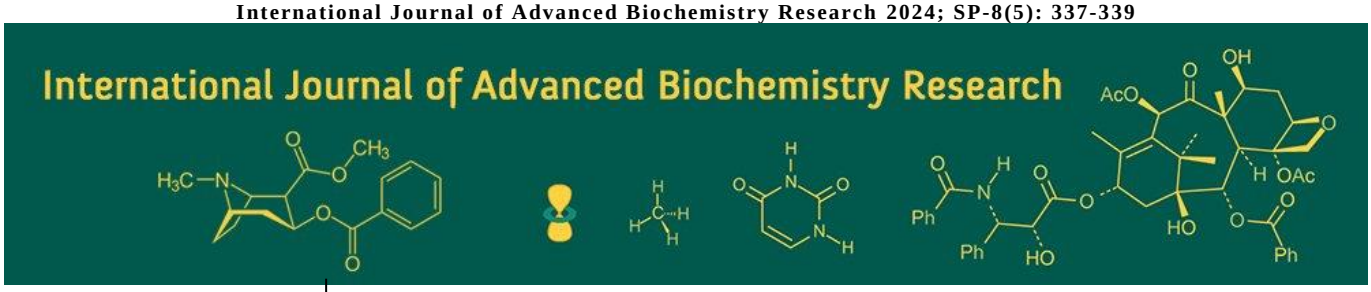

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Comparative efficacy of certain insecticide and bio-pesticides against gram pod borer, *Helicoverpa armigera* (Hubner) on chickpea, *Cicer arietinum* (L.)

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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, India, during the *Rabi* season of 2023. The treatments selected for this experiment were Spinosad, Flubendiamide, Indoxacarb, Neem oil + Indoxacarb, Nisco sixer plus + Novaluron, Emamectin benzoate, Neem seed kernel extract and control to observe the efficacy of the treatments and the cost benefit ratio. The treatments were sprayed for two times to control 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 (1.13) showing a highest yield of 27.22 q/ha against the control yielding only upto 10.42 q/ha. At the same time, the benefit cost ratios of the treatments stands like Spinosad 45% SC (1:3.74) followed by Neem oil 1% + Indoxacarb 14.5 EC (1:3.53), Indoxacarb 14.5 EC (1:3.41), Emamectin benzoate 5SG (1:3.28), Nisco sixer plus + Novaluron 10% EC (1:2.77), Flubendiamide 480 SC (1:2.68), Neem seed kernel extract 5% (1:2.02) as compared to control (1:0.86).

Keywords: Cost benefit ratio, larva population, chickpea, insecticides, biopesticides, efficacy, *Helicoverpa armigera*

Introduction
Chickpea [*Cicer arietinum* (L.)], also known as Chana, Bengal gram, or Gram, is a significant pulse crop grown in a lot of countries 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. It is typically grown under rainfed or for residual soil moisture conditions. In addition to being a feed, chickpeas are utilized for human consumption Its seed is used as a green vegetable, in dishes that are fried or roasted, as snacks, and in the production of flour and dhal.

Globally it was grown on 149.66 lakh ha area, with the total production of 15.97 million metric tons and average productivity of 1252 kg/ha (DES 2023, MOAF and W, Gol). Chickpea production of India was 13.75 million tonnes from an acreage of 10.91 million ha. with a productivity of 12.6 q./ha (DES 2023, MOAF and W, GoI. Chickpea solely contributes nearly 50% of the Indian pulse production. States like Maharashtra (25.97% contribution to national production), Madhya Pradesh (18.59%), Rajasthan (20.65%), Gujarat (10.10%) and Uttar Pradesh (5.64%) are major chickpea producing states of India.

Chickpeas have a nutritional value (per 100 g) of 27.42 g of carbohydrates, 8.86 g of protein, 2.59 g of total fat, 7.6 g of dietary fibre, 172 µg 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.

Chickpea crop is attacked by a number of insect- pests from seedling to its maturity. The major insect- pests attacking chickpea crop are *Helicoverpa armigera*, *Spodoptera litura*, *Agrotis ipsilon*, *Plusia orichalchea* and *Bemisia tabaci* during winter and summer seasons. Gram pod borer is a polyphagous insect belonging to the family Noctuidae and Order- Lepidoptera. It is also known as cotton bollworm, corn earworm, tomato fruit borer, and false budworm. It attacks more than 180 cultivated species from cereals, legumes, vegetables, fruits, forage and wild species. In India, *Helicoverpa armigera* has been recorded in 181 plant species from 45 families. 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%.

Materials and Methods

The experiment was conducted during *rabi* season 2023 at Central research field (CRF), SHUATS, Uttar Pradesh, India, in a Randomized Block Design (RBD) with eight treatments replicated three times using JAKI- 9218 variety in a plot size of (2 m×1 m) at a spacing of (30×10 cm). Two sprays were given at fifteen days interval using a hand operated sprayer during morning hours to avoid photo oxidation of chemicals. Eight treatments which includes seven insecticide. biopesticide and an untreated control were evaluated against *H. armigera* i.e., Spinosad 45 SC, Neem oil 1% + Indoxacarb 14.5 EC, Indoxacarb 14.5 EC, Emamectin benzoate 5SG, Nisco sixer plus + Novaluron 10% EC, Flubendiamide 480 SC and NSKE 5%. The population of gram pod borer was recorded one day before spraying and after 3, 7, 14 days post 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:

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

$$\text{Cost benefit ratio} = \frac{\text{Net returns}}{\text{Total cost incurred}}$$

