

Evaluation of bio-efficacy of botanical and chemical insecticides for the management of gram pod borer (*Helicoverpa armigera*) infesting chickpea in Bihar, India

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ABSTRACT: A field experiment was conducted to evaluate the efficacy of various botanical and chemical insecticides against *Helicoverpa armigera*. Eight treatments including three botanical and four chemical insecticides were tested. All the botanical and chemical insecticides were showed significantly superior to control. Among the treatments indoxacarb (14.5 SC @ 75 g a.i. ha⁻¹) was found most effective in controlling gram pod borer incidence with less pod damage and maximum yield (7.8% pod damage and 1519.97 kg ha⁻¹ respectively) and which was at par with emamectin benzoate 5 SG @ 11 g a.i. ha⁻¹ (9.2% pod damage, and 1454.11 kg ha⁻¹). The control recorded higher pod damage and low yield (23.87% pod damage and 844.20 kg ha⁻¹). On the basis of economic parameters, the highest incremental benefit-cost ratio (IBCR) was recorded in the treatment of indoxacarb 14.5 SC (7.2:1), followed by emamectin benzoate 5 SG (7.0:1), chlorantraniliprole 18.5 SC (4.6:1), fipronil 5 SC (4.0:1), NSKE 5 (%) (2.1:1), neem oil (2%) (1.5:1) and karanj oil (5%) (1.2:1). © 2026 Association for Advancement of Entomology

KEY WORDS: Incremental benefit cost ratio, indoxacarb, pod damage, yield

INTRODUCTION

Chickpea (*Cicer arietinum* L.), a member of the family Fabaceae, is an ancient, self-pollinated leguminous crop widely cultivated across the world. Commonly known as Bengal gram, ceci bean, chana, and garbanzo bean (Patil *et al.*, 2017), it holds significant importance as a major *rabi* season pulse crop in India, where it is often referred to as the king of pulses. Globally, chickpea ranks as the

third most important grain legume after dry beans and peas (Sai *et al.*, 2021). Chickpea seeds are highly nutritious, containing 18-22 per cent protein, 52-70 per cent carbohydrates and 4-10 per cent fat. The crop residue or straw also serves as valuable livestock forage (Shrestha *et al.*, 2011). Moreover, chickpea contributes significantly to soil fertility through biological nitrogen fixation, up to 140 kg N ha⁻¹ Year⁻¹ to the soil (Mustafa *et al.*, 2023). In India chickpea was grown on area of

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10.74 m ha⁻¹ and production was 13.54 million tons with productivity of 1261 kg ha⁻¹. In Bihar chickpea cultivated on area of 0.051 million hectare and production of 0.054 million tons with productivity of 1053 kg ha⁻¹ (Anonymous, 2023). However, a vast number of insect species limit chickpea yield in both field and storage conditions. Among these *Helicoverpa armigera* (Hubner) (Lepidoptera, Noctuidae) is a multivoltine, very polyphagous, and worldwide pest known for its high reproduction rate and short life cycle (Kumar and Singh, 2014). The destructive stages of the insect are its larval stages, which feed on over 182 different host plants, including pigeon pea, chickpea, cotton, maize, and tomato (Gowda *et al.*, 2005). The damaging potential of *H. armigera* on chickpea ranges from 75 to 90 per cent losses in seed yield, despite the application of insecticides (Divija *et al.*, 2024)). Farmers frequently rely extensively on old-generation pesticides, and their indiscriminate use has contributed to the development of pest resistance, as well as a variety of environmental and health issues. Therefore, early and climate-smart pest management interventions are essential to protect pods and prevent significant losses in seed yield (Balraj *et al.*, 2025; Prajapati and Patel, 2025).

To address these challenges, the use of botanical and new generation insecticides that give satisfactory results with minimal effect on the natural enemies, human beings, and the environment. The new generation insecticides act as an effective alternative source with their unique mode of action and less impact on the environment. Overall, studying the efficacy of both botanical and chemical insecticides against gram pod borer is essential for sustainable pest management practices that balance agricultural productivity, environmental protection, human health and economic viability.

MATERIALS AND METHODS

Agricultural research farm at Dholi, positioned at 25.9° N latitude and 85.5° E longitude, with an elevation of 53 meters above sea level. It lies within agro-climatic zone-1, specifically the North West Alluvial Plain Zone of Bihar and is part of the command area of Gandak River. The soil in this

region varies in texture from loamy to sandy loam. The experiment was setup with chickpea variety P-3043 and eight treatments replicated thrice in Randomised Block Design. Each plot is 2 × 2m with a spacing of 30cm×10cm. Two successive pesticide sprays were applied at 15-day intervals, beginning with the blossoming stage. The efficacy of botanical and chemical insecticides, Emamectin benzoate 5 SG, Chlorantraniliprole 18.5 SC, Indoxacarb 15.8 SC, Fipronil 5 SC, Neem Seed Kernal Extract (5%), Karanj oil (5%), and Neem oil (2%), was compared to a control plot against the gram pod borer, *H. armigera*. The agronomic package of strategies is being carried out in accordance with the recommendations of RPCAU, Pusa, Bihar.

