

**Determining the Effect of biopesticides and chemicals against pod borer
[*Helicoverpa armigera* (L.)] on chickpea (*Cicer arietinum* L.)**

ABSTRACT

The field investigation was carried out in the Prayagraj district of Uttar Pradesh. The experiment was conducted in *rabi* 2022 at Central Research Farm (CRF), SHUATS, Naini, Prayagraj district. The field was laid in RBD with three replication and eight treatments control *viz.*, *Beauveria bassiana* (2×10^8 CFU/gram) @ 2ml/lit, *Metarhizium anisopliae* (2×10^8 CFU/gram) @ 2g/lit, *Bacillus thuringiensis* (1×10^9 CFU/ml) @ 2ml/lit, *Ha NPV* (1×10^9 POB's/ml) @ 1ml/lit, Azadirachtin 0.3EC @ 5ml/lit, Spinosad 45% SC @ 0.5ml/lit, Neem seed kernel extract 5% @ 5ml/lit, and untreated controlled plot to check the efficacy of biopesticides against pod borer, on chickpea.

The result on the efficacy of treatments the least larval population was recorded in Spinosad 45% SC (0.96) followed by *Ha NPV* (1×10^9 POB's/ml) (1.20), *Bacillus thuringiensis* (1×10^9 CFU/ml) (1.84), *Beauveria bassiana* (2×10^8 CFU/gram) (1.91), *Metarhizium anisopliae* (2×10^8 CFU/gram) (2.02), Azadirachtin 0.3EC (2.22), Neem seed kernel extract 5% (2.48) and the highest larval population of pod borer was found in control treatment (4.02). In another parameter higher yield and cost benefit ratio was recorded in Spinosad 45% SC (20.33 q/ha) (1:2.84), followed by *Ha NPV* (1×10^9 POB's/ml) (18.60 q/ha) (1:2.59), *Bacillus thuringiensis* (1×10^9 CFU/ml) (17.65 q/ha) (1:2.46), *Beauveria bassiana* (2×10^8 CFU/gram) (15.68 q/ha) (1:2.19), *Metarhizium anisopliae* (2×10^8 CFU/gram) (14.58 q/ha) (1:2.03), Azadirachtin 0.3% EC (13.81 q/ha) (1:1.92) and Neem seed kernel extract 5% (13.58 q/ha) (1:1.89) as compared to control (10.83 q/ha) (1:1.54).

Keywords: Bio-Pesticides, Cost benefit ratio, Efficacy, *Helicoverpa armigera*, Chickpea

INTRODUCTION :-

Chickpea (*Cicer arietinum* L.), a member of Fabaceae, is a self-pollinated crop and is second most important food legume crop after common bean. It is an ancient cool season food legume crop cultivated by man and has been found in middle eastern archaeological sites dated 7500- 6800 BC (Gayathri and Kumar, 2021).

It is one of the most important food legume plants in a sustainable agriculture system because of its low production cost, wider adaptation, ability to fix atmospheric nitrogen and fit in various crop rotations. Nutritional value per 100g of chickpea contains carbohydrates (27.42 g), protein (8.86g), total fat (2.59 g), dietary fibre (7.6g), folates (172 mcg), niacin (0.526 mg), pantothenic acid (0.245 mg), pyridoxine (0.215 mg), riboflavin (0.063), thiamine (0.200 mg), vitamin C (1.3 mg), vitamin A (27 IU), vitamin E (0.35 mg), vitamin K (4.0 mcg), sodium (7.0 mg), potassium (291 mg), calcium (49 mg), iron (2.89 mg), magnesium (48 mg), phosphorous (168 mg), zinc (1.53 mg). (Hanumant and Kumar, 2021).

