BIO-EFFICACY OF NEWER INSECTICIDES AND BIO-PESTICIDES AGAINSTDIAMONDBACK MOTH, *PLUTELLA XYLOSTELLA* (LINN.).

Abstract

The present investigation entitled 'bio-efficacy of newer insecticides and bio-pesticides against diamondback moth,*Plutellaxylostella*(Linn.)was carried out on the cabbage, variety 'Golden Acre' during *Rabi*, 2021/22 and 2022/23. At Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (UP).The data were recorded on five randomly selected plants once in a standard week. Pooled data of both the year (2021 and 2022), After treatments, Spinosad 2.50% SCat 600 ml ha^{-1} consistently showed the lowest larval count on days 3, 7, and 14, with 3.33, 2.17, 2.25 larvae per five plants followed by Emamectin benzoate 5% SGat 200 g ha^{-1}, Diafenthiuron 50% WPat 600g ha^{-1}, *Bacillus thuringiensis* var. *kurstaki*at1000gha^{-1}, *Beauveriabassiana*at 1500 ml ha^{-1} and *Metarhiziumanisopiliae*at 2000 g ha^{-1}, and Nimbecidine 0.03%at2500 ml/ha, respectively. The Nimbecidine 0.03%at 2500 ml ha^{-1} recorded the lowest efficacy. Chemical and biological treatments varied significantly, while chemicals had similar efficacy, and biologicals were equally effective. Control plots had the highest larvae count.

Introduction

Cruciferae is the most important vegetable in Indian diet and play an important role in the economy of the farmers. Cabbage, scientifically known as *Brassica oleracea*var. *capitata* (Linn.), its belongs to the Cruciferae family, which also includes many vegetables and oil seeds like broccoli, cauliflower, Brussels sprouts, cabbage and Mustard. Its diverse varieties, such as green cabbage, red cabbage, and savoy cabbage, offer culinary flexibility, making it a common ingredient in various cuisines. Cabbage, categorized as a Colecrop vegetable, is sometimes considered an exotic veggie and is a preferred leafy option, especially during the winter season. It is consumed widely worldwide and holds particular popularity in India.It is believed to have originated from the coastal regions of Northern Europe or the Mediterranean region**(Snogerup, 1980)**.

Cabbage was introduced to India by the Portuguese during the period spanning the 14th to the17thcenturies. China holds the top position in global cabbage production, with

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India and the Republic of Korea following closely as the second and third largest cabbage producers. In 2021, China produced an impressive approximately 34.5 million metric tons of cabbage, solidifying its status as the leading cabbage producer in the Asia-Pacific region. India, on the other hand, dedicated around 0.412 million hectares to cabbage cultivation, resulting in a production estimate of approximately 9.56 million tons for the fiscal year 2021. Moving into the fiscal year 2022, India saw an increase in cabbage production, reaching about 9.82 milliontons, while the area allocated for cabbage cultivation expanded to approximately 0.423 million hectares (**Anonymous,2022**).

In India, the crop is cultivated in almost all the states. Annual production of Cabbage in West Bengal in 2021-22, ranked first, the state accounted for 24.38 per cent of total production. The cultivated area and average productivity of cabbage were 22.18 tonnes/ha. Cabbage seeds germinate properly at 12.7°C to 15.5°C temperatures. The major cabbage-growing states in the country are West Bengal (24.38 per cent), Odisha (11.77 per cent), Gujrat (8.29 per cent), Madhya Pradesh (8.29 per cent), Assam (7.75 per cent), Bihar (7.52 per cent), Chhattisgarh (4.38 per cent) Uttar Pradesh (3.63 per cent), followed by Haryana, Karnataka and Maharashtra. In Uttar Pradesh, the area under cultivation of cabbage is about 9.06 thousand hectares with a production of about 302.97 thousand tonnes (**Anonymous, 2022**).

Cabbage is a low-calorie vegetable that is rich in nutritional value per 100 g of cabbage consists of carbohydrates 5.8 g, fat 0.1 g, protein 1.28 g, vitamins (thiamine or vitamin B_1 0.061 mg, riboflavin or B_2 0.040 mg, niacin or vitamin B_3 0.234 mg, pantothenic acid or vitamin B_5 0.212 mg, folate or vitamin B_9 43 mg, vitamin C 36.6 mg and vitamin K 76 mg) and minerals Ca 40 mg, Fe 0.47 mg, Mg 12 mg, Mn 0.16 mg, P 26 mg, K 170 mg, Na 18 mg and Zn 0.18 mg (**Sharma *et al.*, 2017**). Besides its culinary uses, cabbage has traditionally been used for its medicinal properties. Se-enriched sauerkraut extracts exhibit high antioxidant and anti-inflammatory properties (**Penas*et al.*, 2012**). Cabbage has an anti-cancer property it protects against bowel cancer due to the presence of indole-3-carbinol. Cabbage juice was used as a remedy against poisonous mushrooms (**Keck*et al.*, 2004**).