Observations on larval population were recorded by counting number of larvae on five randomly selected plants per each replication, with data collected one day prior to the spray and at 1, 3, 7, and 14 days after both first and second spray.

At crop maturity, pods from five randomly selected plants in each treatment and replication were taken to determine the pod damage level of *H. armigera*. The proportion of pod damage was calculated using the following formula. Chickpea grain yields were calculated for each treatment and then converted to ha⁻¹.

$$\text{Pod damage (\%)} = \frac{\text{No of infested pods}}{\text{Total no of pods}} \times 100$$

The gross return was determined by multiplying the total yield by the market price of the produce. and the cost of treatment imposition were then subtracted from the gross returns to calculate additional income over control and the Incremental benefit cost ratio (IBCR) using the following formula:

$$\text{IBCR} = \frac{\text{Additional income over control}}{\text{Cost of protection}}$$

RESULTS AND DISCUSSION

First spray: The mean analysis for the overall effect demonstrated that all the botanicals and chemical insecticidal treatments were significantly

effective in reducing the larval population of *H. armigera* compared to the control plots (Table 1). Among the tested treatments, indoxacarb 14.5 SC (0.92 larvae plant⁻¹) was found to be the most effective in controlling the incidence of the gram pod borer. This was followed by emamectin benzoate 5 SG (1.08 larvae plant⁻¹), chlorantraniliprole 18.5 SC (1.25 larvae plant⁻¹), fipronil 5 SC (1.42 larvae plant⁻¹), neem seed kernel extract (5%) (1.60 larvae plant⁻¹), neem oil (5%) (1.65 larvae plant⁻¹) and karanj oil at 5 per cent (1.72 larvae plant⁻¹). The current findings are in line with the results reported by Tripathi *et al.* (2023), who noted the lowest larval density of the gram pod borer in plots treated with indoxacarb at 79 g a.i. ha⁻¹ (0.59 larvae plant⁻¹). Similarly, Meena *et al.* (2018) found that indoxacarb 14.5 SC was the most effective treatment for reducing the larval population of the gram pod borer, while neem seed kernel extract (NSKE) exhibited moderate efficacy in controlling the gram pod borer. In terms of botanical treatments, the present study aligns closely with Yerrabala *et al.* (2021), who reported that neem seed kernel extract 5 per cent achieving the highest reduction in pod borer population, followed by neem oil 5 per cent. Furthermore, Kumar *et al.* (2019) identified NSKE (5%) as the most efficacy in controlling the gram pod borer, followed by neem oil (2%) significantly reduced pod damage.

Second spray: All insecticidal treatments were significantly reduced the larval population of the gram pod borer compared to the control (Table 1). Among all the treatments, indoxacarb 14.5 SC was the most effective against gram pod borer (0.57 larvae plant⁻¹). The effectiveness of the other treatments was ranked as follows: emamectin benzoate 5 SG (0.75 larvae plant⁻¹), chlorantraniliprole (0.83 larvae plant⁻¹), fipronil (1.13 larvae plant⁻¹), neem seed kernel extract (NSKE) (1.38 larvae plant⁻¹), neem oil (1.50 larvae plant⁻¹), and karanj oil (1.62 larvae plant⁻¹). The present findings consistent with Tripathi *et al.* (2023), who found that indoxacarb applied @ 79 g a.i ha⁻¹ was the showing more efficacy, resulting in only 0.27 larvae per plant. Furthermore, Das *et al.* (2022) evaluated the effectiveness of various

treatments for reducing the larval population of the gram pod borer and reported that neem oil (2 %) and karanj oil (2%) achieved percentage reductions of 45.81 per cent and 37.53, respectively.

Pod damage: The pod damage caused by the gram pod borer across various treatments were significantly lower compared to the control (Table 1). Among all treatments, application of indoxacarb 14.5 SC showed the greatest efficacy, resulting in the least pod damage at 7.8 per cent, which was statistically similar to that of emamectin benzoate 5 SG, which recorded a damage level of 9.2 per cent. Conversely, the highest percentage of pod damage was noted in the plot treated with karanj oil (5%), which exhibited a damage rate of 17.8 per cent. This was closely followed by plots treated with neem oil (2%) at 16.2 per cent and neem seed kernel extract at 14.1 per cent, both of which showed similar levels of damage. The findings of the present study are in close agreement with Tripathi *et al.* (2023) who revealed the efficacy of chemical and botanical insecticides to gram pod borer. Among them indoxacarb 15.8 EC at the rate of 79 g a.i ha⁻¹ showed the highest effectiveness, resulting in lower pod damage at (7.33%), followed by emamectin benzoate showed a pod damage rate of (9.20%) and chlorantraniliprole exhibited a pod damage rate of (10.25%). fipronil (12.3%) and neem oil showed a pod damage rate of (18.35%). Similarly, Meena *et al.* (2018) recorded the per cent pod damage of gram pod borer which was ranged from 4.69 to 20.95 per cent.

