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Efficacy of Newer Selected Insecticides, *Beaveria bassiana* and Neem Oil against Diamond Back Moth (*Plutella xylostella*)(L.) in Cabbage *(Brassica oleracea var capitata*)

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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

The trail was conducted at Crop research farm, Department of Entomology of Naini Agriculture institute, SHUATS, Prayagraj, (U.P) during rabi 2021-2022 to study the efficacy of newer selected insecticides, *Beaveria bassiana* and Neem oil against Diamond back moth (*Plutella xylostella*) in Cabbage (*Brassica oleracea var capitata*) and the experiment was laid out in randomised block design with eight treatments and each was replicated thrice using a variety green soccer 546. The treatments are Spinosad 45% SC, Indoxacarb 14.5%SC, Emamectin benzoate 5%SG, Chlorantraniliprole 18.5%SC, Fipronil 5%SG, *Beaveria bassaina (*1x10^8 CFU/gm), Neem oil 0.3% along with an untreated control. The data on Percent reduction of larval population were significantly superior over control but among all treatments, chlorantraniliprole 18.5% SC is best effective for diamond back moth had showing (80.35%) percent reduction of larval population followed by Spinosad 45% SC (77.06%), Indoxacarb 14.5SC (73.43%), Emamectin benzoate 5%SG (71.77%), Fipronil (68.26%),*Beaveria bassiana* (67.06%) and Neem oil was least effective had showing (61.18%) percent reduction of larval population but superior over control. Among all the treatments, highest yield (314.9q/ha) and Cost-benefit ratio (1:7.59) was recorded in Chlorantraniliprole 18.5 %SC followed by Spinosad 45%SC with a yield of (273.73q/ha) and Cost-benefit ratio (1:6.77) as compared to control.

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1. INTRODUCTION

Cabbage is most popular winter vegetable and it belongs to family Cruciferae and chromosome number 2n = 24. Cabbage is rich source of vitamin C, Na, P, and dietary fibre. It is good for people who are suffering from diabetes. India is the largest producer of cabbage after China. India accounts for 8755000 tonnes of productivity in an area of 388000/ha. In India, Uttar Pradesh accounts for production of 5.7 million tonnes in an area of 0.72 million ha.

Diamond back moth *Plutella xylostella* (L.) (Family: Plutellidae) is one of the most destructive pests causing yield loss of 52 % in Cabbage [1]. Cabbage crop is attacked by 37 insect pests and out of that, diamond back moth is the important circumstance pest and it causing globally yield loss of approximately US$1 billion dollar. Quality and production of cabbage is scale down due to this pest attack [2]. The caterpillar fedoursly feed on cabbage leaves and make a tunnels underside of leaves and in severe infestation leaf was fully scrapped and leads to decline of yield.

In India, Diamond back moth was first observed by Fletcher 1914. Diamond back moth was first documented in Europe region and after that it spreads to almost over the countries but their infestation varies from place to place [3]. Diamond back moth inaugurate resistant to almost all group of insecticides. Due to the massive use and frequent of insecticides leading to environmental pollution, residual effect, decline in natural enemies' population, health hazards, insecticide resistance, so examing all these points, new molecules of insecticides are introduced to break down the chain of these parameters. Especially, avermectins, pyrazoles, microbes, spinosyns, biopesticides playing a major role in managing the diamond back moth.

Diamond back moth has developed resistant to all types of insecticides so it is necessary select new molecules which are highly toxic to insect pests even at low dosages and these new molecules are satifisying the eco-friendly qualities, easy availability in local region, less residual effect, non-toxic to mammals, ecological safety.

By considering above points newer pest management plan was implemented comprising of insecticides/ biopesticide having different mode of action and different formulation were evaluated against major pest of cabbage. Therefore, keeping above facts, recent advance research was undertaken ‘‘Efficacy of Newer Selected insecticides, *Beauveria bassiana*, Neem oil against diamond back moth *Plutella xylostella* (L.) in cabbage (*Brassica oleracea var. capitata*) and to Calculate Cost Benefit ratio.

2. MATERIALS AND METHODS

2.1 Experimental Site and Location

The Crop research farm was located on the right side of Rewa Road at 25° 22’ 15.888” North Latitude and 81°51’ 31.4712” East longitude and is about 98 m above mean sea level and situated 5km away on the right bank of Yamuna River.

2.2 Climate Condition

The climate at Prayagraj is typical subtropical which prevails in the eastern part of Uttar Pradesh. The extremes of both summer and winter are experienced here. The maximum temperature was recorded during summer up to 47°C and the minimum temperature was recorded during winter up to 1.5°C. All necessary facilities for cultivation of crop were made available at research farm.

