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Comparative Efficacy of Certain Insecticides and Biopesticides against Chickpea Pod Borer, *Helicoverpa armigera* (Hubner) on Chickpea, *Cicer arietinum* (L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted at the research plot of the Department of Agricultural Entomology at the Central Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during the *Rabi* season of 2021-22. The treatments selected for this experiment were Emamectin benzoate 5%SG @0.4g/L (T_1), Spinosad 45%SC @0.5ml/L (T_2), Profenophos 50%EC @2ml/L (T_3), Indoxacarb 14.5%SC @1ml/L (T_4), Neem seed kernel extract 5% @5ml/L (T_5), Karanja oil 0.2% @2ml/L (T_6), *Bacillus thuringiensis* (1×10^9 CFU) @2ml/L (T_7) and Control (T_0). The treatments were sprayed 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 the day before spray, 3^{rd},$7^{th,}$ and 14^{th} days after spray. The results revealed that the treatments (insecticides and biopesticides) were successful in bringing down the pest infestation and superior over control. Among all the treatments applied, the lowest infestation of gram pod borer was observed in Spinosad 45%SC followed by Emamectin benzoate 5%SG, Indoxacarb 14.5%SC significantly superior over untreated control. Spinosad 45% SC gave a maximum grain yield of 22.50 q/ha against the control yielding only up to 6.66 q/ha. At the same time, the benefit-cost ratios of the treatments stand like the best and most economical treatment Spinosad (1:3.75) followed by Emamectin benzoate (1:3.71), Indoxacarb (1:2.94), Profenophos (1:2.53), NSKE (1:2.19), Karanja oil (1:1.53), *Bacillus thuringiensis* (1:0.87) and control (1:0:67).

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1. INTRODUCTION

"Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops grown in India, with an acreage of 10.91 million hectares yielding about 8.98 million tones and productivity of 886 kg per hectare" (Anonymous, 2013). "According to De Candolle, the fact that gram has a Sanskrit name Chanaka which indicates that the crop was under cultivation in India longer than in any other country in the world" (Gowda et al. 2007). "It is adapted to relatively cooler climates. The largest area of adaptation is in the Indian subcontinent. In recent years its cultivation has spread to Australia. Chickpea, *Cicer arietinum* (L.) family Leguminaceae (Fabaceae) originated in South-eastern Turkey and spread to other parts of the world [1-7]. Gram commonly known as chickpea or Bengal gram is the most important pulse crop in India. In India, it is also known as the King of pulses" (Anonymous, 2010).

"Two types of chickpea cultivars are recognized globally- *Kabuli* and *desi*. The *Kabuli* types are generally grown in the Mediterranean region including southern Europe, Western Asia, and Northern Africa, and the *desi* types are grown mainly in Ethiopia and the Indian subcontinent. *Desi* chickpeas are characterized by flowers of varying colours, angular to round seeds with dark seed coat, anthocyanin pigmentation, and semi-spreading to erect, semierect, or semi-spreading growth habits, whereas *Kabuli* types generally have owl- or ram-shaped beige-coloured seeds, white flowers, smooth seed surface, lack of anthocyanin pigmentation and semi spreading to erect growth habit" (Malhotra et al. 1987 and Muehlbauer et al. 1987).

"Nutritional value per 100 g of Chickpea contains Carbohydrates (27.42 g), Protein (8.86 g), Total fat (2.59 g), Dietary fibre (7.6 g), Folates (172 mcg), Niacin (0.526 mg), Pantothenic acid (0.245 mg), Pyridoxine (0.215 mg), Riboflavin (0.063 mg), Thiamin (0.200 mg), Vitamin C (1.3 mg), Vitamin A (27 IU), Vitamin E (0.35 mg), Vitamin K (4.0 mcg), Sodium (7 mg), Potassium (291 mg), Calcium (49mg), Iron (2.89 mg), Magnesium (48 mg), Phosphorus (168 mg), Zinc (1.53 mg)". (Source: USDA National Nutrient database 2021).

"The current productivity level 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" (FAO STAT, 2019). In India, chickpea accounts for about 45% of total pulses production. Similar to the case of other pulses, India is the major chickpea-producing country and contributes to over 75% of total world chickpea production. India is the largest producer of world gram production followed by Australia, Myanmar, and Ethiopia (FAO STAT, 2019). "In India, the Bengal gram takes the first position in total pulse production followed by the Black gram. The chickpea production in the country has gone up from 3.65 to 9.53 million tonnes between 1950-51 and 2013-14, registering a modest growth [8-11]. During the period while the area has also gone up from 7.57 to 9.93 million ha, the yield steadily increased from 482 kg/ha to 960" (Maurya et al. 2018).