Globally, Bengal gram is grown in an area of 137 lakh hectares with a production of 142.4 lakh tonnes and productivity of 1038 kg/ha. India contributes 70 per cent of total world bengal gram production of 116.2 lakh tonnes cultivated under 112 lakh hectares with productivity of 1036 kg/hectare in 2020-21. India is the largest producer of world gram production followed by Australia, Myanmar and Ethiopia (Mohanty and Tayde, 2022). In India, bengal gram takes first position in total pulse production followed by Black gram. Madhya Pradesh ranked first contributing an area of 30.76 lakh ha, production 33.98 lakh tonnes and productivity 1105 kg/ha (34.46% and 40.62% of total area and production of country). Maharashtra is one of the second rank for area 15.41 lakh ha (17.26%) and third for production 11.98 lakh tones (14.32%). Whereas, Rajasthan stood second in production (14.47%) and third in area (15.37%). The highest yield was recorded in the state of Telangana (1459 kg/ha) followed by Gujarat (1201 kg/ha) and West Bengal (1163 kg/ha). The lowest yield was recorded in Karnataka (578 kg/ha). (Anil and Kumar, 2022)

The various ecological factors, responsible for low yield of chickpea in India, the insect pests are most important. listed 54 species of insect pests on chickpea of these the gram pod borer, *Helicoverpa armigera* (Hub), a pest of national importance in India, is one of the limiting factors in the successful cultivation of chickpea. Pod borer larvae feed on both foliage and pods of chickpea, yield losses are mainly due to pod damage. (Kumar *et al.*, 2018)

Comment [A1]: What is "Bengal gram"? Explain it earlier.

Comment [A2]: What does it mean?

MATERIALS AND METHODS: -

The experiment was conducted at the experimental research plot of the Department of Entomology, Central Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences during *Rabi* season of 2022 in Randomized Block Design with three replications and eight treatments using a variety Pusa- 362 with 2 × 1 m plot size. The crop of Chickpea (*Cicer arietinum* L.) was used for sowing by maintaining 45 cm inter-row and 15 cm intra-row distance with the seed rate of 70-100 kg/ha. The soil of the experimental site was well drained and medium high. Research field situated at 25°27' North latitude 80°05' East longitudes and at an altitude of 98 meter above sea level the maximum temperature reaches up to 42°C in summer and drops down to 4°C in winter. Agronomical practices were followed to raise the crop. ~~Each treatment was sprayed twice at when larval population reaches its ETL level (3 to 5 larvae per plant). The observation on population of *Helicoverpa armigera* were recorded visually per plant from five randomly selected and tagged plants in each plot.~~

The Biopesticides used for spraying ~~were~~ *Beauveria bassiana* (2×10^8 CFU/gram) @ 2ml/lit, *Metarhizium anisopliae* (2×10^8 CFU/gram) @ 2g/lit, *Bacillus thuringiensis* (1×10^9 CFU/ml) @ 2ml/lit, *Ha* NPV (1×10^9 POB's/ml) @ 1ml/lit, Azadirachtin 0.3EC @ 5ml/lit, Spinosad 45% SC @ 0.5ml/lit, Neem seed kernel extract 5% @ 5ml/lit. Each treatment was sprayed twice (1. , 2.) at when larval population reaches its ETL level (3 to 5 larvae per plant). They were sprayed at and total two sprays were given. The spray solution was applied with the help of a hand compression sprayer. Spraying was done at dawn and dusk time and there must not be much wind currents.

The observation on population of *Helicoverpa armigera* were recorded visually per plant from five randomly selected and tagged plants in each plot. The numbers of larva were counted on 5 randomly selected plants in each plot. The pre-treatment count was made a day before the both sprays whereas, the post- treatment counts were made on 3rd, 7th and 14th day after each spray. The larval population of gram pod borer was calculated by considering the mean of three observations recorded at 3rd, 7th, and 14th day after both sprays.

Preparation of Insecticidal Solution

The desired concentration of insecticidal spray solution for each treatment was freshly prepared each and every time at the site of the experiment, just before the start of spraying operations. The number of spray materials required for crop gradually increased as the crop advanced in age. The spray solution of desired concentration was prepared by adopting the following formula:

Comment [A3]: Co to są za biopreparaty. Coś należy o nich wspomnieć we wstępie.

$$V = (C \times A) / \% \text{ a.i.}$$

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Where,

V= Volume of a formulated pesticide required.

