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Efficacy of Selected Insecticides with Botanicals and Bio-agents against Diamondback Moth, *Plutella xylostella* (L.) in 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 2022-2023 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 T1 Chlorantraniliprole 18.5 % SC, T2 Indoxacarb 14.5% SC, T3 Flubendiamide 39.3 SC, T4 *Bacillus thuringeninsis* ($1x10^8$ CFU/ml), T5 *Metarhizium anisiopilae* ($1x10^8$ CFU/ml), T6 NSKE 5%, T7 Spinosad 45% SC and along with an untreated T8 control against *Plutella xylostella* in Cabbage. Mean reduction in the larval population of Diamond back moth per plant revealed that all treatments significantly superior over control (4.200). Among all the treatments T1 Chlorantraniliprole 18.5 % SC recorded highest larval reduction with mean (1.000) of *Plutella Xylostella* followed by T2 Indoxacarb 14.5% SC

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(1.178), T7 Spinosad 45% SC (1.311), T3 Flubendiamide 39.3 SC (1.322), T5 *Metarhizium anisiopilae* (1x10^8 CFU/ml) (1.456), T4 *Bacillus thuringeninsis* (1x10^8 CFU/ml) (1.522) and T6 NSKE 5% (1.734) and least recorded in T8 control (4.200). Highest yield 336 q/ha as well as B:C ratio (1:5.35) was obtained from the treatment Chlorantraniliprole 18.5% SC followed by T2 Indoxacarb 14.5% SC (1:5.28), T7 Spinosad 45% SC (1:4.85) T3 Flubendiamide 39.3 SC (1:4.83), T5 *Metarhizium anisiopilae* (1x10^8 CFU/ml) (1:4.18), T4 *Bacillus thuringeninsis* (1x10^8 CFU/ml) (1:4.71) and T6 NSKE 5% (1:3.52) superior over the control (1:2.87).

Keywords: Bacillus thuringeninsis; chlorantraniliprole; cost benefit ratio; Metarhizium anisiopilae; NSKE; Plutella xylostella.

1. INTRODUCTION

“Cabbage, (*Brassica oleracea* var. *capitata*) an herbaceous plant of Family Brassicaceae. It is one of the most popular cole vegetables grown in India. It is originated in Europe. It is commonly used fresh as boiled vegetables cooked in curries, process, salad and 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” [1].

“Regular consumption of dark green leafy vegetables is highly recommended because of their potentialin reducing chronic disease and glucosinolates in cabbage reduced risk of cancer induction and development. It is known to possess medicinal properties and its enlarged terminal buds is a rich source of Ca, P, Na, K, S, vitamins A, Vitamin C and dietary fiber. It is said to be good for person suffering from diabetes” [1].

“Leaves are low in calories (27 per cent), fat (0.1 per cent) and carbohydrates (4.6 per cent). It is good sources of protein (1.3 per cent) which contains all essential amino acids, particularly Sulphur containing amino acids. Cabbage is an exceptional source of minerals such as calcium (39 mg), iron (0.8 mg), magnesium (10 mg), sodium (14.1 mg), potassium (114 mg) and phosphorus (44 mg). It has considerable amounts of β carotene provitamin A, ascorbic acid, riboflavin, niacin, and thiamine. Ascorbic acid content varies from 30-65 mg per 100 g fresh weight. Flavor in cabbage leaves is due to the glycoside sinigrin. It contains goitrogens which cause enlargement of thyroid glands. The Lumbee tribe of North carolina has traditionally used the leaves of *Brassica oleracea* in medicine that they believed to have cleansing qualities, as well as a mild laxative, an anti- inflammatory, and treatment for glaucoma and pneumonia” [11].

“In 2020, world production of cabbages was 71 million tones, led by China with 48% of the world total (table). Other substantial producers were India, Russia, and South Korea. (UN food and Agriculture Organization, Corporate Statistical Database)” (FAOSTAT, 2022). “ India is the largest producer of cabbage after China. India accounts for 8755000 tons of productivity in an area of 388000/ha. In India, Uttar Pradesh accounts for production of 5.7 million tones in an area of 0.72 million ha” [2].