Materials and Methods

The field experiments were conducted at the crop research center (CRC) of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, during *Rabi*,2021/22 and 2022/23. The cabbage variety Golden Acre was selected for observation. The

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experiment was laid out in randomization block design (RBD) with three replications each containing eight treatments including control. The plot size for each treatment was kept at 4 x 3 m^2, with spacing between row to row and plant to plant is 60x50 cm. After transplanting of crop and when 2 larval populations of DBM per five plants (ETL) were seen in the experiment, two sprayings were made and data was recorded after the 3^{rd}, $7^{th,}$ and 14^{th} days of each spraying and presented in tables. The observations were recorded on the population of diamondback moth larvae of five randomly selected plants in each plot one day before every spray which served as a pre-treatment observation and the subsequent counts were taken on the 3^{rd}, 7^{th}, and 14^{th} days after each spray (post-treatment) and the observation on the larval population of diamondback moth was recorded during morning hours. However, the performance of each treatment against this pest was assessed by recording the number of diamondback moth larvae in each plot on five randomly selected plants after treatment on the 3^{rd}, 7^{th} and 14^{th} day after each spray. The data of insect population were subjected for calculation of the mean as suggested by **(Devi and Tayde 2017)**. The experiments for the evaluation of botanicals were laid out in Randomized complete block design (RCBD) with three replications and eight treatments for finding out the infestation percentage of *P.xylostella*.All the observations were analyzed statistically to compare the treatment effect on the larval population. The larval population data were transformed using square root transformation as $\sqrt{\times + 0.5}$ value (where observed insect population per plot).

$$\textbf{SE (d)} = \sqrt{\frac{2\,EMS}{r}}$$

Where,

SE (d) = Standard error of difference

EMS = Error mean sum of square

r = Replication

The critical difference was calculated for experiments to find out the better treatment. The statistical analysis was made to determine the standard error and critical difference at 5% level of significance and calculated by following the formula suggested by**Bana (2012).**

$$\textbf{CD = SE (d)} \times \textbf{t (5\%)}$$

Where;

CD = Critical difference

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t = Table value at 5% probability level.

Results and Discussion

Bio-efficacy of newer insecticides and bio-pesticides against diamondback moth,*Plutellaxylostella*(Linn.)

During, *Rabi,* 2021/22.

The effects of different treatments were evaluated against Diamondback moth infestations in cabbage during the *Rabi* seasons of 2021 and 2022. Data was obtained during both cropping seasons and pooled to observe the overall effects. The recorded observations are given below-

One day before first application

The statistically analysed data presented in **(Table 1)** and **(Figure1)** observed that the average larval population of*P.xylostella*at one day before application in all the treatments ranged from 7.00 to 8.00 per five plants on cabbage during *Rabi*, 2021-22. No significant difference was found among all the different treatments.

After first application

Data recorded on third day after first application, the minimum diamondback mothlarvae (3.00 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (3.66 larvae per five plants) followed by Diafenthiuron 50% WP, *Bacillus thuringiensis,Beauveriabassiana, Metarhiziumanisopliae*and Nimbecidine 0.03% with 4.00, 5.33, 5.66, 6.33 and 6.66 larvae per five plants, respectively. The chemical pesticides and biopesticides were significantly different and the chemical treatments were statistically at par in their efficacy, similarly biological treatments had similar efficacy to each other.Meantime,maximum diamondback mothlarvae (8.00 per five plants) were recorded in untreated control.

Similar trend was recorded on seventh day after first application, the minimum diamondback mothlarvae (2.33 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (3.00 larvae per five plants) Followed by Diafenthiuron 50% WP, *B.thuringiensis, B.bassiana, M.anisopliae*andNimbecidine 0.03% with 3.33, 4.67, 5.00, 5.67 and 6.00 larvae per five plants, respectively. Whereas,maximum diamondback mothlarvae (8.33 per five plants) were recorded in untreated control.

Data recorded fourteen days after first application, the minimum diamondback mothlarvae (2.67 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next

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best treatment was Emamectin benzoate 5% SG with (3.33 larvae per five plants) Followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*and Nimbecidine 0.03% with 3.67, 5.00, 5.33, 6.00 and 6.67 larvae per five plants, respectively. Meantime, maximum diamondback mothlarvae (8.67 per five plants) were recorded in control plot.

After second application

The observations were recorded on third day after second application, the minimum diamondback mothlarvae (2.00 larvae per five plants) were recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (2.67 larvae per five plants) Followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*andNimbecidine 0.03% with 3.00, 4.67, 5.00, 5.67 and 6.33 larvae per five plants, respectively. Whereas maximum diamondback mothlarvae (9.00 per five plants) were recorded in the untreated control.

Data were recorded on seventh day after second application, the minimum diamondback mothlarvae (1.33 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (2.00 larvae per five plant) Followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*andNimbecidine 0.03% with 2.67, 3.67, 4.33, 5.00 and 5.67 larvae per five plants, respectively. Whereas,maximum diamondback mothlarvae (9.33 per five plants) were recorded in untreated control.

Similar trend was recorded on fourteen days after second application, the minimum diamondback mothlarvae (1.67 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (2.33 larvae per five plant) followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*andNimbecidine 0.03% with 3.00, 4.00, 4.67, 5.33 and 6.00 larvae per five plants, respectively. Whereas,maximum diamondback mothlarvae (9.00 per five plants) were recorded in untreated control. All the treatments were recorded statistically at par in their efficacy which was significantly superior over control.

During, *Rabi*, 2022/23.

