

**Comparative efficacy and economics of biopesticides with Emamectin benzoate against diamondback moth, *Plutellaxylostella*(L.) in cabbage, *Brassica oleracea* var.*Capitata*(L.)**

**ABSTRACT**

---

A field trial was conducted during *rabi* season 2023-2024 at Central Research Farm (CRF), Sam Higginbottom University of Agriculture, Technology and Sciences, Naini, Prayagraj, Uttar Pradesh. The experiment was laid out in Randomised Block Design (RBD) with eight treatments each replicated thrice using a variety Green Soccer (546). The treatments viz., Emamectin benzoate 5% SG, *Bacillus thuringiensis* 5.0% WP, Spinosad 02.50% SC, *Verticilliumlecanii* 5.0% SC, Neem seed kernel extract 5%, *Beauveriabasssiana*  $1 \times 10^8$  CFU/ml, Azadirechtin 00.03 % WSP and along with an untreated control against *plutellaxylostella* in cabbage. The data on larval population of Diamond back moth over control on first and second spray overall mean revealed that all treatments were significantly superior over control. Among all the treatments minimum larval population was recorded in in T<sub>3</sub> Spinosad 02.50 %SC (1.045) followed by T<sub>1</sub> Emamectin benzoate 5%SG (1.212), T<sub>2</sub> *Bacillus thuringiensis* 5.0% WP (1.345), T<sub>6</sub> *Beauveriabasssiana*  $1 \times 10^8$  CFU/ml (1.512), T<sub>4</sub> *Verticilliumlecanii* 5.0 % SC (1.667), T<sub>5</sub> Neem seed kernel extract 5 % (1.934), T<sub>7</sub> Azadirechtin 00.03 % WSP (2.133). While, the highest yield (298q/ha) was obtained from the treatment T<sub>3</sub> spinosad 02.50%SC as well as B:C ratio (1:5.76) was obtained high from this treatment. It followed by T<sub>1</sub> Emamectin benzoate 5%SG (276q/ha) (1:5.53), T<sub>2</sub> *Bacillus thuringiensis* 5.0% WP (269q/ha) (1:5.42), T<sub>6</sub> *Beauveriabasssiana*  $1 \times 10^8$  CFU/ml (259q/ha) (1:5.24), T<sub>4</sub> *Verticilliumlecanii* 5.0% SC (249q/ha) (1:5.04), T<sub>5</sub> Neem seed kernel extract 5% (233q/ha) (1:4.65), T<sub>7</sub> Azadirechtin 00.03 % WSP (215q/ha) (1:4.42) and the lowest yield and B:C ratio is recorded in T<sub>0</sub> Control (186q/ha) (1:4.05).

**Key word:** Biopesticides, Emamectin benzoate 5% SG, *Plutellaxylostella*, Spinosad 2.5%SC.

**INTRODUCTION**

“Cabbage, (*Brassica oleracea* var *capitata* L.) an herbaceous plant of Family *Brassicaceae*, is a widely cultivated vegetable throughout the world as a longstanding dietary supplement. It has numerous health benefits that have increased its popularity all over the world”. (Maity *et al.*, 2018).

“*Brassica oleracea* used like food and 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”. (Alexandra *et al.*, 2020)

Regular consumption of dark green leafy vegetables is highly recommended because of their potential in reducing chronic diseases. (Miller-Ceberet *et al.*, 2009) and glucosinolates in cabbage reduced risk of cancer induction and development. (Kang *et al.*, 2006)

“Cabbage cultivation is good at mainly on sandy to heavy soils rich in organic matter. Early crops desire light soil while late crops flourish better on heavier soils because of holding the moisture. On heavy soils, plants grow more slowly and the keeping quality is improved. A P<sup>H</sup> range of 6.0-6.5 is considered as optimum for growing cabbage. Plants growing in saline soils are prone to diseases. In India, cabbage is grown in large areas having a cool and moist climate. The temperature range of 15°-21° C is considered as optimum for growth and head formation of the crop. The intensity of flowering depends upon the age of the plants and the period for which they are exposed to low temperatures”. (National Horticulture Board, 2018)