“The major insect pests, which cause maximum yield losses in cabbage are Diamond back moth (*Plutella xylostella* L), cabbage butterfly, (*Pieris brassicae* L), cabbage aphid (*Brevicoryne brassicae* L.), cabbage semilooper (*Trichoplusia ni*), leaf webber (*Crocidolomia binotalis*), cabbage head borer,(*Hellula undalis* Fab.). Diamondback moth is the most destructive pest in cabbage growing areas and the yield loss were reported up to 52% in India” [3].

“However, the set back to optimum cabbage production is the attack of insect pests, the most important of which is the diamondback moth (DBM), *Plutella xylostella* which has become a single limiting factor in the production of quality heads. It is one of the most destructive insect pests of cruciferous vegetables, currently accounting for US$2.7 billion worth of annual worldwide crop losses. Management of this pest depends largely on imposing heavy quantities of synthetic chemical pesticides all over the world” [4]. The DBM has developed resistance to all major classes of insecticides. More management of this pest poses serious concern due to development of insecticide resistance to carbamate andsynthetic pyrethroids [10].

2. MATERIALS AND METHODS

Field experiment was conducted at Central Research Farm (CRF), Department of Entomology, SHUATS, Naini, Prayagraj, Uttar Pradesh ,India in a Randomized Block Design with eight treatments replicated three times using the variety Green Soccer in a plot size of (2mx1m) at a spacing of (60x45cm) with a recommended package of practices excluding plant protection. The soil of the experimental site was well drained and medium high.

All of the insecticides used in the study were sprayed as foliar application. The eight different treatments were used with dosage consisting of T1 Chlorantraniliprole 18.5% SC 0.5ml/L, T2 Indoxacarb 14.5% SC 0.6ml/L, T3 Flubendiamide 39.3 SC 0.2ml/L, T4 *Bacillus thuringeninsis* (1x 10^8 CFU/ml) 2ml/L, T5 *Metarhizium anisiopilae* (1x10^8CFU/ml) 4gm /L, T6 NSKE 5gm/L, T7 Spinosad 45% SC 0.5ml/L, T8 Control. Two sprays were carried out at intervals of 15 days during the experiment to assess the effectiveness of pesticides. On five randomly chosen and tagged plants in each plot, pre and post -treatment observations on the percent damage of Diamondback moth infestation was made shortly before 24 hours and 3rd, 7th and 14thdays , respectively.

Application of treatments was started when the threshold action level of one diamond back moth per plant. Spray was made using manually operated knapsack hand.

Preparation of insecticidal spray solutions: The Insecticidal spray solution of desired concentration as per treatment was freshly prepared every time at the site of experimentation just before the start of spraying operations. The spray solution of a desired concentration was preparing by adopting the following formula,

$$V = \frac{(CXA)}{\%a.i}$$

Where,

V = Volume/ weight of formulated insecticide required.
C = Concentration required.
A = Volume of solution to be prepared.
a.i. = given percentage of active ingredient.

Observation: The population of caterpillar was recorded on 5 plants randomly selected and tagged from each plot. After that mean of three replications was calculated for each treatment and the same was done with the untreated plot. The population of *Plutella xylostella* was recorded 1 day before spraying and on 3rd day, 7th day and 14th day after insecticidal application. The average population of larvae of diamondback moth per plant was worked out for statistical analysis. While recording yield data, only marketable heads was considered. Yield obtained from net plot was converted into per hectare [12].

