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Comparative efficacy of certain chemicals and bio-pesticides against diamondback moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea* L.)

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Abstract
The present investigation entitled "Comparative efficacy of certain chemicals and bio-pesticides against diamondback moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea* L.)" cultivar i.e., "Pride of India" was conducted during *rabi* season November 2021 to March 2022 at Central Research Field, SHUATS. Prayagraj. The Eight treatments, Spinosad 45 SC (0.5ml/lit), Indoxacarb 14.5 SC (1ml/lit) and Emamectin benzoate 5% SG (0.4gm/lit), *Bacillus thuringiensis var. kurstaki* 0.5% WP (2gm/lit), *Beauveria bassiana* 1.15% WP (4gm/lit), NSKE 5% (50gm/lit), Neem oil 1% (10 ml/lit) and untreated control were used against (*Plutella xylostella*) on three replications in randomized block design.
The larval population mean of diamondback moth (*Plutella xylostella*) on cabbage damage population revealed that the larval population of (T_3) Spinosad 45 SC recorded lowest population mean of diamondback moth population i.e. (2.74) which was significantly superior over control followed by (T_1) Indoxacarb 14.5% (3.04) and (T_2) Emamectin benzoate 5% SG (3.25), (T_5) *Bacillus thuringiensis* (3.41), (T_4) *Beauveria bassiana* (3.57), (T_7) Neem oil 1% (3.73) and (T_6) NSKE 5% (3.92) was least effective among all the treatments respectively. The highest yield was recorded in Spinosad 45 SC (217.81 q/ha), followed by Indoxacarb 14.5%SC (180.21 q/ha), Emamectin benzoate 5% SG (165.30 q/ha), *Bacillus thuringiensis* (155.82 q/ha), *Beauveria bassiana* (148.51 q/ha), Neem oil 1% (142.00 q/ha) and NSKE 5% (125.35 q/ha) as compared to untreated check (67.55 q/ha).

Keywords: *Brassica oleracea*, bio-pesticides, cabbage, chemicals, diamondback moth, efficacy, *Plutella xylostella*

Introduction

Cabbage (*Brassica oleracea*), belongs to family cruciferae, is a member of cole group having 18 chromosomes (2n=18, x=9). The term cole originated from the word Colewort meaning wild cabbage. (Singh *et al*., 2021) [13].

Cabbage (*Brassica oleracea* L. var. Capitata) is one of the most important cole crops belonging to family cruciferae and is grown for the thickened main bud called "head". It has been developed from wild cabbage known as cole wart (*Brassica oleracea* L. var Sylvestris). (Meghana *et al*., 2017) [9].

Cabbage is one of the most popular cole vegetables grown in India. It is commonly used fresh as boiled vegetables, cooked in curries and process, salad, etc. It is known to process medicinal properties and its enlarged terminal buds is a rich source of Ca, P, Na, K, S, Vitamin A, Vitamin C and dietary fibre. (Nikam *et al*., 2015) [10].

India is the second largest producer of cabbage after China. India is producing about 8534.5 million tonnes in an area of 372.24 ha with a productivity of 22.9 MT/ha. India is one of the important cabbage growing countries in Asia with an area of 369 thousand hectare and production of 7949 thousand metric tonnes with a productivity of 21.5 metric tonnes per hectare. (Nikam *et al*., 2015) [10]

The impotence insect species of cabbage are Diamondback moth, (*Plutella xylostella* Linnaeus,) Cabbage butterfly, (*Pieris brassicae* Linnaeus,) Cabbage Leaf webber, (*Crocidolomia binotalis* Zeller,) Cabbage head borer, (*Hellula undalis* Fabricius,) Cabbage semilooper, (*Plusia orichalcea* Fabricius,) Cabbage cutworm, (*Agrotis ipsilon* Hufnagel,) Tobacco caterpillar, (*Spodoptera litura* Fabricius,) Bihar hairy caterpillar, (*Spilosoma obliqua* Walker) (Debbarma *et al*., 2017) [2].

Damage Symptom of diamondback moth, *Plutella xylostella* A lot of damage is due to the construction of tunnels in the head as in cabbage and brussel sprouts. Furthermore, crop damage is usually first evident on plants growing on ridges in the crucifier field.

The heavy population *of P. xylostella* can cause more than 90% crop loss and only few fourth stage larvae on a cabbage can make it unsalable. (Gautam *et al*., 2018) [6].