“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”. (Kommoji and Tayde, 2022)

“The major insect pests, which cause maximum yield losses in cabbage are diamond back moth (*Plutellaxylostella* L), cabbage butterfly, (*Pierisbrassicae* L), cabbage aphid (*Brevicorynebrassicae* L.), cabbage semilooper (*Trichoplusiani*), leaf webber (*Crocidolomiabinotalis*), cabbage head borer, (*Hellulaundalis* Fab.). Diamondback moth is the most destructive pest in cabbage growing areas and the yield loss were reported up to 52% in India” (Krishnamoorthy, 2004)

“However, the set back to optimum cabbage production is the attack of insect pests, the most important of which is the diamond back moth (DBM), *Plutellaxylostella* 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. The DBM has developed resistance to all major classes of insecticides". (Maity *et al.*, 2018).

1. To evaluate the efficacy of biopesticides with Emamectin benzoate on the larval population of diamondback moth *Plutella xylostella* (L.) in cabbage.
2. To calculate the cost benefit ratio (C:B) of the treatments.

## MATERIALS AND METHODS

The experiment was conducted during *rabiseason* in 2023-2024 at Central Research Farm (CRF), at Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh (U.P) in a Randomized Block Design with eight treatments replicated three times using variety Green soccer-546 in a plot size of (2m x 1m) maintaining 0.3m borders as a bund with total gross area 105.6m<sup>2</sup> along with a recommended package of practices excluding plant protection. The site was uniform, cultivable with typical sandy loam soil having good drainage.

The treatments used in this experiment were Emamectin benzoate 5% SC, *Bacillus thuringiensis* 5.0% WP, Spinosad 02.50% SC, *Verticillium lecanii* 5.0% SC, *Beauveria bassiana* 1x10<sup>8</sup> CFU/ml, Neem seed kernel extract 5%, Azadirachtin 00.03% WSP (300 ppm) along with untreated control against diamond back moth

As the ETL 2-3 larvae per plant were crossed and application of the two rounds of insecticidal treatments were applied at 15 days interval. (Devi and Tayde, 2017)

"The insect population was counted from randomly selected plants 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 1 day spraying and on 3<sup>rd</sup> day, 7<sup>th</sup> day and 14<sup>th</sup> day after insecticidal application". [7] Healthy cabbage heads were harvested and their weight from each treatment was expressed as marketable yield in quintal per hectare. Ultimately, the cost benefit ratio was calculated on the basis of prevailing market price of yield, insecticides and spraying cost.

$$\text{Larval population} = \frac{\text{Number of Larvae}}{\text{Total number of selected plants}}$$

**Mane et al. (2021)**

**Economics:**

$$\text{Cost Benefit ratio} = \frac{\text{Gross Returns (t/ha)}}{\text{Total Cost of cultivation(t/ha)}}$$

**Nikitha et al. (2021)**

## RESULTS AND DISCUSSION

The data on the larval population of diamondback moth *P. xylostella* in cabbage 3rd, 7th and 14th day after first spray revealed that all the chemical treatments, were significantly superior over control. Among all the treatments lowest larval population was recorded in T<sub>3</sub> Spinosad 02.50 %SC (1.445) was recorded in **Reddy et al.(2018)**, T<sub>1</sub> Emamectin benzoate 5%SG (1.556), T<sub>2</sub> *Bacillus thuringiensis* 5.0% WP (1.689), T<sub>6</sub> *Beauveria bassiana* 1x 10<sup>8</sup> CFU/ml (1.867), T<sub>4</sub> *Verticillium lecanii* 5.0 % SC (2.022), T<sub>5</sub> Neem seed kernel extract 5 % (2.289), T<sub>7</sub> Azadirachtin 00.03% WSP(2.444) and T<sub>0</sub> control(3.511).

