"Comparative efficacy of different microbial biopesticides against gram pod borer, *Helicoverpa armigera* (Hubner) on chickpea, *Cicer arietinum* (L.)"

ABSTRACT

The experiment was conducted at the research plot of the Department of Agricultural Entomology at the Central Research Field, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj during the *Rabi* season of 2022. The treatments selected for this experiment were Emamectin benzoate, *Beauveria bassiana*, Spinosad, *Heterorhabditis indica*, *Metarhizium anisopliae*, *HaNPV*, *Bacillus thuringiensis* and control. The treatments were sprayed for 2 times on the pod borers having crossed their ETL levels at an interval of 15 days. Observations i.e. the larval counts (5 random plants/plot) were taken in an order of day before spray, 3rd, 7th and 14th days after spray. The results revealed that the treatments were successful in bringing down the pest infestation and superior over control. Among all the treatments applied, lowest larval population of gram pod borer was observed in Spinosad 45 SC (1.09) showing a highest yield of 23.79 q/ha against the control yielding only upto 9.03 q/ha. At the same time, the benefit cost ratios of the treatments stands like Spinosad 45% SC (1:2.81) followed by Emamectin benzoate 5% SG (1:2.74), *HaNPV* $2x10^9$ (POB's/ml) (1:2.56), *Beauveria bassiana* $1x10^8$ (CFU/gram) (1:1.74), *Bacillus thuringiensis* $1x10^8$ (CFU/ml) (1:1.54), *Metarhizium anisopliae* $1x10^8$ (CFU/gram) (1:1.37), *Heterorhabditis indica* $5.0x10^9$ IJ (1:1.30) as compared to control (1:0.69).

Key words: Benefit cost ratio, microbial biopesticides, efficacy, *Helicoverpa armigera*.

1. INTRODUCTION

Chickpea *Cicer arietinum* (L.), also known as Chana, Bengal gram, or Gram, is a significant pulse crop grown in many nations throughout the world and accounts for 20% of the world's supply of legumes. It is a member of the Leguminaceae family. South Western Asia is where the chickpea, known as the "King of Pulses," originated. The plant typically develops to a height of 20 to 50 cm during the *Rabi* season and has small, feathery leaves on either side of the stem **(Spoorthi *et.al.*, 2017)**. It is typically grown under rainfed or residual soil moisture conditions. In addition to being fed to animals, chickpeas are utilized for human

UNDER PEER REVIEW

consumption. Its seeds are used as a green vegetable, in dishes that are fried or roasted, as snacks, and in the production of flour and dhal **(Pachundkar *et.al*., 2013)**.

With a total production of 162.25 lakh tonnes and an average productivity of 1252 kg/ha, it was cultivated on 149.66 lakh hectares of land worldwide **(FAOSTAT, 2019)**. In all regions of India, chickpea is primarily grown as a rainfed crop (68% of the total area) **(Dixit *et.al*., 2019)**. Chickpeas were grown in 2016–17 over an area of 99.27 lakh ha, producing 98.80 lakh tonnes at a productivity of 995 kg/ha. About 11.23 million tonnes of chickpeas were produced in 2017–18, accounting for 46% of India's total pulse production (23.95 mt) **(Annual Report, DPD 2016-17)**.

Chickpeas have a nutritional value of 27.42 g of carbohydrates, 8.86 g of protein, 2.59 g of total fat, 7.6 g of dietary fibre, 172 mcg of folates, 0.526 mg of niacin, 0.245 mg of pantothenic acid, 0.216 mg of pyridoxine, 0.063 mg of riboflavin, 0.200 mg of thiamine, 1.3 mg of vitamin C, 27 IU of vitamin A, 0.35 mg of vitamin E, 4.0 mcg of vitamin K, 7.0 mg of sodium, 291 mg of potassium, 49 mg of calcium, 2.89 mg of iron, 48 mg of magnesium, 168 mg of phosphorous, 1.53 mg of zinc per 100 g **(USDA National Nutrient Database 2018)**.

From the time the crop is a seedling until it is fully grown, many different kinds of insects and pests attack it. *Helicoverpa armigera*, *Spodoptera litura*, *Agrotis ipsilon*, *Plusia orichalchea*, and *Bemisia tabaci* are the main insect pests that target chickpea crops in the winter and summer **(Yogeeswarudu and Krishna, 2014)**. A polyphagous insect of the Noctuidae family and Order-Lepidoptera, named gram pod borer. The names cotton bollworm, corn earworm, tomato fruit borer, and false budworm are also used to describe it. It targets more than 180 domesticated species, including those of cereals, legumes, fruits, vegetables, forage, and wild species. *Helicoverpa armigera* has been found in 181 plant species across 45 families in India **(Manjunath *et.al.*,2001)**.