One day before the spray

The statistically analyzed data presented in **(Table no.-2 and Figure-no.-2)** observed that the average larval population of *Plutellaxylostella*one day before application in all the treatments ranged from 7.33 to 8.67 per five plants on cabbage during *Rabi*,2022/23. No significant difference was recorded among all the different treatments.

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After first application

Data recorded on third day after first application, the minimum diamondback mothlarvae (3.67 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (4.00 larvae per five plant) followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*and Nimbecidine 0.03% with 4.33, 5.67, 6.00, 6.67 and 7.00 larvae per five plants, respectively. The chemical pesticides and biopesticides were significantly different and the chemical treatments were statistically at par in their efficacy, similarly biological treatments were similar efficacy to each other.Whereas maximum diamondback mothlarvae (8.00 per five plants) were recorded in untreated control plot.

The similar observation was recorded on seventh day after first application, the minimum diamondback mothlarvae (2.00 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (2.33 larvae per five plants) followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*and Nimbecidine 0.03% with 2.67, 4.00, 5.00, 5.33 and 6.00 larvae per five plant, respectively. On the otherhand,maximum diamondback mothlarvae (9.00 per five plants) were recorded in untreated control plots.

The similar observation was recorded on fourteen days after the first application, the minimum diamondback mothlarvae (2.33 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (2.67 larvae per five plant) followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*and Nimbecidine 0.03% with 3.00, 4.33, 5.33, 5.67 and 6.33 larvae per five plant, respectively. Meantime,diamondback mothlarvae (9.00 per five plants) were recorded in untreated control plots.

After second application

The observations were recorded on third day after second application, the minimum diamondback mothlarvae (1.33 larvae per five plants) were recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (2.00 larvae per five plants). Both Spinosad and Emamectin benzoate were at par with their efficacy and Diafenthiuron 50% WP, significantly different with (2.67 larval per five plants) Followed by *B. thuringiensis, B. bassiana, M. anisopliae*andNimbecidine 0.03% with 3.67, 4.67, 5.00 and 5.67 larvae per five plants, respectively. Whereas,maximum diamondback mothlarvae (9.33 per five plants) were recorded in untreated control.

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Similar trend was recorded on seventh day after second application, the minimum diamondback mothlarvae (1.00 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (1.33 larvae per five plants). Both Spinosad and Emamectin benzoate are at par with their efficacy and Diafenthiuron 50% WP, significantly different with (2.00 larval per five plant). All the biological pesticides are statistically at par with their efficacy followed by *B. thuringiensis, B. bassiana, M. anisopliae*andNimbecidine 0.03% with 3.00, 4.00, 4.33 and 5.00 larvae per five plants, respectively. Whereas,maximum diamondback mothlarvae (8.33 per five plants) were recorded in untreated control.

Data were recorded on fourteen days after second application, the minimum diamondback mothlarvae (1.00 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (1.67 larvae per five plants) Followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*andNimbecidine 0.03% with 2.33, 3.33, 4.33, 4.67 and 5.67 larvae per five plants, respectively. In which all the treatments are statistically at par, there was no significant difference. Whereas maximum diamondback mothlarvae (8.00 per five plants) were recorded in untreated control.

Pool data duringboth years*Rabi*, 2021/22 and 2022/23.

One day before spray

The statistically analysed data presented in **(Table no.-3)** and **(Figure no.-3)** observed that the average larval population of *P.xylostella*at one day before application in all the treatments ranged from 7.00 to 8.00 per five plants on cabbage during both the years 2021/22 to 2022/23. No significant difference was recorded among all the different treatments.

After first application

Data recorded on third day after first application, the minimum diamondback mothlarvae (3.33 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (3.83 larvae per five plants) followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*and Nimbecidine 0.03% with 4.17, 5.50, 5.83, 6.50 and 6.83 larvae per five plants, respectively. The chemical pesticides and biopesticides were significantly different and the chemical treatments were statistically at par in their efficacy, similarly biological treatments had similar efficacy to each other.Whereas maximum diamondback mothlarvae (8.33 per five

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plants) were recorded in untreated control plot.

The similar observation was recorded on seventh day after first application, the minimum diamondback mothlarvae (2.17 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (2.67 larvae per five plant) followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*and Nimbecidine 0.03% with 3.00, 4.33, 5.00, 5.50 and 6.00 larvae per five plant, respectively. Whereas maximum diamondback mothlarvae (8.67 per five plants) were recorded in untreated control plot.

The similar observation was recorded on fourteenth day after first application, the minimumdiamondback mothlarvae (2.50 larvae per five plants) was recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (3.00 larvae per five plants) followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*and Nimbecidine 0.03% with 3.33, 4.67, 5.33, 5.83 and 6.50 larvae per five plants, respectively. Whereas maximum diamondback mothlarvae (8.83 per five plants) were recorded in untreated control plot.

After second application

The observations were recorded on third day after second application, the minimum diamondback mothlarvae (1.67 larvae per five plants) were recorded in the Spinosad 2.50% SC. The second effective treatment was Emamectin benzoate 5% SG with (2.33 larvae per five plants) followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*and Nimbecidine 0.03% , being 2.83, 4.17, 4.83, 5.33 and 6.00 larvae per five plants, respectively. Whereas maximum diamondback mothlarvae (9.17 per five plants) were recorded in untreated control plot.