The data on the larval population of diamondback moth *P. 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 in T<sub>3</sub> Spinosad 02.50 %SC (0.645), T<sub>1</sub> Emamectin benzoate 5%SG (0.867), T<sub>2</sub> *Bacillus thuringiensis* 5.0% WP (1.000), T<sub>6</sub> *Beauveria bassiana* 1x 10<sup>8</sup> CFU/ml(1.156), T<sub>4</sub> *Verticillium lecanii* 5.0% SC(1.311), T<sub>5</sub> Neem seed kernel extract 5 % (1.578), T<sub>7</sub> Azadirachtin 00.03 % WSP(1.822) and T<sub>0</sub> control(3.889).

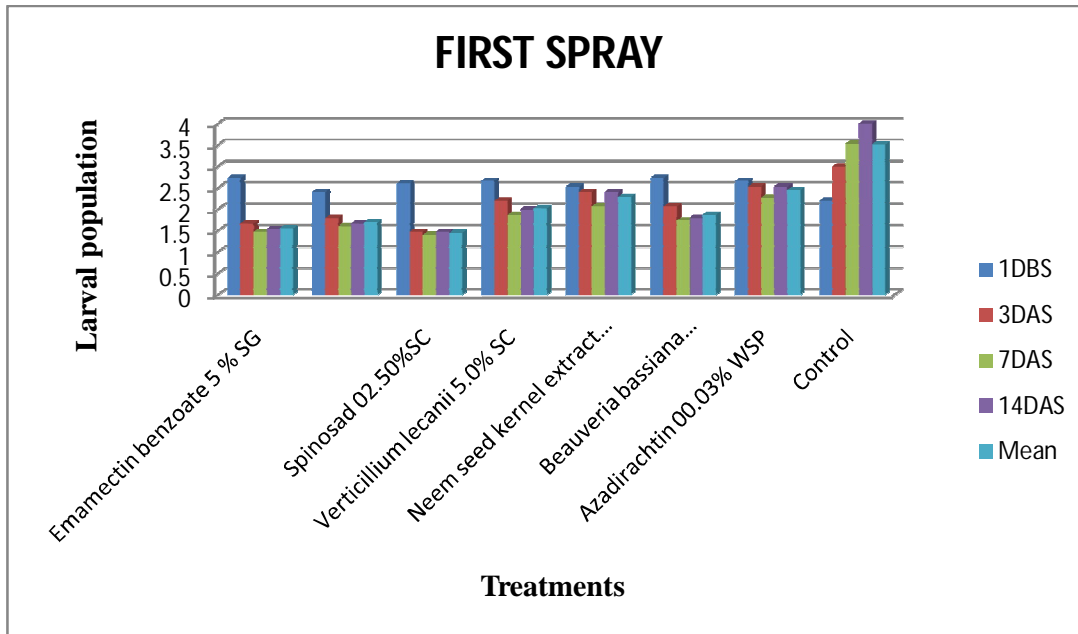
The data revealed on population of *P. xylostella* over control on Overall mean revealed that all the treatments were significantly superior over control (3.700). Among all the treatments minimum larval population was recorded in in T<sub>3</sub> Spinosad 02.50 %SC (1.045) similarly recorded in **Venugopale et al.(2017)** T<sub>1</sub> Emamectin benzoate 5%SG (1.212) similarly recorded in **Harika et al.(2019)**, T<sub>2</sub> *Bacillus thuringiensis* 5.0% WP (1.345), T<sub>6</sub> *Beauveria bassiana* 1x 10<sup>8</sup> CFU/ml (1.512), T<sub>4</sub> *Verticillium lecanii* 5.0 % SC (1.667), T<sub>5</sub> Neem seed kernel extract 5 % (1.934), T<sub>7</sub> Azadirachtin 00.03 % WSP (2.133) similarly recorded in **Puja et al. (2010)**.