This pest attacks chickpea plants at every stage, from seedling to crop maturity, and its larvae may eat leaves, fragile twigs, flowers, and pods to survive. After the pods have formed, the larvae burrow into them, eat on the seeds within and significantly reduce seed production. Its caterpillars consume the developing seeds by creating holes in the young pods and placing half of their bodies inside the pod. Pod borer damage has the potential to lower chickpea yield by 20–30% **(Sarwar, 2012)**.

UNDER PEER REVIEW

2. MATERIALS AND METHODS

The experiment was conducted during *Rabi* season 2022 at Central research field (CRF), SHUATS, Uttar Pradesh, India, in a Randomized Block Design with eight treatments replicated three times using PUSA-362 variety in a plot size of (2m×1m) at a spacing of (30×10cm). Seven treatments of microbial biopesticides were evaluated against, *Helicoverpa armigera* i.e., Emamectin benzoate 5SG, *Beauveria bassiana* 1 x 10^8 (CFU/gram), Spinosad 45SC, *Heterorhabditis indica* 5.0 x 10^9 IJ, *Metarhizium anisopliae* 1 x 10^8 (CFU/gram), *HaNPV* 2 x 10^9 (POB's/ml), *Bacillus thuringiensis* 1 x 10^8 (CFU/ml). The population of gram pod borer was recorded before 1-day spraying and on 3rd day, 7th day and 14th day after insecticidal application. The populations of gram pod borer was recorded on 5 randomly selected and tagged plants from each plot for investigating larval population and cost benefit ratio by following formula:

$$\text{Larval population count} = \frac{\text{Total number of larva}}{\text{5 randomly selected plants}}$$

$$\text{C: B Ratio} = \frac{\text{Net returns}}{\text{Total cost incurred}}$$

3. RESULTS AND DISCUSSION

The data on the larval population of Chickpea pod borer; 3rd 7th and 14th day after first spray revealed that all the treatments were significantly superior over control. Among all the treatments lowest larval population was recorded in T_3 Spinosad 45 SC (1.33%) followed by T_1 Emamectin benzoate 5SG (1.64%), T_6 *HaNPV* 2×10^9 (POB's/ml) (1.80%), T_2 *Beauveria bassiana* ($1x10^8$ CFU/ml) (2.15%), T_7 *Bacillus thuringiensis* 1×10^8 (CFU/ml) (2.26%), T_5 *Metarhizium anisopliae* 1×10^8 (CFU/gram) (2.37%) and T_4 *Heterorhabditis indica* 5.0×10^9 IJ (2.51%). The treatments T_4 Heterorhabditis indica 5.0×10^9 IJ (2.51%) was found to be least effective among all the treatments, yet significantly superior over the control plot T_0 (4.46%).

The data on the larval population of Chickpea pod borer; 3rd 7th and 14th day after second spray revealed that all the treatments were significantly superior over control. Among all the treatments lowest larval population was recorded in T_3 Spinosad 45 SC (0.86%) followed by T_1 Emamectin benzoate 5SG (1.08%), T_6 *HaNPV* 2×10^9 (POB's/ml) (1.22%), T_2

UNDER PEER REVIEW

Beauveria bassiana (1x10^8 CFU/ml) (1.55%), T_7 *Bacillus thuringiensis* 1×10^8 (CFU/ml) (1.64%), T_5 *Metarhizium anisopliae* 1×10^8 (CFU/gram) (1.75%) and T_4 *Heterorhabditis indica* 5.0×10^9 IJ (1.88%). The treatments T_4 *Heterorhabditis indica* 5.0×10^9 IJ (1.88%) was found to be least effective among all the treatments, yet significantly superior over the control plot T0 (4.90%).

The above results are similar to the findings of **Mohanty and Tayde (2022)** where the lowest larval population of gram pod borer was recorded in Spinosad 45SC. These results were also supported by **Chandrasekhar (2017)** where the highest reduction in larval population of gram pod borer (72.12%) was observed with spinosad 45 SC @ 0.5 ml/1.

The results obtained from the experiment performed by **Chaukikar *et.al.*, (2017)** supports the data and results of the present experiment, where Emamectin benzoate 5% WG @ 9.4 and 8.1g a.i. per ha were found to be most effective dose in reducing the *Helicoverpa armigera* larval population followed by Emamectin benzoate 5% WG @ 6.9 and 5.6 g a.i. per ha.