2.3 Experimental Details

The experiment was laid out in a randomized block design with eight treatments replicated three times using variety green soccer 546 in a plot size of (2m×2m) at a spacing of (60×45cm) with a recommended package of practices excluding plant protection. The Efficacy of Selected Insecticides, one biopesticide i.e., *Beauveria bassiana* (Almax) and 1 botanical i.e., Neem oil and five insecticides include Spinosad (Tracer), Indoxacarb (oxadizine) , Emamectin benzoate (Rebel), Chlorantraniprole (coragen), Fipronil (Regent) were purchased from local pesticide traders. For comparison untreated check was included. Treatments application were started once the pest level cut across the ETL i.e., larvae per plant then the second application was given at 15 days interval respectively.

2.4 Assessment of Pest Population

The insect larva was count from randomly selected plant in every plot and population per 5 plants was noted. 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 before 1day spraying and on 3rd day, 7th day and 14th day after insecticidal application.

Then Percent reduction was calculated by this formula:

$$\text{Percent Reduction (\%) formula: } \frac{T_a - T_b}{T_a} \times 100$$

Where,

T_a = Number of pests individuals on particular day after application.
T_b = Number of pest individuals on particular day after application.
P = Percent reduction in population of pest.

2.5 Marketable Head Yield

Healthy cabbage heads were harvested when they reached proper marketable size and weight from each treatment and it was evaluated for quintal per hectare and subjected to statistical analysis for variance.

2.6 Statistical Analysis

The data recorded on larval population of diamondback moth (*Plutella xylostella*) and yield of cabbage of each treatment based on replication wise were subjected to analysis of variance.

2.7 Cost-Benefit Ratio

Cost effectiveness of each treatment was evaluated based on net returns. Net return of each treatment was worked out by deducting total cost of the treatment from gross returns. Total cost of production included both cultivation as well as plant protection charges.

3. RESULTS

3.1 Percent Reduction of Diamond Back Moth after First Spray

The data (Table 2) on mean percent reduction of Diamondback moth on 3rd, 7th, 14th day after first spray reporting that all the treatments were significantly superior over control. Around all the treatments, Chlorantraniliprole 18.5%SC recorded best effective for Diamondback moth (DBM) had showing maximum (70.23%) percent reduction of larval population followed by Spinosad 45%SC (67.38%) and Indoxacarb 14.5SC (63.51%) was observed par with Emamectin Benzoate 5% SG (61.68%) on percent reduction of larval population whereas, Fipronil 5% SC (57.72%), Beauveria bassiana (1X108 CFU/gm) (56.58%) was found par with each other on percent reduction of larval population over control. Neem oil 0.3% was found least effective around all treatments with minimum larval percent reduction of (50.35%) but significantly superior over control.

3.2 Percent Reduction of Diamond Back Moth after Second Spray

The data (Table 2) on mean percent reduction of Diamond back moth on 3^{rd},7^{th},14^{th} day after second spray reporting that all the treatments were significantly superior over control. Around the treatments Chlorantraniliprole 18.5%SC recorded best effective for Diamondback moth had showing maximum (90.38%) percent reduction of larval population followed by with Spinosad 45% SC (86.74%) and Indoxacarb 14.5% SC (83.35%) was observed par with Emamectin Benzoate 5% SG (81.86%) on percent reduction of larval population whereas, Fipronil 5% SC (78.80%), *Beauveria bassiana* ($1X10^8$ CFU/gm) (77.55%) was found par with each other on percent reduction of larval population over control, Neem oil 0.3% was found least effective among all treatments with minimum percent reduction of (72.01%) larval population but significantly superior over control.

3.3 Percent Reduction of Diamond Back Moth after First and Second Spray

The data (Table 2) on mean percent reduction of Diamond back moth after first and second spray reporting that all the treatments were significantly superior over control. Around all the treatments Chlorantraniliprole 18.5%SC recorded best effective for Diamondback moth had showing maximum (80.35%) percent reduction of larval population followed by with Spinosad 45% SC (77.06%) and Indoxacarb 14.5% SC (73.43%) was observed par with Emamectin Benzoate 5% SG (71.77%) on percent reduction of larval population whereas, Fipronil 5% SC (68.26%), Beauveria bassiana (1X108 CFU/gm) (67.06%) was found par with each other on percent reduction of larval population over control, Neem oil 0.3% was found least effective among all treatments with minimum percent reduction of (61.18%) larval population but significantly superior over control.