In India, 52% yield loss on cabbage due to diamondback moth, and also yield loss caused by this pest varied from 31-100%. The overall management cost in world for diamondback moth is estimated at US $ 4-5 billion annually. To control this pest, insecticides have been used indiscriminately, resulting, in the development of resistance to every synthetic insecticide used against it in the field. In India, the first report of insecticide resistance development in diamondback moth was around 1966 in Ludhiana, Punjab, against DDT and Parathion. After that, the pest has developed resistance to about 82 compounds belonging to different classes of insecticides over 17 countries. (Harika *et al*. 2019) [7].

Materials and Methods

The investigation was conducted at the Central Research Field, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh during *rabi* season of 2021-2022. Experiment was lay out in randomized block design (RBD) with 8 treatments including untreated control and replicated three times. One month old cabbage ("Pride of India") seedlings were transplanted in the plot of 2m x 2m area with 60cm x 45cm spacing.

All the recommended agronomic management practices were followed for raising the crop except the insecticidal spray. The field efficacy of selected Chemicals and Insecticides Spinosad 45 SC (0.5ml/lit), Indoxacarb 14.5 SC (1ml/lit) and Emamectin benzoate 5% SG (0.4gm/lit), *Bacillus thuringiensis var. kurstaki* 0.5% WP (2gm/lit), *Beauveria bassiana* 1.15% WP (4gm/lit), NSKE 5% (50gm/lit), Neem oil 1% (10 ml/lit) *viz*., was compared with untreated control.

Applications of the treatments were started as soon as the pest level crossed the ETL i.e., 4-5 larvae per plant the second spray was given after 15 days respectively. The population count of diamondback moth larvae was recorded by randomly selecting five plants from each plot. The population count of Diamondback moth larvae was recorded one day before every spray which served as observation and the subsequent counts were taken on 3rd, 7th and 14th days after each spray. Observation on the larval population were recorded during morning hours. In order to evaluate the effect of the treatments on the yield, the weight of cabbage heads was recorded. After attaining a desirable size, the cabbage head were pluck. The weights of harvested heads in the plot of each treatment were sum-up to the total yield and computed on hectare basis by using hectare factor.

Method of observation

The population counts were recorded by randomly selecting 5plants. The population mean of diamondback moth larvae was recorded on the day before every spray which served as pre-treatment observation and the subsequent counts were taken on three, seven and fourteen days after spray (post-treatment).

Number basis

Total number of larvae present on five selected plants from each treatment replication wise recorded.

$$\text{Larval population Mean} = \frac{\text{Total no. of larvae}}{\text{5 randomly selected plant}}$$

Cost benefit ratio of treatments

Gross returns were 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,

$$\text{BCR} = \frac{\text{Net returns}}{\text{Total cost of treatment}}$$

Results and Discussion

The present study entitled "Comparative efficacy of certain chemicals and bio-pesticides against diamondback moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea* L.)" was undertaken at the Central Research Farm, SHUATS, Prayagraj. The data so obtained through observation on various aspects were subjected to statistical analysis wherever necessary and the compiled mean data are tabulated in the following pages. Result thus obtained is presented aspect wise here under.

The data on larval population of mean of *Plutella xylostella* over control on Third, Seven and Fourteen days after spraying revealed that all the treatments were significantly superior over control.

Among all the treatments (T_3) Spinosad 45 SC recorded lowest population mean of diamondback moth population mean i.e. (2.97) which was significantly superior over control following by (T_1) Indoxacarb 14.5% SC (3.28), (T_2) Emamectin benzoate 5% SG (3.51) (T_5) *Bacillus thuringiensis var. kurstaki* (3.57), (T_4) *Beauveria bassiana* (3.71), (T_7) Neem oil 1% (3.86) (T_6) NSKE 5% (4.04) was least effective among all the treatments.

Table 1: Effect of bio-pesticides and chemicals against diamondback moth (*P. xylostella*) on cabbage during *rabi* season of 2021-22. (First spray)