The observations were recorded on seventh day after second application, the minimum diamondback mothlarvae (1.17 larvae per five plants) were recorded in the Spinosad 2.50% SC. The second effective treatment was Emamectin benzoate 5% SG with (2.67 larvae per five plant) followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*and Nimbecidine 0.03% , being 2.33, 3.33, 4.17, 4.67 and 5.33 larvae per five plant, respectively. Whereas maximum diamondback mothlarvae (8.83 per five plants) were recorded in untreated control plot.

Data were recorded on fourteen days after second application, the minimum diamondback mothlarvae (1.33 larvae per five plants) were recorded in the Spinosad 2.50% SC. The next best treatment was Emamectin benzoate 5% SG with (2.00 larvae per

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five plants) followed by Diafenthiuron 50% WP, *B. thuringiensis, B. bassiana, M. anisopliae*andNimbecidine 0.03% with 2.67, 3.67, 4.50, 5.00 and 5.83 larvae per five plants, respectively. Whereas maximum diamondback mothlarvae (8.00 per five plants) were recorded in untreated control plot. In which all the treatments are statistically at par, there was no significant difference.

These findings are supported by**Sharma *et al*. (2022)** whoreported that the Spinosad was most effective and reduced up to 94.33 per cent of diamondback moth population followed by Indoxacarb (91.00 per cent) and Flubendiamide (78.66 per cent). The insecticides, *viz*., Fipronil, Emamection Benzoate and Chlorantraniliprole were found to be moderately effective as they resulted in 70.66, 70.33 and 68.66 per cent reduction, respectively and Chlorfenapyr, Pyridalyl and Acephate were proved least effective reduced up to 55.33, 56.66 and 56.00 per cent, respectively. The present finding also get supported from the observations of **Kumar *at el*. (2022)** the*B. t.* var. *kurstaki*(Dipel 8 L) at 0.2 per cent as spray on standing crop with 41.85 per cent population reduction over control proved best among all treatments by reducing mean number of larvae 0.48/plant. The second most effective treatment applied to the cabbage on standing crop as spray form was *B.bassiana*1.15% WP at 0.2 per cent with 38.30 per cent population reduction over control with mean number of larvae 0.75 plant^{-1}, followed by Nimbecidine 0.15 per cent EC (Azardirachtin 1500 ppm) at 0.3 per cent (37.29 per cent) it was statistically superior in comparison to control in which 4.98 mean larvae were recorded.

Conclusion

Pooled data of both the year (2021 and 2022), After treatments, Spinosad 2.50% SC consistently showed the lowest larval count on days 3, 7, and 14, with 3.33, 2.17, 2.25 larvae per five plants followed by Emamectin benzoate 5% SG, Diafenthiuron 50% WP, *B. t.* var. *kurstaki,, B. bassiana,M. anisopliae* and Nimbecidine 0.03%, respectively. The Nimbecidine 0.03% recorded the lowest efficacy. Chemical and biological treatments varied significantly, while chemicals had similar efficacy, and biologicals were equally effective. Control plots had the highest larvae count.

Acknowledgment

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Table 1.Efficacy of newer insecticides and bio-pesticides against *Plutellaxylostella* (Linn.) in cabbage during *Rabi*, 2021-22.

S. No.	Treatments	Dose (g/mlha^{-1})	No. of Diamondback moth per five plants						
				1st Spray after days			2nd Spray after days		
			1DBS	3	7	14	3	7	14
T1	Spinosad 2.50% SC	600 ml	7.00 (2.83)	3.00 (1.99)	2.33 (1.82)	2.67 (1.91)	2.00 (1.73)	1.33 (1.52)	1.67 (1.63)
T2	Emamectin Benzoate 5% SG	200 g	7.33 (2.89)	3.66 (2.16)	3.00 (2.00)	3.33 (2.08)	2.67 (1.91)	2.00 (1.73)	2.33 (1.82)
T3	Diafenthiuron 50% WP	600 g	7.67 (2.94)	4.00 (2.23)	3.33 (2.08)	3.67 (2.16)	3.00 (2.00)	2.67 (1.82)	3.00 (2.00)
T4	*Bacillus thuringiensis* var. *kurstaki*	1000 g	7.33 (2.89)	5.33 (2.51)	4.67 (2.38)	5.00 (2.44)	4.67 (2.38)	3.67 (2.16)	4.00 (2.24)
T5	*Beauveriabassiana*	1500 ml	7.67 (2.94)	5.66 (2.57)	5.00 (2.44)	5.33 (2.52)	5.00 (2.45)	4.33 (2.31)	4.67 (2.51)
T6	*Metarhizium anisopliae*	2000 g	7.33 (2.89)	6.33 (2.71)	5.67 (2.58)	6.00 (2.71)	5.67 (2.58)	5.00 (2.44)	5.33 (2.51)
T7	Nimbecidine 0.03%	2500 ml	8.00 (3.00)	6.66 (2.77)	6.00 (2.26)	6.67 (2.77)	6.33 (2.71)	5.67 (2.58)	6.00 (2.65)
T8	Untreated (Control)	-	7.67 (2.94)	8.00 (3.00)	8.33 (3.05)	8.67 (3.11)	9.00 (3.16)	9.33 (3.21)	9.00 (3.16)
CD at 5%			**N/S**	**1.06**	**1.18**	**1.33**	**0.96**	**1.10**	**1.05**
SE (m) (±)			**0.30**	**0.35**	**0.39**	**0.43**	**0.31**	**0.36**	**0.34**