All the insecticides were found very effective and significantly superior over control. The minimum larval population and the highest yield was recorded in T<sub>3</sub> Spinosad 02.50%SC (298q/ha) was recorded in **Lal et al.(2021)** T<sub>1</sub> Emamectin benzoate5%SG (276q/ha) **Patel et al.(2020)**, T<sub>2</sub> *Bacillus thuringiensis* 5.0% WP (269q/ha), T<sub>6</sub> *Beauveria bassiana* 1x 10<sup>8</sup>CFU/ml (259q/ha) was similarly recorded in **Khan and Tayde, (2022)**, T<sub>4</sub> *Verticillium lecanii* 5.0% SC (248q/ha), T<sub>5</sub> Neem seed kernel extract 5% (233q/ha) similarly recorded in **Kumar and Kumar,(2020)**, T<sub>7</sub> Azadirachtin 00.03% WSP (215q/ha) and the lowest yield is recorded in T<sub>0</sub> Control (186q/ha).

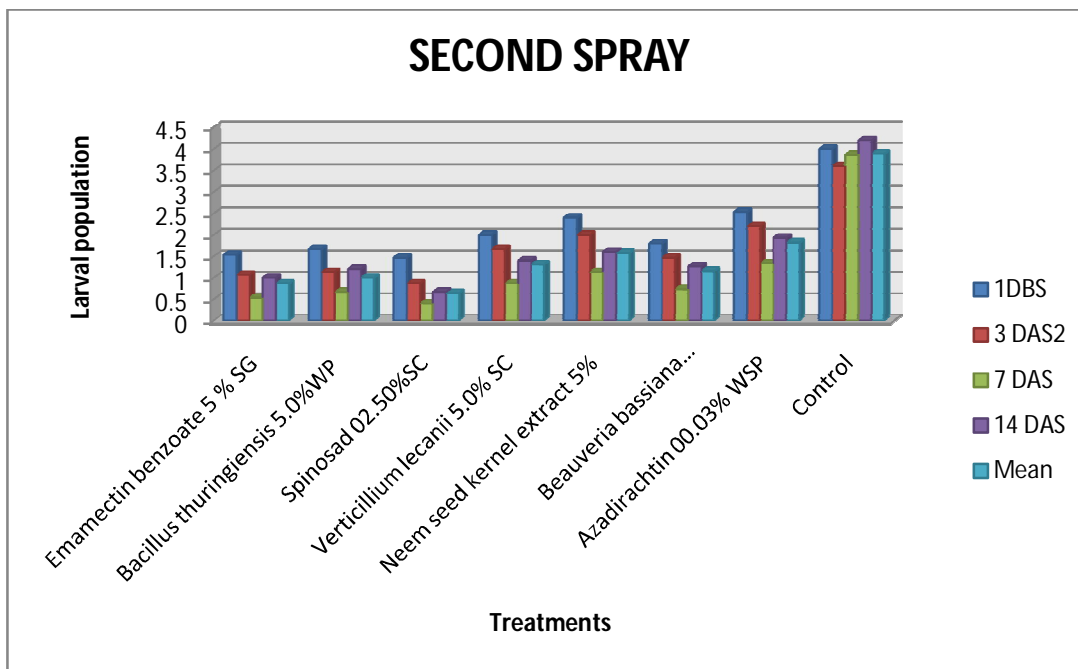
When cost benefit ratio worked out, interesting result was achieved, among the treatment studied, the best and most economical treatment is in T<sub>3</sub> Spinosad 02.50%SC (1:5.76) similarly recorded in **Yadav et al.(2017)**, followed by T<sub>1</sub> Emamectin benzoate 5%SG (1:5.53) was recorded in **Kumar and Devappa, (2006)**, T<sub>2</sub> *Bacillus thuringiensis* 5.0% WP (1:5.42) T<sub>6</sub> *Beauveria bassiana* 1x 10<sup>8</sup>CFU/ml (1:5.24), T<sub>4</sub> *Verticillium lecanii* 5.0% SC (1:5.04) recorded in **G Laxman et al. (2019)**, T<sub>5</sub> Neem seed kernel extract 5 % (1:4.65), T<sub>7</sub> Azadirachtin 00.03 % WSP (1:4.42) and T<sub>0</sub> Control (1:4.05).