		Larval population of diamondback moth /five plants				
Treatment No	**Treatment**	**One day before spray**	**3 DAS**	**7 DAS**	**14 DAS**	**Mean**
T_0	Control	4.66	5.13	5.33	6.20	5.55
T_1	Indoxacarb	4.06	3.53	2.66	3.66	3.28
T_2	Emamectin benzoate	4.33	3.80	2.86	3.86	3.51
T_3	Spinosad	4.13	3.20	2.26	3.46	2.97
T_4	*Beauveria bassiana*	4.20	4.00	3.13	4.00	3.71
T_5	*Bacillus thuringiensis*	4.26	3.86	2.93	3.93	3.57
T_6	NSKE 5%	4.46	4.20	3.40	4.53	4.04
T_7	Neem oil 1%	4.40	4.06	3.20	4.33	3.86
	Overall Mean	4.31	3.97	3.22	4.25	3.81
	F-test	NS	S	S	S	S
	S. Ed (+/-)	0.189	0.102	0.077	0.094	0.176
	C. D. (P=0.05)	-	0.223	0.162	0.204	0.378

The data on larval population of mean of *Plutella xylostella* over control on Third, Seven and Fourteenth days after spraying revealed that all the treatments were significantly superior over control.

Among all the treatments (T_3) Spinosad 45 SC recorded lowest population mean of diamondback moth population mean i.e. (2.51) which was significantly superior over control following by (T_1) Indoxacarb 14.5% SC (2.80), (T_2) Emamectin benzoate 5% SG (3.00) (T_5) *Bacillus thuringiensis var. kurstaki* (3.24), (T_4) *Beauveria bassiana* (3.44), (T_7) Neem oil 1% (3.60) (T_6) NSKE 5% (3.80) was least effective among all the treatments.

Table 2: Effect of bio-pesticides and chemicals against diamondback moth (*P. xylostella*) on cabbage during *rabi* season of 2021-22. (Second spray).

		Larval population of diamondback moth /five plants				
Treatment No	**Treatment**	**One day before spray**	**3 DAS**	**7 DAS**	**14 DAS**	**Mean**
T_0	Control	6.20	6.66	6.80	7.26	6.91
T_1	Indoxacarb	3.66	3.13	2.53	2.73	2.80
T_2	Emamectin benzoate	3.86	3.33	2.73	2.93	3.00
T_3	Spinosad	3.46	2.80	2.20	2.53	2.51
T_4	*Beauveria bassiana*	4.00	3.73	3.20	3.40	3.44
T_5	*Bacillus thuringiensis*	3.93	3.53	3.00	3.20	3.24
T_6	NSKE 5%	4.53	4.13	3.66	3.60	3.80
T_7	Neem oil 1%	4.33	3.80	3.46	3.53	3.60
	Overall Mean	4.25	3.89	3.45	3.60	3.66
	F-test	NS	S	S	S	S
	S. Ed (+/-)	0.094	0.085	0.092	0.138	0.149
	C. D. (P=0.05)	-	0.185	0.197	0.297	0.328

Table 3: Economics of cultivation

Tr no	**Treatment**	**Yield q/ha**	**Cost of yield ₹/q**	**Total cost of yield (₹)**	**Common cost (₹)**	**Treatment cost (₹)**	**Total cost (₹)**	**Net Returns (₹)**	**C: B ratio**
T_0	Control	67.55	1000	67550	36020				1:1.87
T_1	Indoxacarb 14.5 SC @ 1ml/ lit	180.21	1000	180210	36020	2980	39000	141210	1:3.62
T_2	Emamectin Benzoate 5 SG @ 0.4 gm/lit	165.30	1000	165300	36020	1660	37680	127620	1:3.38
T_3	Spinosad 45 SC @ 0.5 ml/lit	217.81	1000	217810	36020	6559	42579	175231	1:4.11
T_4	*Beauveria Bassiana* 1.15% WP @ 4 gm/lit	148.51	1000	148510	36020	2083	38103	112287	1:2.94
T_5	*Bacillus Thuringiensis* 3 ml /lit	155.82	1000	155820	36020	2524	38544	117606	1:3.05
T_6	NSKE 5% @ 50 gm/lit	125.35	1000	125350	36020	1800	37820	87770	1:2.32
T_7	Neem oil 1% 20 ml/ lit	142.00	1000	142000	36020	4880	40900	102780	1:2.51