Table 1: Treatments Shows 1st spray and 2nd spray

Treatments	1st Spray					2nd Spray						
	1 DBS	3 DAS	7 DAS	14 DAS	Mean	3 DAS	7 DAS	14 DAS	Mean	Overall mean	Yield	B:C Ratio
T_1- NSKE 5%	2.60	2.40	2.53	3.33	2.75	2.86	3.06	3.26	3.06	2.90	12.23	1:2.02
T_2- NSKE 5% + Indoxacarb 14.5 EC	2.73	1.93	1.33	1.73	1.66	1.33	0.73	1.06	1.04	1.35	26.17	1:3.53
T_3- Nisco sixer plus +Novaluron 10% EC	2.80	2.26	1.93	2.33	2.17	2.06	1.80	1.93	1.93	2.05	19.37	1:2.77
T_4- Indoxacarb 14.5 EC	2.66	2.00	1.46	1.80	1.75	1.40	0.93	1.26	1.19	1.47	24.22	1:3.41
T_5- Spinosad 45% SC	2.26	1.80	0.93	1.46	1.39	1.20	0.60	0.86	0.88	1.13	27.22	1:3.74
T_6- Flubendiamide 480 SC	2.60	2.33	2.13	2.46	2.30	2.26	1.93	2.33	2.17	2.22	17.78	1:2.68
T_7 – Emamectin benzoate	2.26	2.13	1.86	2.26	2.08	1.93	1.60	1.80	1.77	1.92	20.08	1:3.28
T_8- Control	3.06	4.66	5.53	5.66	5.35	5.73	5.80	5.93	5.82	5.55	10.42	1:0.86
F- test	NS	S	S	S	S	S	S	S	S	S		
S. Ed. (±)	0.47	0.92	1.42	1.35	1.22	1.47	1.70	1.65	1.61	1.41		
C. D. (P = 0.05)	N/A	0.281	0.248	0.305	0.545	0.234	0.221	0.240	0.283	0.700		

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 Neem oil 1% + Indoxacarb 14.5 EC (1.66), Indoxacarb 14.5 EC (1.75), Emamectin benzoate 5SG (2.08), Nisco sixer plus + Novaluron 10% EC (2.17), Flubendiamide 480 SC (2.30). Among all the treatments and NSKE (2.75) were significantly superior over control (5.35).

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 (0.88) followed by Neem oil 1% + Indoxacarb 1 4.5 EC (1.04), Indoxacarb 14.5 EC (1.19), Emamectin benzoate 5SG (1.77), Nisco sixer plus + Novaluron 10% EC (1.93), Flubendiamide 480 SC (2.17%). Among all the treatments and NSKE (3.06) were significantly superior over control (5.82).

The above results are similar to the findings of Hanumant and Kumar (2022) [9] where the lowest larval population of gram pod borer was recorded in Spinosad 45SC.These results were also supported by Mohapatra and Yadav (2023) [12] where lowest larva in larval population of gram pod borer (1.09) was observed with spinosad 45 SC.

The yields among the treatments were significant. The highest marketable yield was recorded in Spinosad 45% SC (27.22 q/h) followed by Neem oil 1% + Indoxacarb 14.5 EC (26.17 q/h), Indoxacarb 14.5 EC (24.22 q/h), Emamectin benzoate 5SG (20.08 q/h), Nisco sixer plus + Novaluron 10% EC (19.37 q/h), Flubendiamide 480 SC (17.78 q/h). Among all the treatments and NSKE (12.23 q/h) were significantly superior over control (10.42 q/h).Agreed with the findings of Reddy and Kumar (2022) [13] who revealed that Spinosad 45% SC (21.66 q/ha).

The highest cost benefit ratio was recorded in Spinosad 45% SC (1:3.74) followed by Neem oil 1% + Indoxacarb 14.5 EC (1:3.53), Indoxacarb 14.5 EC (1:3.41), Emamectin benzoate 5SG (1:3.28), Nisco sixer plus + Novaluron 10% EC (1:2.77), Flubendiamide 480 SC (1:2.68), NSKE (1:2.02) as compared to control (1:0.86).

Maximum B:C ratio was obtained in the treatment Spinosad 45SC as the similar finding was made by Hanumant and Kumar (2022) [9] followed by Neem oil 1% + Indoxacarb

14.5 EC was reported by Sai *et.al*, (2021) [16]. These findings were also supported by Mohapatra and Yadav (2023) [12], Meena *et al*., (2018) [11].

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 Neem oil 1% + Indoxacarb 14.5 EC, Indoxacarb 14.5 EC, Emamectin benzoate 5SG, has shown average results. Other pesticides like Nisco sixer plus + Novaluron 10% EC Flubendiamide 480 SC, NSKE 5% found to be the least effective in managing *Helicoverpa armigera.* Among the treatments studied Spinosad 45% SC gave the highest cost benefit ratio (1:3.74) and marketing yield (27.22 q/ha) followed by Neem oil 1% + Indoxacarb 14.5 EC (1:3.53 and 26.17 q/ha), Indoxacarb 14.5 EC (1:3.41 and 24.22 q/ha), Emamectin benzoate 5SG (1:3.28 and 20.08 q/ha), Nisco sixer plus + Novaluron 10% EC (1:2.77 and 19.37 q/ha),Flubendiamide 480 SC (1:2.68 and 17.78 q/ha), NSKE (1:2.02 and 12.23 q/ha). Hence, it is suggested that the effective insecticides may be alternated in harmony with existing Integrated Pest Management programs in order to avoid the problems associated with insecticidal resistance, pest resurgence, etc.

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