**Table:1 Efficacy of biopesticideswith Emamectin benzoate on the larval populationof *P.xylostella* in cabbage, Yield and Cost Benefit ratio**

|                      | Treatments  | Larval population of diamond back moth per five cabbage heads |          |          |          |          |                       |          |          |          | Overall Mean | Yield (q/ha) | C:B Ratio |
|----------------------|---|---|----------|----------|----------|----------|-----------------------|----------|----------|----------|--------------|--------------|-----------|
|                      |   | 1 <sup>st</sup> Spray   |          |          |          |          | 2 <sup>nd</sup> Spray |          |          |          |              |              |           |
|                      |   | 1DBS  | 3 DAS    | 7 DAS    | 14 DAS   | Mean     | 3 DAS                 | 7 DAS    | 14 DAS   | Mean     |              |              |           |
| <b>T<sub>1</sub></b> | Emamectin benzoate 5% SG                            | 2.733   | 1.667    | 1.467    | 1.533    | 1.556    | 1.067                 | 0.533    | 1.0      | 0.867    | 1.212        | 276          | 1:5.53    |
| <b>T<sub>2</sub></b> | <i>Bacillus thuringiensis</i> 5.0% WP               | 2.4   | 1.8      | 1.6      | 1.667    | 1.689    | 1.133                 | 0.667    | 1.2      | 1.000    | 1.345        | 269          | 1:5.42    |
| <b>T<sub>3</sub></b> | Spinosad 02.50 % SC                                 | 2.6   | 1.467    | 1.4      | 1.467    | 1.445    | 0.867                 | 0.4      | 0.667    | 0.645    | 1.045        | 298          | 1:5.76    |
| <b>T<sub>4</sub></b> | <i>Verticilliumlecanii</i> 5.0% SC                  | 2.667   | 2.2      | 1.867    | 2.0      | 2.022    | 1.667                 | 0.867    | 1.4      | 1.311    | 1.667        | 248          | 1:5.04    |
| <b>T<sub>5</sub></b> | Neem seed kernel extract 5 %                        | 2.533   | 2.4      | 2.067    | 2.4      | 2.289    | 2.0                   | 1.133    | 1.6      | 1.578    | 1.934        | 233          | 1:4.65    |
| <b>T<sub>6</sub></b> | <i>Beauveria bassiana</i> 1 x10 <sup>8</sup> CFU/ml | 2.733   | 2.067    | 1.733    | 1.8      | 1.867    | 1.467                 | 0.733    | 1.267    | 1.156    | 1.512        | 259          | 1:5.24    |
| <b>T<sub>7</sub></b> | Azadirachtin 00.03% WSP                             | 2.667   | 2.533    | 2.267    | 2.533    | 2.444    | 2.2                   | 1.333    | 1.933    | 1.822    | 2.133        | 215          | 1:4.42    |
| <b>T<sub>8</sub></b> | <b>Control</b>                                      | 2.2   | 3.0      | 3.533    | 4.0      | 3.511    | 3.6                   | 3.867    | 4.2      | 3.889    | 3.700        | 186          | 1:4.05    |
|                      | <b>F-test</b>                                       | <b>NS</b>   | <b>S</b> | <b>S</b> | <b>S</b> | <b>S</b> | <b>S</b>              | <b>S</b> | <b>S</b> | <b>S</b> | <b>S</b>     |              |           |
|                      | <b>S. Ed. (±)</b>                                   | 0.269   | 0.106    | 0.054    | 0.118    | 0.173    | 0.102                 | 0.081    | 0.057    | 0.167    | 0.222        |              |           |
|                      | <b>C.D.(P= 0.05)</b>                                | -   | 0.231    | 0.121    | 0.185    | 0.372    | 0.221                 | 0.177    | 0.121    | 0.358    | 0.645        | -            | -         |