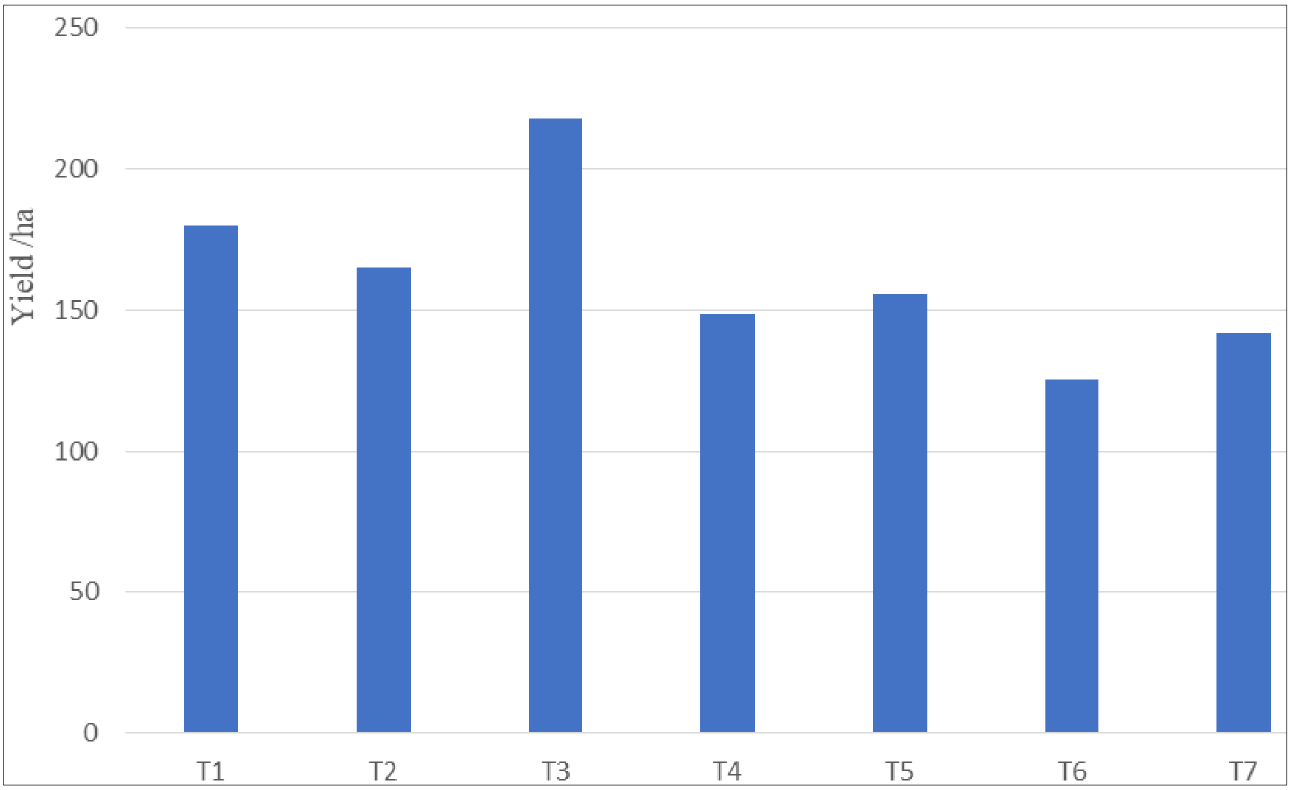

Fig 1: Effect of treatments on production of cabbage

Economics of various treatments

The yields among the treatment were significant. The highest yield was recorded in (T_3) Spinosad 45 SC (217.81 q/ha), followed by (T_1) Indoxacarb 14.5%SC (180.21 q/ha). (T_2) Emamectin benzoate 5% SG (165.30 q/ha), (T_5) *Bacillus thuringiensis var. kurstaki* (155.82 q/ha), (T_4) *Beauveria bassiana* (148.51 q/ha), (T_7) Neem oil 1% (142.00 q/ha) (T_6) NSKE 5% (125.35 q/ha) as compared to control T_0 (67.55 q/ha). When cost benefit ratio was worked out, interesting result was achieved. Among the treatment studied, the best and most economical treatment was (T_3) Spinosad 45 SC (1:4.11), followed by (T_1) Indoxacarb 14.5%SC (1:3.62), (T_2) Emamectin benzoate 5% SG (1:3.38), (T_5) *Bacillus thuringiensis var. kurstaki* (1:3.05), (T_4) *Beauveria bassiana* (1:2.94), (T_7) Neem oil 1% (1:2.51), (T_6) NSKE 5% (1:2.32), as compared to control (1:1.87).

Discussion

Cabbage (*Brassica oleraceae* var. Capitata) is an important vegetable crop commercially grown in almost all part of India. Successful cultivation of this crop in hampered due to the incidence of large number of pests, since the period of seedling transplanting to harvest of cabbage heads. the various pests, Diamondback moth (*Plutella xylostella*) play an important role causing a considerable yield loss, Bosides, the head quality is also deteriorated.