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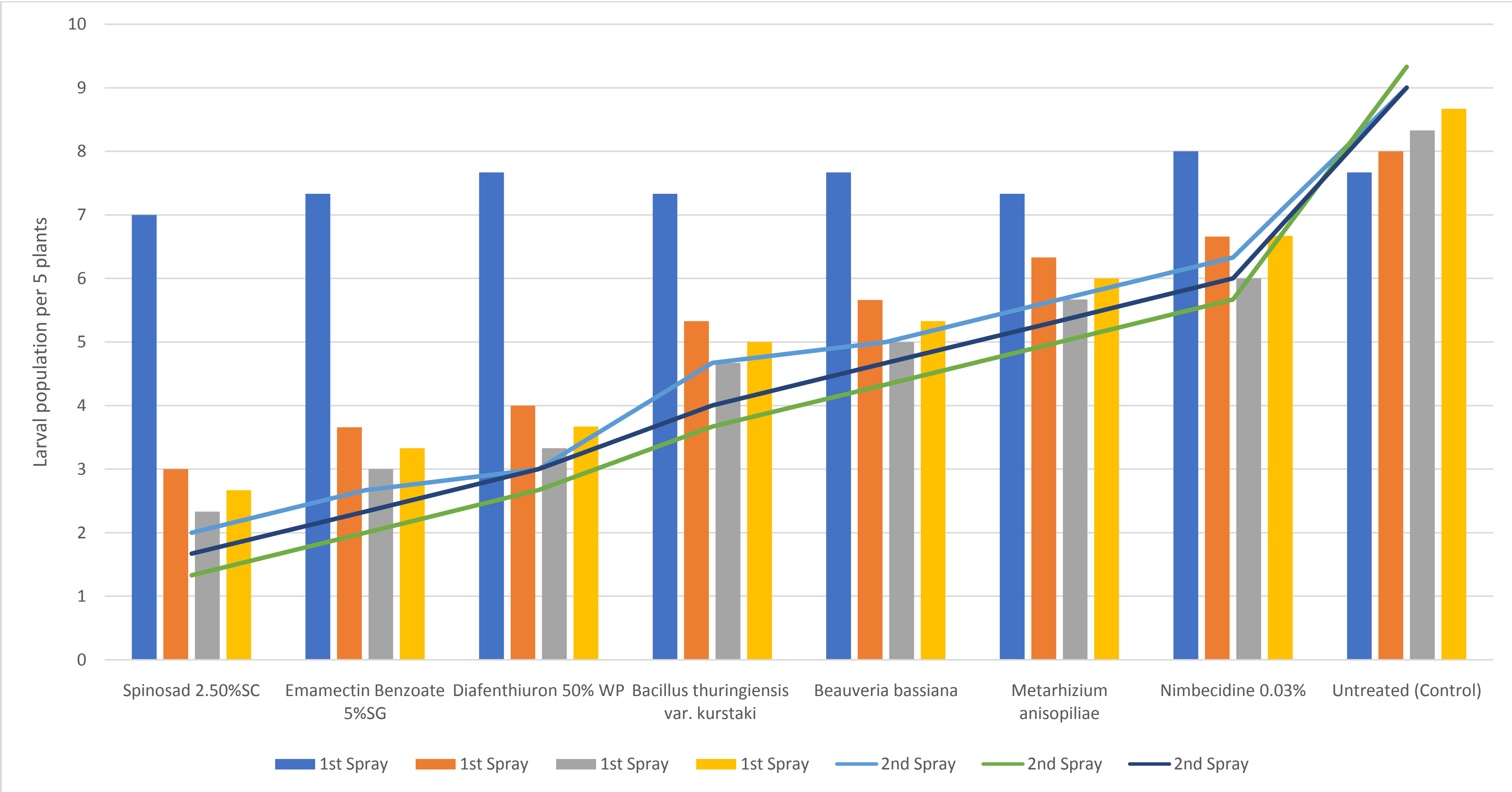

Figure1.Efficacy of newer insecticides and bio-pesticides against *Plutellaxylostella* (Linn.) in cabbage during *Rabi*, 2021/22.

Table 2. Efficacy of newer insecticides and bio-pesticides against *Plutellaxylostella* (Linn.) in cabbage during *Rabi*, 2022/23