Cost benefit ratio of treatments: Gross returns was calculated by multiplying total yield with market price of the produce. Cost of cultivation and cost of treatments was deducted from the gross returns, to find out returns and cost benefit of ratio by following formula,

$$\text{BCR} = \frac{\text{Gross Returns}}{\text{Cost of Cultivation}}$$

Where,
Benefit Cost Ratio

3. RESULTS AND DISCUSSION

The present study entitled, "Efficacy of selected insecticides with Botanical and Bio-agents against diamondback moth, *Plutella xylostella* (L.) in Cabbage, *Brassica oleracea* var *capitata* (L.)" The data so obtained through observation on various aspects were subjected to statistical analysis wherever necessary and the data was compiled. Results thus obtained are presented aspect wise here under, the data on the larval population of Diamondback moth *Plutella xylostella* in cabbage 3rd,7th and 14th after first spray revealed that all the chemical treatments, were significantly superior over control (3.711). Among all the treatments lowest larval population was recorded in T1 Chlorantraniliprole 18.5 % SC (1.289), T2 Indoxacarb 14.5% SC (1.489), T7 Spinosad 45% SC (1.533) T3 Flubendiamide 39.3 SC (1.533) followed by T5 *Metarhizium anisiopilae* (1x108 CFU/ml) (1.666), T4 *Bacillus thuringeninsis* (1x108 CFU/ml) (1.711) and T6 NSKE 5% (2.067).

The data on the larval population of Diamondback moth *Plutella xylostella* in cabbage 3rd,7th and 14th day after Second spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest larval population was recorded in T1 Chlorantraniliprole 18.5 % SC (0.711),

Table 1. Efficacy of selected insecticides with botanicals and bio-agents against diamondback moth, *Plutella xylostella* (L.) in cabbage, *Brassica oleracea var capitata* (L.)

S. No	Treatments	Larval Population of diamondback moth								Overall mean	Yield (q/ha)	C:B Ratio
		First Spray				Second spray						
		1 DBS	3 DAS	7DAS	14DAS	1DAS	3DAS	7DAS	14DAS			
T1	Chlorantraniliprol 18.5%SC	3.333	2.000^{c}	0.600^{e}	1.067^{d}	1.067^{d}	0.800^{d}	0.600^{e}	0.733^{c}	1.000^{b}	336	1:5.35
T2	Indoxacarb 14.5% SC	3.000	2.067^{c}	0.733^{de}	1.400^{cd}	1.400^{cd}	0.867^{d}	0.733^{de}	1.000^{bc}	1.178^{b}	325	1:5.28
T3	Flubendiamide 39.3 SC	2.800	2.200^{bc}	1.000^{bcd}	1.467^{c}	1.467^{c}	1.138^{bcd}	1.000^{bcd}	1.200^{bc}	1.322^{b}	265	1:4.83
T4	*Bacillus thuringeninsis* ($1x10^{8}$ CFU/ml)	2.867	2.267^{bc}	1.133^{bc}	1.600^{bc}	1.600^{bc}	1.467^{bc}	1.133^{bc}	1.400^{b}	1.522^{b}	241	1:4.71
T5	*Metarhizium anisiopilae* ($1x10^{8}$ CFU/ml)	2.867	2.333^{bc}	1.067^{bcd}	1.533^{c}	1.533^{c}	1.400^{bc}	1.067^{bcd}	1.267^{b}	1.456^{b}	217	1:4.18
T6	NSKE	3.333	2.600^{b}	1.267^{b}	1.933^{b}	1.933^{b}	1.533^{b}	1.267^{b}	1.400^{b}	1.734^{b}	192	1:3.52
T7	Spinosad 45% SC	3.000	2.133^{bc}	0.867^{cde}	1.400^{cd}	1.400^{cd}	1.067^{cd}	0.867^{cde}	1.333^{b}	1.311^{b}	318	1:4.85
T8	Control	2.733	3.533^{a}	4.600^{a}	3.867^{a}	3.867^{a}	4.467^{a}	4.600^{a}	5.000^{a}	4.200^{a}	140	1:2.87
	F-test	NS	S	S	S	S	S	S	S	S	--	
	C.D. (P=0.05)		0.480	0.338	0.389	0.389	0.446	0.383	0.495	0.894	--	
	C.V	8.978	11.451	13.291	12.449	12.499	15.988	15.533	16.945	22.048	--	

*DBS**-Day Before Spray*, DAS***- Day After Spray **, NS= Non-Significant***, S-Significant ****

T2 Indoxacarb 14.5% SC (0.867), T7 Spinosad 45% SC (1.089) T3 Flubendiamide 39.3 SC (1.111) followed by T5 *Metarhizium anisiopilae* (1x108 CFU/ml) (1.245), T4 *Bacillus thuringeninsis* (1x108 CFU/ml) (1.333) and T6 NSKE 5% (1.400) and control plot (4.689).