"The chickpea crop is attacked by nearly 57 species of insect and other arthropods in India" (Lal, 1992). "Among them, pod borer *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is the most important. And accounts for about 90 to 95 % of the total damage caused by all insect pests" (Sachan and Katti, 1994).

Gram pod borer is considered a notorious pest of chickpea. It also attacks pigeon pea, moong bean, lentil, soybean, okra, maize, berseem, sunflower, sorghum, tobacco, and tomato. Besides gram pod borer, it is also known as cotton bollworm, gram caterpillar, tomato fruit worm, and tobacco budworm Pod borer is the most serious insect pest of chickpea. Percent larval survival and pupation were the maxima on chickpea as compared to other host plants (Lateef and Reed, 1983).

1.1 Objectives

To study the Effect of certain insecticides and biopesticides on the larval population of *Helicoverpa armigera* (Hubner) on chickpea [12-14].

To Calculate Economics of the Crop – Benefit-Cost ratio [B: C ratio].

2. MATERIALS AND METHODS

The experiment was conducted during *rabi* season 2021 at a Central Research Farm, Uttar Pradesh, India, in a Randomized Block Design with eight treatments replicated three times using local variety in a plot size of (2m×2m) at a

Table 1. Comparative effect and economics of selected insecticides and biopesticides against chickpea podborer, *Helicoverpa armigera* (Hubner) on chickpea, *Cicer arietinum* (L.) during *Rabi* season of 2021-22

S. No.	Treatments	Larval population									Yield (q/ha)	B:C Ratio
		First spray				Second spray						
		3DAS	7DAS	14DAS	Mean	3DAS	7DAS	14DAS	Mean	Overall Mean		
T_1	Spinosad 45%SC	2.60^{f}	0.93^{g}	3.26^{e}	2.26^{e}	1.93^{f}	0.86^{h}	3.13^{f}	1.97^{f}	2.11^{c}	22.50	1:3.75
T_2	Emamectin benzoate 5%SG	2.86^{f}	1.26^{fg}	3.66^{de}	2.57^{de}	2.33^{e}	1.13^{g}	3.66^{e}	2.34^{ef}	2.45^{bc}	18.33	1:3.71
T_3	Indoxacarb 14.5%SC	3.20^{e}	1.46^{ef}	4.06^{cd}	2.90^{cde}	2.66^{f}	1.46^{f}	4.00^{d}	2.68^{de}	2.79^{bc}	10.83	1:2.94
T_4	Profenophos 50%EC	3.46^{de}	1.80^{de}	4.06^{cd}	3.10^{cd}	2.86^{d}	1.73^{e}	4.33^{c}	2.97^{cde}	3.03^{bc}	13.33	1:2.53
T_5	Neem seed kernel extract 5%	3.66^{cd}	2.00^{d}	4.33^{bc}	3.30^{bcd}	3.20^{c}	2.00^{d}	4.53^{c}	3.24^{bcd}	3.27^{bc}	20.0	1:2.19
T_6	Karanjoil 0.2%	3.86^{c}	2.40^{c}	4.46^{bc}	3.57^{bc}	3.46^{b}	2.26^{a}	4.86^{b}	3.52^{bc}	3.54^{bc}	15.0	1:1.53
T_7	*Bacillus thuringiensis* (1×10^{9}cfu/ml)	4.20^{b}	2.80^{b}	4.80^{b}	3.93^{b}	3.66^{b}	2.60^{b}	5.13^{b}	3.77^{b}	3.85^{b}	8.3	1:0.87
T_0	Control	5.80^{a}	6.53^{a}	7.53^{a}	6.62^{a}	8.46^{a}	9.26^{a}	10.00^{a}	9.24^{a}	7.93^{a}	6.6	1:0.67
	F-test	S	S	S	S	S	S	S	S	S	-----	-----
	S. Ed (±)	0.107	0.095	0.143	0.198	0.059	0.064	0.082	0.180	0.328	-----	-----
	C.D. (P = 0.5)	0.270	0.355	0.533	0.738	0.223	0.242	0.309	0.672	1.651	-----	-----

spacing of (30×10cm) with a recommended package of practices excluding plant protection. The soil of the experimental site was well drained and medium-high. The crop research farm is situated at 25°24'North latitude 81°51' East Longitude and at an altitude of 98m above mean sea level. The experiment was conducted in a randomized complete block design with three replications. A good tilth area was divided into three main blocks. Each main block was sub-divided into 8 sub-plots each of which was 2m × 2m with maintaining 30cm borders as bunds and the treatments should be assigned randomly. Spraying was done when the pest has crossed ETL level (upon observation of (4 to 5 larvae per plant) at an interval of 15 days with the help of a hand compression sprayer. Spraying was done at dawn and dusk time when there were not many wind currents. Observations i.e., the larval counts (5 randomly selected plants per plot) were taken in an order of the day before spray, 3rd, 7th and 14th day after spray. Observations were taken daily in order to observe the incidence of *Helicoverpa armigera*.