S. No.	Treatments	Dose (g/mlha^{-1})	No. of Diamondback moth per five plants						
			1[st] Spray after days				2[nd] Spray after days		
			1DBS	3	7	14	3	7	14
T1	Spinosad 2.50%SC	600 ml	8.00 (3.00)	3.67 (2.16)	2.00 (1.73)	2.33 (1.82)	1.33 (1.52)	1.00 (1.41)	1.00 (1.38)
T2	Emamectin Benzoate 5%SG	200 g	8.67 (3.11)	4.00 (2.23)	2.33 (1.82)	2.67 (1.91)	2.00 (1.73)	1.33 (1.52)	1.67 (1.63)
T3	Diafenthiuron 50% WP	600 g	7.67 (2.94)	4.33 (2.31)	2.67 (1.91)	3.00 (2.00)	2.67 (1.91)	2.00 (1.73)	2.33 (1.82)
T4	*Bacillus thuringiensis* var. *kurstaki*	1000 g	8.33 (3.05)	5.67 (2.58)	4.00 (2.24)	4.33 (2.31)	3.67 (2.16)	3.00 (1.99)	3.33 (2.08)
T5	*Beauveriabassiana*	1500 ml	7.33 (2.89)	6.00 (2.64)	5.00 (2.44)	5.33 (2.52)	4.67 (2.38)	4.00 (2.24)	4.33 (2.38)
T6	*Metarhizium anisopliae*	2000 g	8.33 (3.05)	6.67 (2.77)	5.33 (2.52)	5.67 (2.58)	5.00 (2.44)	4.33 (2.31)	4.67 (2.38)
T7	Nimbecidine 0.03%	2500 ml	8.00 (3.00)	7.00 (2.83)	6.00 (2.64)	6.33 (2.71)	5.67 (2.58)	5.00 (2.45)	5.67 (2.58)
T8	Untreated (Control)	-	8.33 (3.05)	8.67 (3.11)	9.00 (3.16)	9.00 (3.16)	9.33 (3.21)	8.33 (3.05)	8.00 (3.00)
CD at 5%			**N/S**	**1.07**	**1.15**	**1.15**	**0.81**	**0.92**	**1.10**
SE (m) (±)			**0.43**	**0.35**	**0.37**	**0.38**	**0.26**	**0.30**	**0.36**

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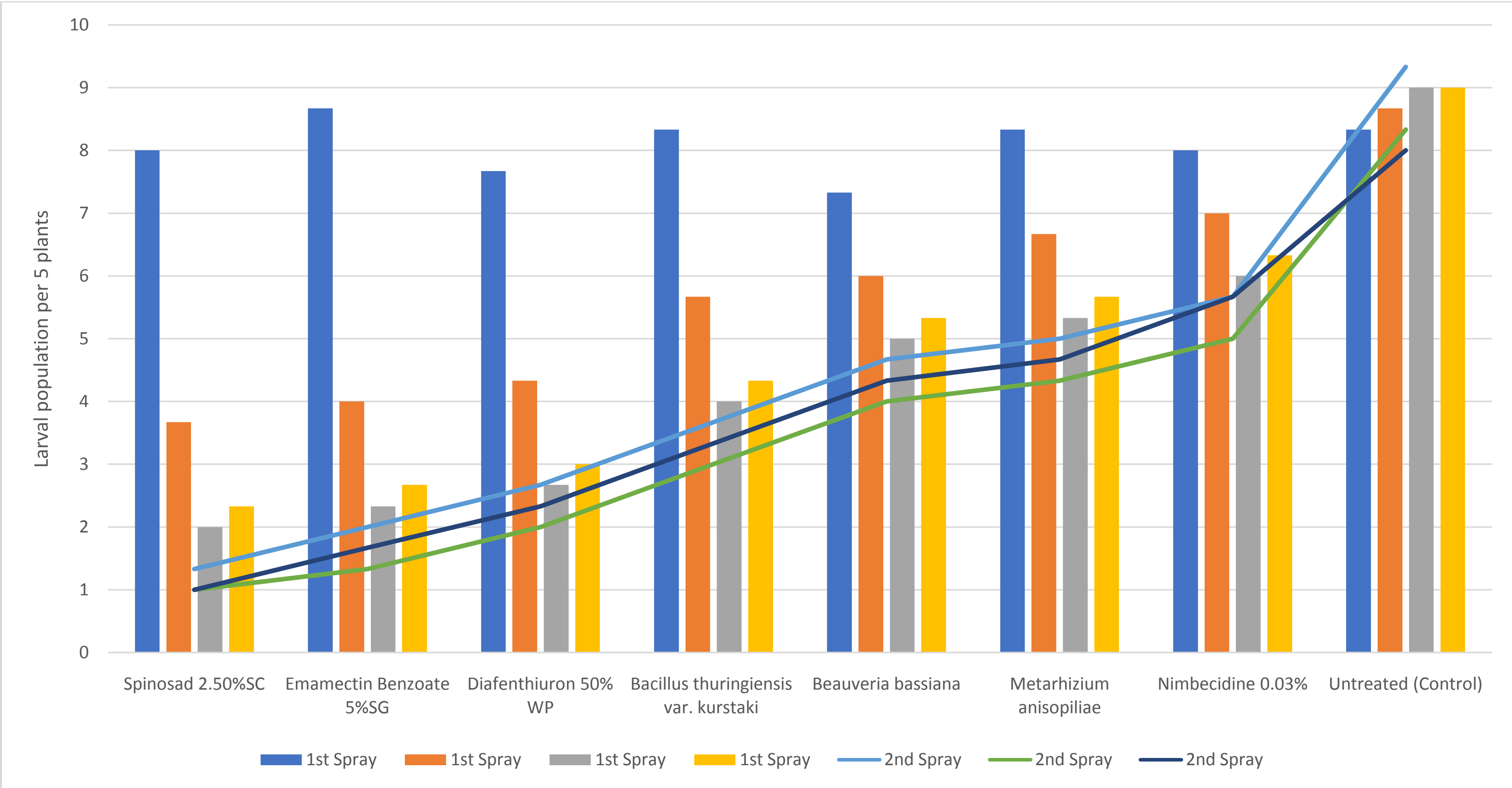

Figure2.Efficacy of newer insecticides and bio-pesticides against *Plutellaxylostella* (Linn.) in cabbage during *Rabi*, 2022/23.