Among all the treatments Spinosad 45 SC recorded lowest larval population mean of diamondback moth population i.e. (2.74) which was significantly superior over control followed by Indoxacarb 14.5% SC (3.04), Emamectin benzoate 5% SG (3.25), *Bacillus thuringiensis var. kurstaki* (3.41), *Beauveria bassiana* (3.47), Neem oil 1% (3.73) and NSKE 5% (3.92) was least effective among all the treatments.

From the experimental finding the treatment (T_3) Spinosad 45 SC (2.74) were recorded consistently lowest larval population of dimondback moth. The similar finding was also reported by Sawant and Patil (2018) [12] (1.46), Dotasara *et al.* (2017) [3] (3.94). (T_1) indoxacarb 14.5% SC was found to be the next best treatment with the lowest larval population (3.04). (T_2) Emamectin benzoate 5% SG was found to be next best treatments with lowest larval population (3.25) as similar finding was reported by Gaikwad *et al*. (2018) [5] (2.87). (T_5) *Bacillus thuringiensis* was found to be best treatments with the lowest larval population (3.41) as the similar finding was reported by Sing *et al.* (2021) [13] (6.73). (T_4) *Beauveria bassiana* was found to be next best treatment with the lowest larval population (3.57). (T_6) NSKE was found to be next best treatment with the lowest larval population (3.92) as similar finding was reported by Sing *et al.* (2021) [13]) (6.15).

The yields among the treatment were significant. The highest yield was recorded in (T_3) Spinosad 45 SC (217.81 q/ha), followed by (T_1) Indoxacarb 14.5%SC (180.21 q/ha). (T_2) Emamectin benzoate 5% SG (165.30 q/ha), (T_5) *Bacillus thuringiensis var. kurstaki* (155.82 q/ha), (T_4) *Beauveria bassiana* (148.51 q/ha), (T_7) Neem oil 1% (142.00 q/ha) (T_6) NSKE 5% (125.35 q/ha) as compared to control (T0) (67.55 q/ha). agreed with finding of Stanikzi *et al.* (2016) [11] (187.60 q/ha), Bhandari (2019) [1] (214.87 q/ha). The treatments (T1) indoxocarb 14.5 SC highest yield was (180.21 q/ha) similar finding was reported by Harika *et al.* (2019) [5] (219.10 q/ha), Stanikzi *et al.* (2016) [11] (178.25 q/ha) Gaddam *et al.* (2020) (4) (275 q/ha). The treatments (T2) Emamectin benzoate 5% SG yield was (165.30 q/ha) similar finding was reported by Stanikzi *et al.* (2016) [11] (173.75 q/ha), Bhandari (2019) [1] (203.08 q/ha). The treatments (T5) *Bacillus thuringiensis* yield was (155.82 q/ha) silimilar finding was reported by Bhandari (2019) [1] (195.95 q/ha). The treatments (T4) *Beauveria bassiana* yield was (148.51 q/ha) similar finding was reported Bhandari (2019) [1] (187.92 q/ha).

Benefit Cost Ratio

Higher benefit cost ratio (1:4.11) was obtained from T_3 Spinosad 45 SC as the similar finding was made by Kumar and Kumar (2020) [8] (1:3.27). the study revealed the treatment T_1 Indoxacarb 14.5 SC the cost benefit ratio of (1:3.62) as the similar findings were made by Gaddam *et al.* (2020) [4] (1:5.97), the treatment T_3 Emamectin benzoate 5 SG (1:3.38), the treatments T_5 *Bacillus thuringiensis var. kurstaki* (1:3.05) as the similar finding was made by Gaddam *et al.* (2020) [4] (1.5.57), the treatment (T_4) *Beauveria bassiana* (1:2.94), the treatment (T_7) Neem oil 1% (1:2.51), the treatment (T_6) NSKE 5% (1:2.32).

Conclusion

From the critical analysis of the present findings "Comparative efficacy of certain chemicals and bio-pesticides against diamondback moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea* L.)*"* It was concluded that among the Spinosad 45 SC proved to be the best treatment followed by Indoxacarb 14.5% SC, Emamectin benzoate 5% SG, *Beauveria bassiana*, *Bacillus thuringiensis var. kurstaki*, Neem oil 1%, NSKE 5% proved to be the best treatment in managing *Plutella xylostella* larval population. Therefore, insecticides of short residual effect and bio-pesticide like Spinosad may be useful in devising proper integrated pest management strategy against diamondback moth.

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