The yields among the treatments were significant. The highest marketable yield was recorded in Spinosad 45%SC (23.79q/h), followed by Emamectin benzoate 5%SG (20.67q/h), *HaNPV* 2×10^9 (POB's/ml) (19.75), *Beauveria bassiana* 1×10^8 (CFU/gram) (15.24q/h), *Bacillus thuringiensis* 1×10^8 (CFU/ml) (14.42q/h), *Metarhizium anisopliae* 1×10^8 (CFU/gram) (13.36q/h), *Heterorhabditis indica* 5.0×10^9 IJ (12.89q/h) and the lowest was recorded in control (9.03q/ha) agreed with the findings of **Narayan *et.al.*, (2015)** who revealed that Spinosad 45%SC recorded the highest yield followed by Emamectin benzoate.

The highest cost benefit ratio was recorded in Spinosad 45%SC (1:2.81) followed by Emamectin benzoate 5% SG (1:2.74), *HaNPV* 2x109 (POB's/ml) (1:2.56), *Beauveria bassiana* 1x108 (CFU/gram) (1:1.74), *Bacillus thuringiensis* 1x108 (CFU/ml) (1:1.54), *Metarhizium anisopliae* 1x108 (CFU/gram) (1:1.37), *Heterorhabditis indica* 5.0x109 IJ (1:1.30) as compared to control (1:0.69).

Maximum B:C ratio was obtained in the treatment Spinosad 45SC followed by Emamectin benzoate 5SG was reported by **Mohanty and Tayde (2022)**. These findings were also supported by **Dinesh *et.al.*, (2017)**, **Meena *et.al.*, (2018)** and **Mohite and Khan (2022)**.

UNDER PEER REVIEW

Table 1. Comparative effect and economics of different microbial biopesticides against gram pod borer, *Helicoverpa armigera* (Hubner) on chickpea, *Cicer arietinum* (L.) during *Rabi* season of 2022-23

S.No.	Treatments	Larval population/ 5 plants									Yield (q/ha)	C: B Ratio
		First spray				Second spray						
		3DAS	7DAS	14DAS	Mean	3DAS	7DAS	14DAS	Mean	Overall Mean		
T_1	**Emamectin benzoate 5SG**	2.13	1.13	1.66	1.64	1.40	0,80	1.06	1.08	1.36	20.67	1: 2.74
T_2	***Beauveria bassiana* 1×10^8 (CFU/gram)**	2.66	1.60	2.20	2.15	1.93	1.20	1.55	1.55	1.85	15.24	1: 1.74
T_3	**Spinosad 45SC**	1.73	0.86	1.40	1.33	1.13	0.60	0.86	0.86	1.09	23.79	1: 2.81
T_4	***Heterorhabditis indica* 5.0×10^9 IJ**	3.00	2.00	2.53	2.51	2.26	1.53	1.86	1.88	2.19	12.89	1: 1.30
T_5	***Metarhizium anisopliae* 1×10^8 (CFU/gram)**	2.80	1.86	2.46	2.37	2.13	1.40	1.73	1.75	2.06	13.36	1: 1.37
T_6	***HaNPV* 2×10^9 (POB's/ml)**	2.20	1.40	1.80	1.80	1.53	0.93	1.20	1.22	1.51	19.75	1: 2.56
T_7	***Bacillus thuringiensis* 1×10^8 (CFU/ml)**	2.73	1.80	2.26	2.26	2.00	1.33	1.60	1.64	1.95	14.42	1: 1.54
T_0	**Control**	4.26	4.46	4.66	4.46	4.73	4.93	5.06	4.90	4.68	9.03	1: 0.69
	F-test	S	S	S	S	S	S	S	S	S	-----	-----
	S. Ed (±)	0.346	0.341	0.303	0.175	0.322	0.259	0.292	0.135	0.258	-----	-----
	C.D. (P = 0.5)	0.742	0.732	0.649	0.375	0.691	0.554	0.627	0.289	0.611	-----	-----

*DAS=Day After Spray, **S-Significant

UNDER PEER REVIEW

4. CONCLUSION

From the critical analysis of the present findings it can be concluded that, among the treatments used spinosad 45%SC was found to be most superior in managing chickpea pod borer. However, emamectin benzoate 5% SG, *HaNPV* 2 x 10^9 (POB's/ml), *Beauveria bassiana* 1 x 10^8 (CFU/gram), has shown average results. Other biopesticides like *Bacillus thuringiensis* 1 x 10^8 (CFU/ml), *Metarhizium anisopliae* 1 x 10^8 (CFU/gram), *Heterorhabditis indica* 5.0 x 10^9 IJ found to be the least effective in managing *Helicoverpa armigera*. Among the treatments studied Spinosad 45%SC gave the highest cost benefit ratio (1:2.81) and marketing yield (23.79 q/ha) followed by Emamectin benzoate 5%SG (1:2.74 and 20.67 q/h), *HaNPV* 2 x 10^9 (POB's/ml) (1:2.56 and 19.75 q/ha), *Beauveria bassiana* 1 x 10^8 (CFU/gram) (1:1.74 and 15.24 q/ha), *Bacillus thuringiensis* 1 x 10^8 (CFU/ml) (1:1.54 and 14.42 q/ha), *Metarhizium anisopliae* 1 x 10^8 (CFU/gram) (1:1.37 and 13.36 q/ha) and *Heterorhabditis indica* 5.0 x 10^9 IJ (1:1.30 and 12.89 q/ha) under Prayagraj agroclimatic conditions as such more trials are required in future to validate the findings.