Table 1. Particulars of treatments used

Treatment No.	Treatment	Dose	Trade name	Group
T 1	Spinosad 45SC	0.5ml/L	Tracer	Spinosyn
T 2	Indoxacarb 14.5SC	0.25ml/L	Kare plus	Oxadiazine
T 3	Emamectin Benzoate 5% SG	0.45ml/L	Rebel	Avermectin
T 4	Chlorantraniliprole18.5%SC	0.1ml/L	Coragen	Diamide
T 5	Fipronil 5% SC	25-50gma.i./ha	Regent	Phenyl pyrazole
T6	*Beauveria bassiana* (1X10^{8} CFU/gm)	5gm/L	Almax	Biopesticide
T 7	Neem oil 0.3%	3ml/L	Neem Aura	Botanical
T 8	Control	_____	_____	_____

3.4 Cost- Benefit Ratio

All the treatments were resulted very effective and significantly superior over control. The data (Table 3) on cabbage head yield open up that Chlorantraniliprole 18.5%SC recorded highest yield (283.6q/ha) followed by Spinosad 45%SC (273.71q/ha) Indoxacarb 14.5%SC (233.48 q/ha), Emamectin benzoate 5% SG (221.72 q/ha), Fipronil 5% SC (211.27 q/ha), *Beauveria bassiana* (1X108CFU/gm) (201.57 q/ha), Neem oil 0.3% (194.90 q/ha) when compared compared to control (165.15q/ha).

When the Cost benefit ratio analysis was carried out, incredible results were obtained. Chlorantraniliprole 18.5%SC acquire highest CBR (1:7.59) followed by Spinosad 45%SC (1:6.77), Indoxacarb 14.5%SC (1:6.33), Emamectin Benzoate 5% SG (1:5.25), Fipronil 5% SC (1:5.78), *Beauveria bassiana* (1X10^{8} CFU/gm) (1:5.50), Neem oil 0.3% (1:5.1) as compared to control (1:4.32)

4. DISCUSSION

The present study entitled "Efficacy of selected newer insecticides, *Beaveria bassiana* and Neem oil against diamond back moth(*Plutella xylostella*) in cabbage (Brassica *oleracea var capitata*).

The data (Table2) on percent reduction of Diamondback moth on Cumulative mean of first and second spray reported that all the treatments were significantly superior over control. Around all the treatments used, Maximum reduction of diamond back moth was observed in Chlorantraniliprole 18.5%SC (80.35%) recorded best effective this results supported by Dostara et al., [4] followed by Spinosad 45%SC (77.06%) Mandal et al., [5] and Indoxacarb 14.5%SC (73.43%) supported by Jaishree banjaree [6], Emamectin Benzoate 5% SG (71.77%) AD *et al* [7], Fipronil 5% SC(68.26%) supported Deivendran et al., [8], *Beauveria bassiana* (1X10^{8} CFU/gm) (67.06%)supported by Shelton et al., [9]. Nikhil et al., [10] reported that Neem oil 0.3% was found least effective among all treatments with minimum percent reduction of (61.18%) but significantly superior over control.

The data (Table 3) on cabbage head yield open up that Chlorantraniliprole 18.5%SC recorded highest yield (283.6q/ha) finding supported by Dostara et al., [4] followed by Spinosad 45%SC (273.71q/ha)supported by Sawant et al., [11], Indoxacarb 14.5%SC (233.48 q/ha) results supported by Nikhita et al., [1] Emamectin benzoate 5% SG (221.72 q/ha) Prasad et al., [12], Fipronil 5% SC (211.27 q/ha) supported by Deivendran et al., [8]

Beauveria bassiana (1X108CFU/gm) (201.57 q/ha) supported by Shelton et al., [9]. Neem oil 0.3% (194.90 q/ha) results supported by Devi et al., [13] when compared compared to control (165.15q/ha).

The present above studies revealed that Chlorantraniliprole, Spinosad, Indoxacarb, was superior and they were highly effective for diamond back moth larval population whereas ,Emamectin benzoate, Fipronil, *Beaveria bassiana* was moderately effective against diamond back moth. Deivendran et al., [8] supported our finding that fipronil is moderately effective against Diamond back moth. Yadav et al., [14] supported our finding that indoxacarb had better effective than neem but it is less efficient than Spinosad. Nikam et al., [15] supported our finding that Spinosad has better efficacy and highly toxic to DBM. Lal and meena [16] supported our finding that chlorantraniliprole is a commanding molecule against diamond back moth. Mandal et al., [5] supported our finding that Spinosad is superior molecule against diamond back moth.