C= Concentration required.

A= Volume of total solution to be prepared.

% a.i. = Given Percentage strength of a formulated pesticide.

$$\text{Larval Population count} = \frac{\text{Total no of larvae}}{5 \text{ randomly selected plant}} \times 100 \text{ (Mohanty and Tayde, 2022)}$$

$$\text{C: B Ratio} = \frac{\text{Gross returns ₹/ha}}{\text{Cost of Plant Cultivation ₹/ha}} \text{ (Lavanya and Kumar, 2022)}$$

Where,

C:B Ratio = Cost Benefit Ratio

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Treatments		Larval population of gram pod borer (<i>H. armigera</i>) (Number)/plot										Yield (q/ha)	C: B Ratio
		1 st spray					2 nd spray						
		One day before spray	3DAS	7 DAS	14 DAS	Mean	3 DAS	7 DAS	14 DAS	Mean	Overall mean (1&2 spray)		
T ₁	<i>Beauveria bassiana</i> (2×10 ⁸ CFU/gram) @ 2ml/lit	2.80	2.33 ^{bc}	1.93 ^{bc}	2.20 ^{bc}	2.15 ^{cd}	2.13 ^{bc}	1.33 ^{cd}	1.53 ^{bc}	1.66 ^d	1.91 ^{bc}	15.68	1:2.19
T ₂	<i>Metarhizium anisopliae</i> (2×10 ⁸ CFU/gram) @ 2g/lit	2.66	2.46 ^b	2.06 ^b	2.33 ^b	2.28 ^{cd}	2.26 ^b	1.40 ^{cd}	1.60 ^b	1.75 ^{cd}	2.02 ^b	14.58	1:2.03
T ₃	<i>Bacillus thuringiensis</i> (1X10 ⁹ CFU/ml) @ 2ml/lit	2.93	2.26 ^{bc}	1.86 ^{bc}	2.13 ^{bc}	2.08 ^d	2.06 ^{bc}	1.26 ^d	1.46 ^{bc}	1.60 ^d	1.84 ^{bc}	17.65	1:2.46
T ₄	<i>Ha</i> NPV (1×10 ⁹ POB's/ml) @ 1ml/lit	2.80	1.66 ^{cd}	1.26 ^{cd}	1.53 ^{cd}	1.48 ^e	1.46 ^{cd}	0.53 ^e	0.73 ^{cd}	0.91 ^e	1.20 ^{cd}	18.60	1:2.59
T ₅	Azadirachtin 0.3EC @ 5ml/lit	2.93	2.53 ^b	2.13 ^b	2.40 ^b	2.35 ^c	2.33 ^b	1.86 ^{bc}	2.06 ^b	2.08 ^{bc}	2.22 ^b	13.81	1:1.92
T ₆	Spinosad 45% SC @ 0.5ml/lit	2.46	1.40 ^d	1.00 ^d	1.33 ^d	1.24 ^f	1.20 ^d	0.33 ^e	0.533 ^d	0.68 ^e	0.96 ^d	20.33	1:2.84
T ₇	Neem seed kernel extract 5% @ 5ml/lit	3.06	2.80 ^{ab}	2.33 ^b	2.66 ^b	2.60 ^b	2.53 ^b	2.20 ^b	2.40 ^b	2.37 ^b	2.48 ^b	13.58	1:1.89
T ₈	Control	3.20	3.46 ^a	3.66 ^a	3.86 ^a	3.66 ^a	4.20 ^a	4.40 ^a	4.53 ^a	4.37 ^a	4.02 ^a	10.83	1:1.54
Overall Mean		2.85	2.36	8.11	2.49	2.23	2.27	1.66	1.85	1.92	2.08		
F- test		NS	S	S	S	S	S	S	S	S	S		
S. Ed. (±)		0.17	0.34	0.33	0.32	0.10	0.35	0.23	0.23	0.18	0.18		
C. D. (P = 0.05)		N/A	0.72	0.70	0.69	0.20	0.72	0.49	0.69	0.38	0.72		

Table 1. Larval population of gram pod borer (*H. armigera*)

Comment [A4]: Explain what the superscript letters mean.

