madhya Pradesh 686.91 tonnes, Bihar 673.44 tonnes, and Uttar Pradesh 302.97 (NHB, 2017-2018).

The brassica crop has a multiple insect pest complex. A total of 37 insect pests have been reported to feed on cabbage in India [5]. The important insect pest species are Diamondback moth (*Plutella xylostella* L), Cabbage caterpillar (*Pieris brassicae* Linnaeus), Cabbage semi-looper (*Thysanoplusia orichalcea* Fabricius) and (*Autographa nigrisigna* Walker), Tobacco caterpillar *(Spodopteralitura* Fabricius), Cabbage leaf Webber *(Crocodolomia binotalis* Zeller), Cabbage borer (*Hellula undalis* Fabricius) and Cabbage aphid *(Brevicoryne brassicae* W).Of these Diamondback moth, *Plutella xylostella* (L.) is the most destructive pest [6] and is the limiting factor for the successful cultivation of cruciferous crops. "*Plutella xylostella* was first recorded in 1746 and probably from European origin. About 128 countries or regions reported infestation by this insect pest in 1972.The level of infestation varies from place to place for example the infestation is serious in south and southeast Asian countries and moderate in other Asian countries than the Mediterranean region. *Plutella xylostella* (L.) is a common pest" [7].

2. MATERIALS AND METHODS

The experiment was conducted at Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj Uttar Pradesh (U.P) during the *rabi* season of 2021-2022 with a recommended package of practices excluding plant protection. Cabbage seedlings (var 'Green Soccer-546') transplanted after 40 days at 60 cm x 45 cm spacing. The experiment was laid down in Randomized Block Design (RBD) with eight treatments replicated thrice with each plot size of 2m X 2m and proper irrigation was provided. The treatments comprising of Chlorantraniliprole 18.5%SC, Spinosad 45% SC, Indoxacarb 14.5% SC, Emamectin benzoate 5% SG, *Bacillus thuringeninsis* ($1x10^8$CFU/ml), *Beauveria bassiana* ($1x10^8$CFU/ml), *Metarhizium anisopliae* ($1x10^8$CFU/ml), and were applied in two sprayings at 15 days interval with recommended doses when larval population reaches its ETL level.

Observations on total number of larvae on cabbage of five observational plants from each treatment replication wise were recorded at 1 Day before spraying, 3^{rd}, 7^{th} and 14^{th} days after imposing treatments. The data recorded in the different treatments were subjected to statistical analysis after suitable transformation by following standard procedures of RBD experiment. After harvesting of cabbage from each individual plots produce were calculated to work out the yield of the treatments. Yield of healthy heads was converted into quintal per hectare.

The cost of Insecticides and biopesticides used in the experiment was obtained from the local market. The total cost of plant protection consisted of cost of treatment, sprayer, rent and labour charges for the spray. There are two sprays throughout the research period and the overall plant protection expenses was calculated.

Table 1. Effect of certain insecticidesand bioagents on larval population of diamondback moth (*Plutella xylostella*)

S.No	Treatments	Larval population of diamondback moth									Overall mean population	Yield (q/ha)	C:B ratio
		1st spray					2nd spray						
		1DBS	**3DAS**	**7DAS**	**14DAS**	**MEAN**	**3DAS**	**7DAS**	**14DAS**	**MEAN**			
T1	Chlorantraniliprole 18.5 % SC (0.3ml/l)	04.06 (11.60)*	02.6^{d} (9.27)*	01.8^{e} (7.70)*	02.13^{e} (8.39)*	2.17 (8.46)*	01.13^{e} (6.10)*	00.93^{f} (5.53)*	00.53^{f} (4.17)*	0.86 (5.27)*	01.52	325	1:6.37
T2	Indoxacarb 14.5% SC (1ml/l)	04.26 (11.91)*	03.13^{c} (10.18)*	02.33^{de} (8.76)*	02.5^{cd} (9.09)*	2.65 (9.35)*	01.6^{cd} (7.25)*	01.26^{ef} (6.45)*	01.2^{de} (6.27)*	1.35 (6.66)*	02.00	300	1:6.33
T3	Emamectin benzoate 5 %SG (0.6 gm/l)	04.6 (12.32)*	03.26^{c} (10.39)*	02.66^{cd} (9.37)*	02.93^{b} (9.85)*	2.95 (9.82)*	01.73^{c} (7.56)*	01.53^{de} (7.1)*	01.6^{cd} (7.24)*	1.62 (7.31)*	02.28	295	1:6.25
T4	Spinosad 45% SC (2ml/l)	04.4 (12.09)*	02.73^{d} (9.50)*	02.06^{e} (8.23)*	02.33^{de} (8.78)*	2.37 (8.84)*	01.26^{de} (6.44)*	01.2^{ef} (6.27)*	00.93^{ef} (5.51)*	1.13 (6.08)*	01.75	310	1:5.75
T5	*Beauveria bassiana* (1x10^{8}CFU/ml) (2ml/l)	04.46 (12.19)*	04.73^{b} (12.58)*	03.2^{bc} (10.30)*	02.73^{bc} (9.51)*	3.55 (10.79)*	02.46^{b} (9.02)*	02.2^{bc} (8.51)*	01.93^{bc} (7.98)*	2.2 (8.51)*	02.87	270	1:5.72
T6	*Metarhizium anisiopliae* (1x10^{8}CFU/ml) (2ml/l)	04.8 (12.63)*	04.86^{ab} (12.72)*	03.26^{b} (10.39)*	02.86^{b} (9.47)*	3.66 (10.95)*	02.66^{b} (9.39)*	02.4^{b} (8.90)*	02.06^{b} (8.26)*	2.37 (8.85)*	03.02	260	1:5.50
T7	*Bacillus thuringiensis* (1x10^{8}CFU/ml) (2ml/)	04.46 (12.19)*	04.6^{b} (12.37)*	03.06^{bc} (10.08)*	02.66^{bc} (9.38)*	3.44 (10.61)*	02.33^{b} (8.77)*	01.86^{cd} (7.85)*	01.6^{cd} (7.26)*	1.93 (7.92)*	02.68	280	1:5.97
T0	Control	04.33 (11.97)*	05.2^{a} (13.16)*	05.73^{a} (13.84)*	06.4^{a} (14.65)*	5.77 (13.89)*	06.73^{a} (15.03)*	07.2^{a} (15.56)*	07.8^{a} (16.21)*	7.24 (15.60)*	06.51	150	1:3.34
	F-test	NS	S	S	S	S	S	S	S	S	-	-	-
	C.D. at 0.5%	---	00.35	00.55	00.30	0.99	00.41	00.41	00.40	0.51	-	-	-
	S.EdA (±)	00.29	00.16	00.82	00.14	0.46	00.18	00.19	00.18	0.24	-	-	-