Table 3.Pooled Efficacy of newer insecticides and bio-pesticides against *Plutellaxylostella* (Linn.) in cabbage during Rabi, 2021-22 and 2022/23

S. No.	Treatments	Dose (g/mlha^{-1})	No. of Diamondback moth per five plants						
				1st Spray after days			2nd Sprayafter days		
			1 DBS	3	7	14	3	7	14
T1	Spinosad 2.50% SC	600 ml	7.50 (2.91)	3.33 (2.07)	2.17 (1.78)	2.50 (1.87)	1.67 (1.63)	1.17 (1.47)	1.33 (1.50)
T2	Emamectin Benzoate 5% SG	200 g	8.00 (3.00)	3.83 (2.19)	2.67 (1.91)	3.00 (2.00)	2.33 (1.82)	1.67 (1.63)	2.00 (1.72)
T3	Diafenthiuron 50% WP	600 g	7.67 (2.94)	4.17 (2.27)	3.00 (2.00)	3.00 (1.99)	2.83 (1.96)	2.33 (1.78)	2.67 (1.91)
T4	*Bacillus thuringiensis* var. *kurstaki*	1000 g	7.83 (2.97)	5.50 (2.54)	4.33 (2.31)	4.67 (2.38)	4.17 (2.27)	3.33 (2.07)	3.67 (2.16)
T5	*Beauveriabassiana*	1500 ml	7.50 (2.91)	5.83 (2.61)	5.00 (2.44)	5.33 (2.52)	4.83 (2.41)	4.17 (2.27)	4.50 (2.38)
T6	*Metarhizium anisopliae*	2000 g	7.83 (2.97)	6.50 (2.74)	5.50 (2.55)	5.83 (2.61)	5.33 (2.51)	4.67 (2.38)	5.00 (2.44)
T7	Nimbecidine 0.03%	2500 ml	8.00 (3.00)	6.83 (2.80)	6.00 (2.64)	6.50 (2.74)	6.00 (2.64)	5.33 (2.51)	5.83 (2.61)
T8	Untreated (Control)	-	8.00 (3.00)	8.33 (3.05)	8.67 (3.11)	8.83 (3.13)	9.17 (3.19)	8.83 (3.13)	8.50 (3.08)
CD at 5%			**N/S**	**1.24**	**1.17**	**1.24**	**1.03**	**1.01**	**1.07**
SE (m) (±)			**0.37**	**0.41**	**0.38**	**0.40**	**0.34**	**0.33**	**0.35**

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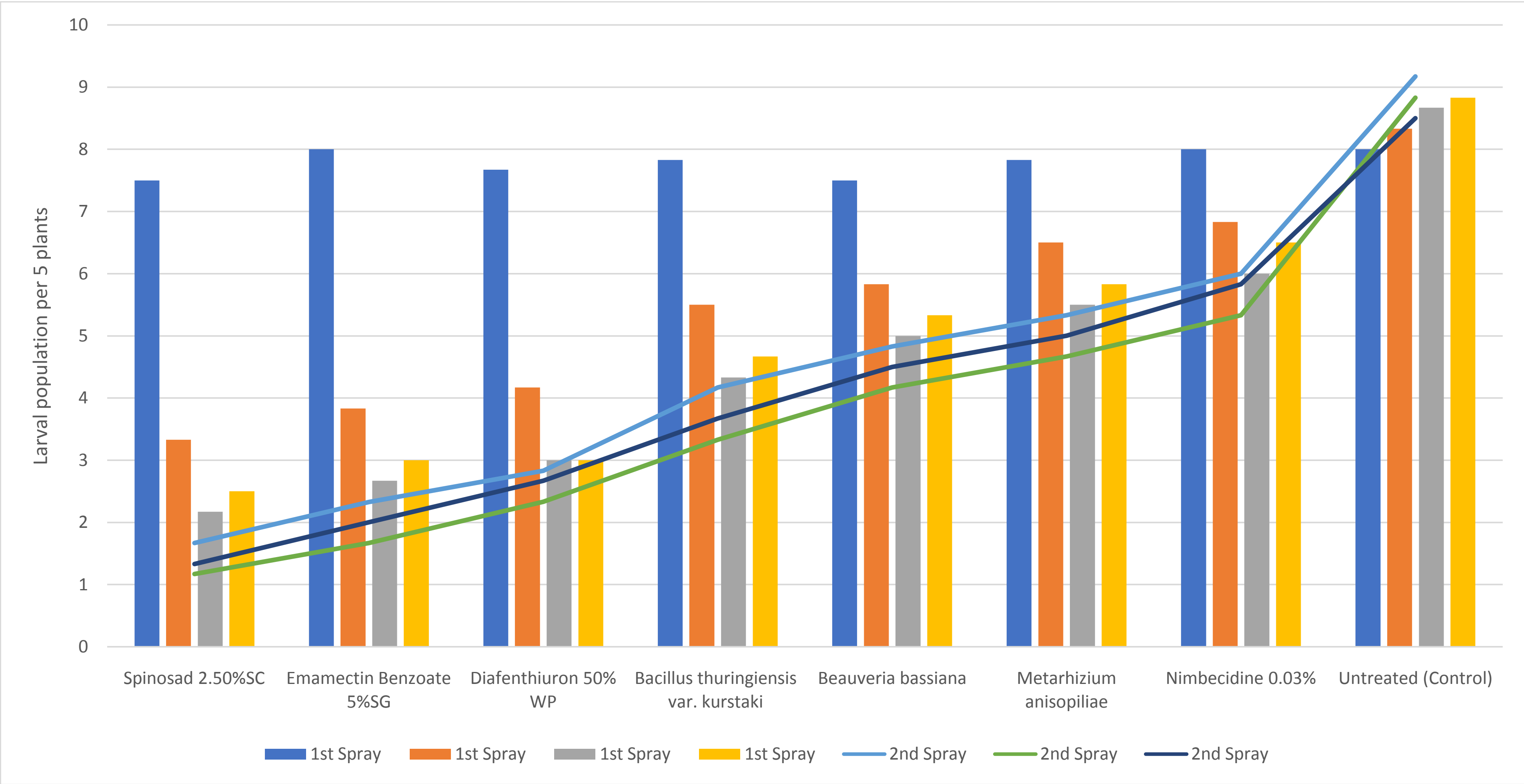