2.1 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:

V = (C x A) / % a.i.

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.

Larval Population count = $\frac{Total\ no.of\ larvae \times 100}{5\ randomly\ selected\ plants}$

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

Where,
B:C Ratio = Benefit Cost Ratio

3. RESULTS

The data on the Larval population of pod borer three days after 1st spray (3DAS) revealed that all the treatments (insecticides and biopesticides) were significantly superior to control. Among all the treatments, the lowest larval population of chickpea pod borer was recorded in Spinosad 45%SC (2.6%) followed by Emamectin benzoate 5%SGss (2.86%), Indoxacarb 14.5%SC (3.2%), Profenophos 50%EC (3.46%), Neem seed kernel extract 5% (3.66%), Karanja oil 0.2% (3.86%), *Bacillus thuringiensis* (4.2%) is found to be a least effective among all the treatments as compared to control (5.8%).

The data on the Larval population of pod borer seven days after 1st spray (7DAS) revealed that all the treatments (insecticides and biopesticides) were significantly superior to control. Among all the treatments, lowest larval population of chickpea pod borer was recorded in Spinosad 45%SC (0.93%) followed by Emamectin benzoate 5%SGss (1.26%), Indoxacarb 14.5%SC (1.46%), Profenophos 50%EC (1.8%), Neem seed kernel extract 5% (2.0%), Karanja oil 0.2% (2.4%). Among all the treatments *Bacillus thuringiensis* (2.8%) is found to be the least effective but comparatively superior over the control (6.53%).

The data on the Larval population of pod borer fourteen days after 1st spray (14DAS) revealed that all the treatments (insecticides and biopesticides) were significantly superior to control. Among all the treatments, the lowest larval population of chickpea pod borer was recorded in Spinosad 45%SC (3.26%) followed by Emamectin benzoate 5%SGss (3.66%), Indoxacarb 14.5%SC (4.06%) and Profenophos 50%EC (4.06%), Neem seed kernel extract 5% (4.3%), Karanja oil 0.2% (4.4%). Among all the treatments and *Bacillus thuringiensis* (4.8%) was significantly superior to the control (7.53%).

The data on the Larval population of pod borer three days after 2nd spray (3DAS) revealed that all the treatments (insecticides and biopesticides) were significantly superior to control. Among all the treatments, the lowest larval population of chickpea pod borer was recorded in Spinosad 14.5%SC (1.93%) followed by Emamectin benzoate 5%SGss (2.33%), Indoxacarb 14.5%SC (2.66%), Profenophos 50%EC (2.86%), Neem seed kernel extract 5% (3.2%), Karanja oil 0.2% (3.46%), *Bacillus thuringiensis* (3.66%) were significantly superior over control (8.46%).

The data on the Larval population of pod borer seven days after 2nd spray (7DAS) revealed that all the treatments (insecticides and biopesticides) were significantly superior to control. Among all the treatments, lowest larval population of chickpea pod borer was recorded in Spinosad 14.5%SC (0.86%) followed by Emamectin benzoate 5%SGss (1.13%), Indoxacarb 14.5%SC (1.46%), Profenophos 50%EC (1.73%), Neem seed kernel extract 5% (2.0%), Karanja oil 0.2% (2.2%), *Bacillus thuringiensis* (2.6%) were significantly superior over control (9.26%).

The data on the Larval population of pod borer fourteen days after 2nd spray (14DAS) revealed that all the treatments (insecticides and biopesticides) were significantly superior to control. Among all the treatments, the lowest larval population of chickpea pod borer was recorded in Spinosad 14.5%SC (3.13%) followed by Emamectin benzoate 5%SGss (3.6%), Indoxacarb 14.5%SC (4.0%), Profenophos 50%EC (4.33%), Neem seed kernel extract 5% (4.53%), Karanja oil 0.2% (4.86%), *Bacillus thuringiensis* (5.13%) were significantly superior over control (10.00%).