The data revealed on population of *Plutella xylostella* over control on Overall mean revealed that all the treatments were significantly superior over control (4.200). Among all the treatments minimum larval population was recorded in T1 Chlorantraniliprole 18.5 % SC (1.000) similar findings made by Kommoji et al. [2], T2 Indoxacarb 14.5% SC (1.178), similar findings made by Pavithra et al. [9], T7 Spinosad 45% SC (1.311) similar findings made by Devi and Tayde, [5], T3 Flubendiamide 39.3 SC (1.322) similar findings made by Lal et al., [6] followed by T5 *Metarhizium anisiopilae* (1x108 CFU/ml) (1.456),similar findings made by Devi and Tayde, [5], T4 *Bacillus thuringeninsis* (1x108 CFU/ml) (1.522) similar findings made by Purushotam et al. [8] and T6 NSKE 5% (1.734) similar findings made by Khan and Tayde, [1].

All the insecticides were found very effective and significantly superior over control. The minimum larval population and the highest yield was recorded in T1 Chlorantraniliprole 18.5 % SC (336q/ha), followed by T2 Indoxacarb 14.5% SC (325q/ha), T7 Spinosad 45% SC (318q/ha) T3 Flubendiamide 39.3 SC (265q/ha) followed by T5 *Metarhizium anisiopilae* (1x10^8 CFU/ml) (217q/ha), T4 *Bacillus thuringeninsis* (1x10^8 CFU/ml) (241q/ha) and T6 NSKE 5% (192q/ha) and the lowest yield is recorded in T0 Control (140q/ha) similar findings made by Kumar and Kumar, [7], Khan and Tayde, [1], Kommoji et al. [2].

Cost benefit ratio (CBR): When cost benefit ratio worked out, interesting result was achieved, among the treatment studied, the best and most economical treatment is in T1 Chlorantraniliprole 18.5 % SC (1:5.35) similar findings made by Kommoji et al. [2], T2 Indoxacarb 14.5% SC (1:5.28),similar findings made by Pavithra et al. [9], T7 Spinosad 45% SC (1:4.85) similar findings made by Devi and Tayde [5], T3 Flubendiamide 39.3 SC (1:4.83) similar findings made by Lal et al., [6] followed by T5 *Metarhizium anisiopilae* (1x108 CFU/ml) (1.4.18),similar findings made by Devi and Tayde, [5], T4 *Bacillus thuringeninsis* (1x108 CFU/ml) (1:4.71) similar findings made by Purushotam et al. [8] and T6 NSKE 5% (1:3.52) similar findings made by Khan and Tayde, [1] and control T0 (1:2.87) similar findings made by Kumar and Kumar, [7], Khan and Tayde, [1], Kommoji et al. [2].

4. CONCLUSION

From the present study finding, it was revealed that among all treatment T1 Chlorantraniliprole 18.5%SC recorded best and proved best effective for Diamondback moth, (*Plutella xylostella*) followed by T2 Indoxacarb 14.5% SC, T7 Spinosad 45% SC and T3 Flubendiamide 39.3 SC in controlling (*Plutella xylostella*) in cabbage (*Brassica oleracea*) on mean larval population. Therefore, the botanicals *i.e*., T5 *Metarhizium anisiopilae* (1x10^8 CFU/ml), T4 *Bacillus thuringeninsis* (1x10^8 CFU/ml) and T6 NSKE 5% may be useful in devising proper integrated pest management strategy against Diamond Back Moth *(Plutella xylostella*).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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