**Fig 1 Assessment of insecticides against diamondback moth, *Plutellaxylostella* in cabbage(1<sup>st</sup>spray)**



**Fig.2. Assessment of insecticides against diamondback moth, *Plutellaxylostella*(L.) in cabbage (2<sup>nd</sup> Spray).**

## **CONCLUSION**

From the analysis of present study finding, it was concluded that among all treatment Spinosad 02.50%SC recorded best and proved best effective for Diamondback moth, (*Plutellaxylostella*) and Emamectin benzoate, 5% SG proved the 2<sup>nd</sup> effective followed by *Bacillus thuringiensis* 5.0% WP, *Beauveria bassiana*  $1 \times 10^8$  CFU/ml, *Verticillium lecanii* 5.0% SC in managing (*Plutellaxylostella*) in cabbage (*Brassica oleracea*) on mean larval population. Therefore, the botanicals *i.e* Neem seed kernel extract 5% and Azadirachtin 00.03 % WSP may be useful in devising proper integrated pest management strategy against on Diamond Back Moth (*Plutellaxylostella*).

## **ACKNOWLEDGEMENTS**

The authors are grateful to Prof.(Dr.) Rajendra B. Lal Hon'ble Vice Chancellor, SHUATS, Prof.(Dr.) Alok Milton. Lall, Director of Research, Prof.(Dr.) Biswarup mehera, Dean, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, technology and Sciences, Prayagraj for making their keen interest and encouragement to carry out this research work.

## **COMPETING INTERESTS**

Authors have declared that no competing interest exist.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have been used during writing or editing of manuscripts. This explanation will include the

name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

- 1.
- 2.
- 3.

## REFERENCES

- 1.Alexandra, S. I. M. and Andrea Daniela, O. N. A. (2020).**Cabbage (*Brassica oleracea*L.). Overview of the health benefits andtherapeutical uses. *Hop and Medicinal Plants*, **1(2):**150-169.
- 2.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.
- 3.Harika, G., Dhurua, S., Suresh, M.andSreesandhya, N. (2019).** Evaluation of Certain Insecticides against Diamondback Moth (DBM) *Plutellaxylostella* on Cauliflower. *International Journal of Bio-resource and stress Management*, **10(1):** 70-76.
- 4.Kang, J. Y., Ibrahim, K. E., Juvik, J. A., Kim, D. H. and Kang, W. J. (2006).** Genetic and environmental variation of glucosinolate content in Chinese cabbage. *Horticulture Science*, **41(6):** 1382-1385.
- 5.Khan, S. A. R. and Tayde, A. R. (2022).** Comparative Efficacy and Economics of Chemicals Insecticides and Bioagents against Diamondback Moth (*Plutellaxylostella*) on Cabbage (*Brassica oleracea* var. *Capitata* L.). *International Journal of Plant & Soil Science*, **1(4)**85-89.
- 6.Krishnamurthy , A. (2004).** Biological control of diamond back moth *Plutellaxylostella* (L.), an Indian scenario with reference to past and future strategies. In Proceedings of the International Symposium, **2(7):**204-11.