DBS= Days before spraying, *Figures in parenthesis are Arc sin transformed values*

Total income was realized by multiplying the total yield per hectare by the prevailing market price, while the net benefit is obtained by subtracting the total cost of plant protection from the total income. Benefit over the control for each sprayed treatment was obtained by subtracting the income of the control treatment from that of each sprayed treatment.

3. RESULTS AND DISCUSSION

Effect of different insecticides and biopesticides on the incidence of *Plutella xylostella* revealed that all the treatments were significantly superior in reducing the infestation of Diamondback moth resulting in increasing the yield, significantly as compared to control. The first spray was given after 30 days of transplanting. The larval population of Diamondback moth on cabbage after first spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest larval population, was recorded in Chlorantraniliprole 18.5% SC (2.17) followed by Spinosad 45% SC (2.37), Indoxacarb 14.5% SC (2.65), Emamectin benzoate 5SG (2.95), *Bacillus thuringeninsis* ($1x10^8$CFU/ml) (3.44) and *Beauvaria bassiana* ($1x10^8$CFU/ml) (3.55). The treatment *Metarhizium anisiopilae* ($1x10^8$CFU/ml) (3.66) was least effective among all the treatments but maximum damage was recorded in control plot (5.77) (Table 1).

The second spray was after 15 days of first spray. The data for second spray shows minimum larval population in Chlorantraniliprole 18.5% SC (0.86) followed by Spinosad 45%SC (1.13), Indoxacarb 14.5% SC (1.35), Emamectin benzoate 5% SG (1.62), *Bacillus thuringeninsis* ($1x10^8$CFU/ml) (1.93) and *Beauvaria bassiana* ($1x10^8$CFU/ml) (2.2) The treatment *Metarhizium anisiopliae* ($1x10^8$CFU/ml) (2.37) was least effective among all the treatments. The highest mean larval population was recorded in Control plot (7.24) (Table 1).

All the insecticides were found very effective and significantly over control. The data for overall mean larval population was recorded of which least larval population was recorded in Chlorantraniliprole 18.5% SC (1.52), Spinosad 45%SC (1.75), Indoxacarb 14.5% SC (2.00), Emamectin benzoate 5%SG (2.28), *Bacillus thuringeinsis* ($1x10^8$CFU/ml) (2.68) and *Beauvaria bassiana* ($1x10^8$CFU/ml) (2.87) The treatment *Metarhizium anisiopliae* ($1x10^8$CFU/ml) (3.02) was least effective among all the treatments but control treatment had higher mean larval population of 6.51 (Table 1).

Highest yield and benefit cost ratio was recorded in Chlorantraniliprole 18.5% SC (325 q/ha) (1:6.37) is similar to the findings of Sharma et al., [8], Spinosad 45% SC (310 q/ha) (1:5.75) is similar to the findings of Gill et al., [9] and Gaddam et al., [10], Indoxacarb 14.5% SC (300 q/ha) (1:6.33) is similar to the findings of Harika et al., [11] and Gaddam et al., [10], Emamectin benzoate 5% SG (295 q/ha) (1:6.25) is similar to the findings of Akbar et al., [12], Bacillus thuringeinsis ($1x10^8$CFU/ml) (280 q/ha) (1:5.97) is similar to the findings of Choyon et al., [13] and Beauvaria bassiana ($1x10^8$CFU/ml) (270q/ha) (1:5.72) is similar to the findings of Debbarma et al., [14] The treatments Metarhizium anisiopliae ($1x10^8$CFU/ml) (260 q/ha) (1:5.50) is similar to the findings of Singh et al., [15], and the lowest yield was recorded in control (150 q/ha) (1:3.34) (Table 1).

4. CONCLUSION

From the present study, the results it showed that T_1 Chlorantraniliprole 18.5 % SC most effective treatment against diamondback moth of Mean larval population and producing maximum yield and recorded highest Cost-Benefit ratio compared to other treatments. While T2 Indoxacarb 14.5% SC, T_3 Emamectin benzoate 5 %SG, T4 Spinosad 45% SC , has shown average results has proved to be least effective chemicals. *Beauveria bassiana*, *Metarhizium annisopliae* and *Bacillus thuringiensis,* found to be least effective in managing *Plutella xylostella*. Botanicals are the part of integrated pest management in order to avoid indiscriminate use of pesticides causing pollution in the environment and not much harmful to beneficial insects.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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