Yield: The data regarding chickpea grain yield, as presented in (Table 2), indicated that all treatments resulted in a significant increase in grain yield compared to the control. The grain yield for chickpeas varied from (844.20 to 1519.97 kg ha⁻¹) across the different treatments, while the control (844.20 kg ha⁻¹). The highest yield was observed in the plot treated with indoxacarb 14.5 SC (1519.97 kg ha⁻¹), followed closely by emamectin benzoate 5 SG, (1454.11 kg ha⁻¹), which were statistically similar. Conversely, the minimum grain yield was noted in karanj oil (1021.45 kg ha⁻¹), followed by neem oil (1064 kg ha⁻¹) and NSKE (1098 kg ha⁻¹).

The findings of the present study are in close agreement with Meena *et al.* (2018), who reported yield data (ranging from 8.63 to 14.83 q ha⁻¹). The plot treated with indoxacarb 14.5 SC achieved the highest yield, while the lowest yield was recorded in the control plot.

Determination of incremental benefit cost ratio: The IBCR analysis for the various botanical and chemical insecticides used against the chickpea gram pod borer are shown in Table 2. Among all the treatments, the highest incremental benefit-cost ratio was attained with indoxacarb 14.5 SC (7.2:1),

Table 1. Efficacy of botanical and chemical insecticides against pod borer in chickpea during Rabi, 2023 -2024

Treatments/ Dosage (g a.i. /ha)	Mean incidence after			Pod damage (%)
	DBS	I spray	II spray	
Fipronil 5% SC @50	1.93	1.42	1.13	12.84
Chlorantraniliprole 18.5% SC @25	2.00	1.25	0.83	11.4
Indoxacarb 14.5% SC @75	1.93	0.92	0.57	7.8
Emamectin benzoate 5% SG @11	1.87	1.08	0.75	9.2
Neem oil @2%	1.93	1.65	1.50	16.2
Neem seed kernal extract @5%	2.00	1.60	1.38	14.1
Karanj oil @5%	1.93	1.72	1.62	17.8
Control	2.00	2.25	3.03	23.87
SEm(±)	0.11	0.06	0.08	0.83
CD ($p=0.05$)	(NS)	0.19	0.23	2.50
CV (%)	9.73	8.50	11.79	10.11

Table 2. Economics of treatments against gram pod borer on chickpea during Rabi, 2023 – 2024

Treatments	Yield (kg ha ⁻¹)	Yield over control (kg ha ⁻¹)	Income over control (Rs ha ⁻¹)	Cost of PP (Rs ha ⁻¹) (2 Sprays)	Income over control (Rs ha ⁻¹)	IBCR
Fipronil 5 % SC	1249.99	405.79	21507	4300	17207	4.0:1
Chlorantraniliprole 18.5 % SC	1365.00	520.80	27602	4966	22636	4.6:1
Indoxacarb 14.5 % SC	1519.97	675.77	35816	4380	31436	7.2:1
Emamectin benzoate 5 % SG	1454.11	609.91	32325	4032	28293	7.0:1
Neem oil 2%	1064.00	219.80	11649	4600	7049	1.5:1
Neem Seed Kernal Extract 5%	1098.00	253.80	13451	4400	9051	2.1:1
Karanj oil 5%	1021.45	177.25	9394	4260	5134	1.2:1
Control	844.20	-	-	-	-	-

followed by emamectin benzoate 5 SG (7.0:1), chlorantraniliprole 18.5 SC (4.6:1), fipronil 5 SC (4.0:1), NSKE (2.1:1), neem oil (1.5:1), and karanj oil (1.2:1). The current findings are closely linked to those of Meena *et al.* (2018) and Tripathi *et al.* (2023), who indicated that the insecticide indoxacarb 14.5 SC had the highest cost-benefit ratio. Similarly, Yerrabala *et al.* (2021) revealed that fipronil was the most cost-effective treatment, followed by NSKE (5%), and neem oil (2%).

The study found that all insecticidal treatments considerably reduced *H. armigera* infestations in chickpea compared to the control. Indoxacarb 14.5 SC consistently demonstrated to be the most effective, with the lowest larvae population, minimal pod damage, and greatest grain production. Emamectin benzoate and chlorantraniliprole also worked well, with botanical treatments providing moderate control. Economic study revealed that indoxacarb had the greatest IBCR, followed by emamectin benzoate. Overall, indoxacarb 14.5 SC proved to be the most effective and cost-effective solution for gram pod borer control.

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