RESULT AND DISCUSSION:

The data after first spray table 1, revealed that all the treatment were significantly superior over control. Among the treatments most effective treatment in controlling larval population of gram pod borer was recorded in Spinosad 45% SC (1.24 larvae per 5 plants) followed by *Ha* NPV (1×10^9 POB's/ml) (1.48), *Bacillus thuringiensis* (1×10^9 CFU/ml) (2.08), *Beauveria bassiana* (2×10^8 CFU/gram) (2.15), *Metarhizium anisopliae* (2×10^8 CFU/gram) (2.28) and Azadirachtin 0.3% EC (2.35) respectively. Neem seed kernel extract 5% (2.60). was found to be least effective among all the treatments but superior over control (3.66).

The data after second spray revealed that all the treatment were significantly superior over control. Among the treatments most effective treatment in controlling larval population of gram pod borer was recorded in Spinosad 45% SC (0.68 larvae per 5 plants) followed by *Ha* NPV (1×10^9 POB's/ml) (0.91), *Bacillus thuringiensis* (1×10^9 CFU/ml) (1.60), *Beauveria bassiana* (2×10^8 CFU/gram) (1.66), *Metarhizium anisopliae* (2×10^8 CFU/gram) (1.75) and Azadirachtin 0.3% EC (2.08) respectively. Neem seed kernel extract 5% (2.37). was found to be least effective among all the treatments but superior over control (4.37).

The highest yield was recorded in Spinosad 45% SC (20.33 q/ha) of chickpea as against (10.83 q/ha) in untreated control. Whereas the *Ha* NPV (1×10^9 POB's/ml) (18.60 q/ha) yield of chickpea followed by *Bacillus thuringiensis* (1×10^9 CFU/ml) (17.65 q/ha), *Beauveria bassiana* (2×10^8 CFU/gram) (15.68 q/ha), *Metarhizium anisopliae* (2×10^8 CFU/gram) (14.58 q/ha) Azadirachtin 0.3% EC (13.81 q/ha) and Neem seed kernel extract 5% (13.58 q/ha).

When the treatment studied, the best and most economical treatment found was in Spinosad 45% SC (1:2.84) followed by *Ha* NPV (1×10^9 POB's/ml) (1:2.59), *Bacillus thuringiensis* (1×10^9 CFU/ml) (1:2.46), *Beauveria bassiana* (2×10^8 CFU/gram) (1:2.19), *Metarhizium anisopliae* (2×10^8 CFU/gram) (1:2.03), Azadirachtin 0.3% EC (1:1.92), and Neem seed kernel extract 5% (1:1.89) was found minimum cost benefit ratio among the treatments over untreated control (1:1.54).

The data on mean population after both sprays revealed that all the bio pesticides were found very effective and significantly superior over untreated control. Among all treatments minimum population of pod borer larva was found in Spinosad 45% SC (0.96) same results was reported by **Anil and Kumar (2022)**, **Reddy and Tayde (2022)**, **Kumar and Tayde (2022)**, *Ha* NPV (1×10^9 POB's/ml) which was found to be the next effective treatment with larval number (1.20) also reported the efficacy of *Ha* NPV by **Barwa et al., (2022)**, **Jagtap et al., (2022)**, *Bacillus thuringiensis* (1×10^9 CFU/ml) was found the next best effective treatments with the larval number (1.84) which is in supported by the findings of **Sai et al., (2021)**, **Reddy and Tayde (2022)**, **Anil and Kumar (2022)**.

Comment [A5]: This position is not listed in sec. "Reference"

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Comment [A6]: In the text, Barwa et al. is given, not Barwa and Kumar

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Comment [A7]: In the text, 2021 is given

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