The data on the larval population of pod borer of an overall mean of 1st spray from Table 1 revealed that all treatments (insecticides and biopesticides) were significantly superior to control. Among all the treatments, the lowest larval population of chickpea pod borer was recorded in Spinosad 45%SC (2.26%) followed by Emamectin benzoate 5%SGss (2.57%), Indoxacarb 14.5%SC (2.90%), Profenophos 50%EC (3.1%), Neem seed kernel extract 5% (3.3%), Karanja oil 0.2% (3.5%). Among all the treatments and *Bacillus thuringiensis* (3.9%). were significantly superior over control (6.62%).

The data on the larval population of pod borer of an overall mean of 2nd spray from Table 1 revealed that all treatments (insecticides and biopesticides) were significantly superior to control. Among all the treatments, the lowest larval population of chickpea pod borer was recorded in Spinosad 14.5%SC (1.97%) followed by Emamectin benzoate 5%SGss (2.34%), Indoxacarb 14.5%SC (2.686%), Profenophos 50%EC (2.97%), Neem seed kernel extract 5% (3.24%), Karanja oil 0.2% (3.52%), *Bacillus thuringiensis* (3.77%) were significantly superior over control (9.24%).

The yields among the treatment were significant. The highest yield was recorded in Spinosad 45%SC (22.50 q/ha) followed by Emamectin benzoate 5%SGss (20 q/ha), Indoxacarb 14.5%SC (18.33 q/ha), Profenophos 50%EC (15 q/ha), Neem seed kernel extract 5% (13.33 q/ha), Karanja oil 0.2% (10.83 q/ha), *Bacillus thuringiensis* (8.33 q/ha) and control (6.66 q/ha).

The cost-benefit ratio worked out, the interesting result was achieved, among the treatment studied, the best and most economical treatment was Spinosad 45% SC (1:3.75) followed by Emamectin benzoate 5%SGss (1:3.71), Indoxacarb 14.5%SC (1:2.94), Profenophos 50%EC (1:2.53), Neem seed kernel extract 5% (1:2.19), Karanja oil 0.2% (1:1.53), *Bacillus thuringiensis* (1:0.87), as compared to Control (1:0.67). However, all the treatments controlled the chickpea pod borer infestation effectively compared to the untreated control.

4. DISCUSSION

The overall mean of both the sprays raveled that among all the treatments, the lowest larval population of *Helicoverpa armigera* attacking chickpea was observed Spinosad 45% SC (2.11%) followed by Emamectin benzoate 5%SGss (2.45%), Indoxacarb 14.5%SC (2.79%), Profenophos 50%EC (3.03%), Neem seed kernel extract 5% (3.27%), Karanja oil 0.2% (3.54%), *Bacillus thuringiensis* (3.85%) and control (7.93%). The highest yield was recorded in Spinosad 45%SC (22.50 q/ha) followed by Emamectin benzoate 5%SGss (20 q/ha), Indoxacarb 14.5%SC (18.33 q/ha), Profenophos 50%EC (15 q/ha), Neem seed kernel extract 5% (13.33 q/ha), Karanja oil 0.2% (10.83 q/ha), *Bacillus thuringiensis* (8.33 q/ha) and control (6.66 q/ha).

The present results are in accordance with the findings of Narayan et al. [15] who reported that the highest yields were recorded from Spinosad 45%SC @ 200 g/ha + Emamectin benzoate 5%SG @ 30g/ha treated plots i.e., 1931 kg/ ha as compared to the untreated control plot (670 kg/ha), respectively and also Shekhara et al. (2015) revealed that Spinosad 45%SC recorded pod damage of 6.04 and 7.62 percent by Helicoverpa armigera respectively. These findings are in agreement with the findings of Kumar et al. 2010.

5. 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, Indoxacarb 14.5% SC, and Profenophos 50% EC, have shown average results. Biopesticides like Neem seed kernel extract 5%, Karanja oil 0.2%, and *Bacillus thuringiensis* (1×10^{9}cfu) were found to be the least effective in managing *Helicoverpa armigera.* Among the treatments studied Spinosad 45%SC gave the highest cost-benefit ratio (1:3.75) and marketing yield (22.50 q/ha) followed by Emamectin benzoate 5%SGss (1:3.71) and 20.0 q/h), Indoxacarb 14.5%SC (1:2.94 and 18.33 q/h), Profenophos 50%EC (1:2.53 and 15.0 q/h), Neem seed kernel extract 5% (1:2.19 and 13.33 q/ha), Karanja oil 0.2% (1:1.53 and 10.83 q/h) And *Bacillus thuringiensis* (1:0.87 and 8.3 q/h) under Prayagraj agroclimatic conditions as such more trials are required in future to validate the findings.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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