- 7.Kommoji, T., and Tayde, A. R.(2022).**Efficacy of newer selected Insecticides, *Beaveriabassiana* and Neem oil against Diamondback moth (*Plutellaxylostella*)(L.) inCabbage(*Brassica oleracea*varcapitata).*International Journal of Plant and Soil Science*, **34**(20): 485-491.
- 8.Kumar, A. N. and Kumar, A. (2020).** Comparative efficacy of certain chemicals with biopesticides against diamondback moth, *Plutellaxylostella* (L.) in cabbage, *Brassica oleracea* (L.). *Journal of Entomology and Zoology Studies*,**8**(6): 1350-1353
- 9.Kumar, P. and Devappa, V. (2006).** Bio-efficacy of Emamectin Benzoate 5% SG (Proclaim) against diamondback moth in cabbage. *Pestology*, **30**(2): 23-25.
- 10.Laxman, G., Sharma, R.K.and Sinha, S.R.(2019)**Field Efficacy of Biopesticides against Diamondback Moth and Aphids on Cabbage.*PesticideResearch Journal* 0970-6763.
- 11.Lal, J., Swaminathan, R., Meena, A. K. and Nagar, R. (2021).** Field efficacy of biorational insecticides against major pestiferous insects of cabbage. *International Journal of Pest Management*, 1-7.
- 12.Maity, L., Padhi, G. and Samanta, A. (2018).** Population dynamics and management of diamond back moth *Plutellaxylostella* (L.) in cabbage ecosystem of West Bengal. *International Journal of Chemical Studies*, **6**(1): 381-385.
- 13.Mane, P. D., Singh, B. B. and Singh, P. K. (2021).** Effect of different insecticides on the management of diamond back moth (*Plutellaxylostella* Linn.) on winter cabbage. *Journal of Entomology and Zoology Studies* 2021; **9**(2): 1426-1428.
- 14.Miller-Cebert, R. L., Sistani, N. A. and Cebert, E. (2009).** Comparative protein and foliate content among canola cultivars and other cruciferous leafy vegetables *Journal of Food, Agriculture and Environment*,**7**(2):42-49.
- 15.(National Horticulture Board, 2018)**
- 16.Nikitha,R.G., Srivastava, K.V., Tayde, A.R. and Tripathi.A.(2021).** Comparative efficacy of microbials and botanicals against diamondback moth (*Plutellaxylostella* Linn) on cabbage. *Journal of Entomology and Zoology Studies* 2021; **9**(1): 497-499.
- 17.Patel , D. N. and Patel, D. R. (2020).** Efficacy of insecticides against diamomd back moth in cauliflower. *Indian Journal of Entomology*, **82**(1): 131-133 (2020).

- 18.Rani.P. and Kumar,V.J.(2010).**Bioefficacy of biological-based insecticides against diamondback moth (*Plutellaxylostella*) on cabbage (*Brassica oleracea*). *Indian Journal of Agricultural Sciences***80** (4): 345–7.
- 19.Reddy, M. S., Sathua, S. K., Sulagitti, A. and Singh, N. N. (2018).** Bio-efficacy of different novel insecticides and their interaction between numbers of sprays against diamondback moth (*Plutellaxylostella* L.) infesting cabbage. *Journal of Entomological Research*, **42**(1): 51-56.
- 20.UN food and Agriculture Organization, Corporate Statistical Database (FAOSTAT). 2022.**
- 21.Venugopal, U., Kumar, A., Kota, S and Ramya, V. (2017).** Efficacy of certain insecticides against diamondback moth (*Plutellaxylostella*L.) on cabbage (*Brassica oleracea*var. capitata L.). *Agriculture Update*, **12**(6): 1612-1616.
- 22.Yadav, S., Raju, S., Yadav, M., Srivastava, A. and Dwivedi, P. (2017).** Bio-efficacy of new insecticidal molecules against the Diamondback moth (*Plutellaxylostella* L.) on cauliflower. *Journal of Experimental Zoology*, **20**(1): 465-469.
- 23 Mushinamwar, D. R., Yadav, U., Gafar, B. B., &Rajawat, S. (2024).** Efficacy of Selected Biopesticides against Mustard Aphid, *Lipaphiserysimi* (Kalt.) (Hemiptera: Aphididae). *Journal of Advances in Biology & Biotechnology*, **27**(6), 702–707. <https://doi.org/10.9734/jabb/2024/v27i6930>
- 24 Dipak, and Ashwani Kumar. 2024.** “Comparative Efficacy of Selected Insecticides Against *Helicoverpa Armigera* (Hubner) on Cowpea, *Vigna Unguiculata* (L.) in Prayagraj, U.P., India”. *Journal of Experimental Agriculture International* **46** (6):570-74. <https://doi.org/10.9734/jeai/2024/v46i62510>.
- 25 Malinga LN, Laing MD.** Efficacy of three biopesticides against cotton pests under field conditions in South Africa. *Crop Protection*. 2021 Jul 1;**145**:105578.