Figure3. Pooled Efficacy of newer insecticides and bio-pesticides against *Plutellaxylostella* (Linn.) in cabbage during *Rabi*, 2021/22.and2022/23.

References

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Devi, H. D. and Tayde, A. R. (2017). Comparative efficacy of bio-agents and botanicals on the management of diamondback moth *Plutellaxylostella*(Linn.) on cabbage under Allahabad agroclimatic conditions. *International Journal of Current Microbiology and Applied Sciences*, **6** (7): 711-716.

Gautam, M. P., Singh H., Verma, A. P., Patel A. and Singh,G. (2021). Efficacy of certain IPM modules on the population ofSpider in cabbage (*Brassica oleracea* Linn.). *Journal of Experimental Zoology. India*, **24** (1): 589-594.

Nyaupane, S., Tiwari, S., Thapa, R. B. and Jaishi, S. (2020). Testing of bio-rational and synthetic pesticides to manage cabbage aphid *Brevicorynebrassicae*(Linn.)in cabbage field at Rampur, Chitwan, Nepal. *Journal of Agriculture and Natural Resources*,**4** (2): 29-39.

Mollah, M., M., I., Rahman, M., M. and Alam, M., Z.(2012). Toxic Effect of Some Insecticides on Predatory Lady Bird Beetles (Coleoptera: Coccinellidae) in Country Bean *Lablab purpureus*(Linn.) Field. *World Journal of Zoology*, **7** (4): 347-350

Bana, J. K., Jat, B. L. and Bajya, D. R. (2012).Seasonal incidence of major pests of cabbage and their natural enemies. *Indian Journal of Entomology*, **74** (3): 236-240.

Snogerup, S. V. E. N. (1980). The wild forms of the *Brassica oleracea* group (2n= 18) and their possible relations to the cultivated ones. *Brassica Crops and Wild Allies*, (1): 121-132.

Anonymous. (2022). Indian Horticultural Data Base, National Horticulture Board, Ministry of Agriculture, Govt. of India., 242.

Sharma, P., Kumawat, K. C. and Lal, J. (2017). Seasonal abundance of diamondback moth and natural enemies on cabbage. *Journal of Entomology and Zoology Studies.*, **5** (3): 176-179.

Penas, E., Martinez-Villaluenga, C., Frias, J., Sánchez-Martínez, M. J., Pérez-Corona, M. T., Madrid, Y. and Vidal-Valverde, C. (2012). Se improves indoleglucosinolate hydrolysis products content, Se-methyl selenocysteine content, antioxidant capacity and potential anti-inflammatory properties of sauerkraut. *Food Chemistry*, **132**(2): 907-914.

Keck, A. S. and Finley, J. W. (2004). Cruciferous vegetables: cancer protective

UNDER PEER REVIEW

mechanisms of glucosinolate hydrolysis products and selenium. *Integrative Cancer Therapies.***3** (1): 5–12.

Bana, J. K., Jat, B. L. and Bajya, D. R. **(2012)**.Seasonal incidence of major pests of cabbage and their natural enemies. *Indian Journal of Entomology,* **74** (3): 236-240.

Begum, A., Latif, M. A., Ali, M. and Farhana, F. (2021). Effect of Biopesticides and Pheromone Traps on Major Insect-Pests and Their Natural Enemies of Cabbage. *Journal of Experimental Agriculture International*, **43** (4): 64-75.

Devi, H. D. and Tayde, A. R. (2017). Comparative efficacy of bio-agents and botanicals on the management of diamondback moth *Plutellaxylostella*(Linn.) on cabbage under Allahabad agroclimatic conditions. *International Journal of Current Microbiology and Applied Sciences,* **6** (7): 711-716.

Kumar, L., Singh, D. R. and Umrao, R. S. (2022). Bio-efficacy of certain botanicals and bio-pesticides against diamondback moth, *Plutellaxylostella* (Linn.) on cabbage *Brassica oleracea* var. capitata (Linn.) under field condition. *The Pharma Innovation Journal*, **11** (7): 633-638.

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