UNDER PEER REVIEW

REFERENCES

Annual Report DPD. 2016-17. Directorate of Pulses Development, Ministry of Agriculture and Farmers Welfare, Government of India. DPD/Pub/TR/19/2016-17.

Chandrasekhar, G. V. (2017). Efficacy of certain chemicals and neem products against *Helicoverpa armigera* (Hubner) on chickpea (*Cicer arietinum* L.). *Journal of Biopesticides*, **8**(4): 3154-3157.

Chaukikar, K., Bhowmick, A. K., Das, S. B., Marabi, R. S. and Tomar, V. S. (2017). Bio- efficacy of emamectin benzoate against *Helicoverpa armigera* (Hubner) and its natural enemies on chickpea (*Cicer arietinum*) crop. *International Journal of Bio-resource and Stress Management*, **8**(5), 716-720.

Dinesh, K., Singh, R. B., Kavita, K. and RS, C. (2017). Relative efficacy of newer insecticides and biopesticides against *Helicoverpa armigera* (Hubner) in chickpea. *Journal of Entomology and Zoology Studies*, **5**(3): 455-462

Dixit, G.P., Srivastava, A.K. and Singh, N.P. (2019). Marching towards self-sufficiency in chickpea. *Current Science*, **116**(2): 239-242.

Food and Agriculture Organization (2019). FAOSTAT Statistical Database of the United Nation Food and Agriculture Organization Statistical Division, Rome.

Manjunath, T. M., Bhatnagar, V. S., Pawar, C. S., and Sithanantham, S. (1989). Economic importance of *Heliothis* spp. in India and an assessment of their natural enemies and host plants. In *Proceedings of the Workshop on Biological Control of Heliothis: Increasing the Effectiveness of Natural Enemies,* (Eds.): E.G. King and R.D. Jackson. Far Eastern Regional Research Office, U. S. Department of Agriculture, New Delhi, India, 1989, 197-228.

Meena, R. K., Naqui, A. R., Meena, D. S., and Shibbhagvan, S. (2018). Evaluation of bio-pesticides and indoxacarb against gram pod borer on chickpea. *Journal of Entomology and Zoology studies*, **6**(2): 2208-2212.

Mohanty, S., and R Tayde, A. (2022). Comparative efficacy of certain insecticides and biopesticides against chickpea pod borer, *Helicoverpa armigera* (Hubner) on Chickpea, *Cicer arietinum* (L.). *International Journal of Plant and Soil Science*, **34**(22): 734-740.

Mohite, P. A., and Khan, S. A. R. (2022). Field evaluation of certain chemicals and biopesticides against pod borer, *Helicoverpa armigera* (Hubner) in Chickpea: An Experimental Research. *Research Highlights in Agricultural Sciences*, **6**: 45-54.

Narayan, S. R. P., Singh, P. S., and Singh, S. K. (2015). Evaluation of certain new insecticides against *Helicoverpa armigera* (Hubner) on chickpea (*Cicer arietinum* L.). *Journal of Experimental Zoology, India*, **18**(1): 227-235.

Pachundkar, N., Kamble, P., Patil, P. and Gagare, P. (2013). Management of gram pod borer *Helicoverpa armigera* in chickpea with neem and kernel extract as a natural pest management practice in bhojdari village. *International Journal of Current Research*, **5**(10): 2934-2935.

Sarwar, M., (2012). Competency of natural and synthetic chemicals in controlling gram pod borer, *Helicoverpa armigera* (Hubner) on chickpea crop. *International Journal of Agricultural Sciences*, **2**(4): 132-135.

UNDER PEER REVIEW

Spoorthi, G. S., Singh, R., Sharma, R., Kumar, S., Singht, N., and Tomar, S. S. (2017). Efficacy of insecticide and bio pesticides against *Helicoverpa armigera* (Hubner) on chickpea in Western Uttar Pradesh. *Journal of Pharmacognosy and Phytochemistry*, **6**(6S): 1034-1039.

USDA National Nutrient Database 2018.

Yogeeswarudu, B., and Krishna V. K. (2014). *Helicoverpa armigera* (Hubner) infesting on Chickpea. *Journal of Entomology and Zoology Studies*, **2**(5): 35-38.

UNDER PEER REVIEW