Our results, justify that chlorantraniliprole is best effective insecticide for controlling diamond back moth showing maximum reduction of larval population supported by

Table 2. Efficacy of different insecticides, *Beauveria bassiana* and Neem oil against diamond back moth (*Plutella xylostella*) in Cabbage (*Brassica oleracea var capitata)*

		Percent Reduction of Larval Population/ 5 Plants								
		First spray				Second spray				Cumulative mean
	Treatments	3DAS	7DAS	14DAS	MEAN	3DAS	7DAS	14DAS	Mean	
T_1	Spinosad 45%SC	59.60^{a}	73.33^{ab}	69.23^{ab}	67.38^{b}	77.87^{ab}	90.10^{b}	92.26^{b}	86.74^{b}	77.06^{b}
T_2	Indoxacarb 14.5%SC	55.77^{b}	69.52^{bc}	65.47^{bc}	63.51^{c}	74.15^{bc}	87.34^{bc}	88.56^{c}	83.35^{c}	73.43^{c}
T_3	Emamectin benzoate 5%SG	53.62^{b}	67.61^{cd}	63.62^{cd}	61.68^{d}	72.31^{cd}	86.49^{c}	86.78^{cd}	81.86^{c}	71.77^{d}
T_4	Chlorantraniliprole 18.5%SC	62.49^{a}	76.18^{a}	72.04^{a}	70.23^{a}	80.67^{a}	93.81^{a}	96.66^{a}	90.38^{a}	80.35^{a}
T_5	Fipronil 5% SC	49.97^{c}	63.80^{de}	59.91^{de}	57.72^{e}	68.66^{de}	82.87^{d}	84.87^{d}	78.80^{d}	68.26^{e}
T_6	Beaveria bassiana (1x 10^{8} CFU/gm)	48.03^{c}	62.85^{e}	58.96^{e}	56.58^{f}	66.83^{e}	81.92^{d}	83.92^{d}	77.55^{d}	67.06^{e}
T_7	Neem oil 0.3%	42.29^{d}	56.37^{f}	52.40^{f}	50.35^{g}	61.19^{f}	75.45^{e}	79.40^{e}	72.01^{e}	61.18^{f}
T_0	Control	-------	---------	-------	---------	---------	--------	---------	----------	---------
	Sem+_	1.66	1.46	1.44	0.20	1.90	1.32	1.62	1.20	0.27
	CD (0.05)	3.62	3.20	3.14	0.45	4.08	2.88	3.54	1.53	1.38

Table 3. Economics of cultivation

Sr. No:	Treatment	Yield of q/ha	Market price q/ (□)	Total cost of yield (□)	Common cost (□)	Treatment cost (□)	Net profit	Total cost	B:C Ratio
T1	Spinosad 45SC	273.71	750	2,05,283	26494	3800	174989	30,294	1:6.77
T2	Indoxacarb 14.5SC	233.48	750	1,75,110	26494	1145	147471	27,639	1:6.33
T3	EmamectinBenzoate 5% SG	221.72	750	166290	26494	5175	134621	31,669	1:5.25
T4	Chlorantraniliprole 18.5%SC	283.6	750	212700	26494	1495	186206	27,989	1:7.59
T5	Fipronil 5% SC	211.27	750	158453	26494	910	131049	27,404	1:5.78
T6	*Beauveria bassiana*(1X108 CFU/gm)	201.57	750	151178	26494	980	123704	27,474	1:5.50
T7	Neem oil 0.3%	194.9	750	146175	26494	2112	115256	28,606	1:5.10
T0	Control	152.15	750	123750	26494	----------	109369	26,494	1:4.32

Venkestwarulu [17] and Jakhar et al., [18] supported that Spinosad is effective for Diamondback moth had showing maximum reduction of larval population.

The highest yield and cost benefit ratio was recorded in Chlorantraniliprole (283.6q/ha) (1:7.59) respectively and this result supported by Sawant et al., [22] followed by Spinosad (273.71q/ha) (1:6.77) this results supported by Purushotam et al., [19,20].

5. CONCLUSION

From the analysis of present study, it was concluded that Chlorantraniliprole 18.5%SC (0.1ml/L) recorded best and proved best effective for Diamondback moth (DBM) among all treatments followed by Spinosad 45SC (0.5ml/L), Indoxacarb 14.5SC, (0.25ml/L),Emamectin Benzoate 5% SG (0.45gm/L), Fipronil 5% SC (25-50gma.i./ha) in managing (*Plutella xylostella*) in cabbage (*Brassica oleracea*) on Percent reduction of larval population. Therefore, the biopesticide i.e., *Beauveria bassiana* (Almax) and botanical i.e., Neem oil may be useful in devising proper integrated pest management strategy against on Diamond Back Moth *(Plutella xylostella*).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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