



Economic evaluation of bio-pesticides for the management of *Helicoverpa armigera* (Hübner) on chickpea

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Abstract

The economic performance of bio-pesticides was evaluated for the management of *Helicoverpa armigera* (Hübner) on chickpea during Rabi 2025–26 at Akola, Maharashtra. The experiment comprised eight treatments arranged in a Randomized Block Design with three replications. Economic assessment was based on grain yield, treatment cost, additional return over the untreated control, net gain and incremental cost-benefit ratio (ICBR). Among the treatments, *Bt* commercial (Delfin) recorded the highest grain yield (18.20 q ha⁻¹) and maximum net gain over control (Rs. 40,681.26 ha⁻¹), with an ICBR of 1:10.71. PDKV *Bt* strain (PDKV SY-4 25% WP) and *HaNPV* followed with ICBRs of 1:9.80 and 1:9.18, respectively. The untreated control, which served as the basis for incremental economic calculations recorded the lowest grain yield (9.69 q ha⁻¹). Among the evaluated treatments, *Bt* commercial (Delfin), PDKV *Bt* strain (PDKV SY-4 25% WP) and *HaNPV* provided the most favourable economic returns under the prevailing experimental conditions. The results indicate that economic evaluation based on ICBR can effectively distinguish bio-pesticidal treatments offering greater returns relative to their application cost.

Keywords: *Helicoverpa armigera*, chickpea, bio-pesticides, economic evaluation, incremental cost-benefit ratio, ICBR

Introduction

Chickpea (*Cicer arietinum* L.) is an important pulse crop, and its productivity is substantially affected by the gram pod borer, *Helicoverpa armigera* (Hübner). The pest remains a major constraint to profitable chickpea production, making economically feasible management practices essential under field conditions.

Bio-pesticides provide an important option for reducing dependence on conventional insecticides; however, their suitability for adoption depends not only on pest-management performance but also on the return obtained relative to the cost of application. Economic indicators such as additional yield, net return and incremental cost-benefit ratio (ICBR) therefore provide a practical basis for comparing the profitability of different management options. Earlier studies have demonstrated considerable variation in ICBR among bio-pesticidal treatments against *H. armigera* in chickpea, indicating that treatment cost and yield response jointly determine economic advantage (Ojha *et al.*, 2019; Jagtap *et al.*, 2020) ^[1, 2].

Recent studies have also reported differences in the economic efficiency of biorational treatments against *H. armigera*. Yadav *et al.* (2023) ^[4] recorded favourable cost-benefit ratios with *Bacillus thuringiensis*, *HaNPV* and *Beauveria bassiana*, while demonstrating that economic ranking may differ from efficacy ranking because of differences in treatment cost and yield response. Therefore, treatment-specific economic evaluation under local field conditions is necessary for identifying bio-pesticides that provide greater returns per unit of additional expenditure. The present study was undertaken to evaluate the economic performance of selected bio-pesticides against *H. armigera* on chickpea with particular emphasis on treatment cost, additional monetary return and ICBR.

Materials and Methods

Experimental site

The field experiment was conducted during Rabi 2025–26 at the Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India. Chickpea variety JAKI-9218 was used for the experiment.

Experimental design and treatments

The field experiment was conducted in a Randomized Block Design (RBD) with eight treatments and three replications using chickpea variety JAKI-9218. The treatments included *HaNPV* (1 × 10⁹ POBs ml⁻¹) @ 10 ml per 10 L water, commercial *Bt* (Delfin) @ 10 g per 10 L water, PDKV *Bt* strain (PDKV SY-4 25% WP; 1.7 × 10⁸ spores g⁻¹) @ 10 g per 10 L water, neem oil 2% @ 7–8 ml per 10 L water, neem seed extract (NSE) 5%, *Beauveria bassiana* (1 × 10⁹ CFU ml⁻¹) @ 50 ml per 10 L water, *Metarhizium anisopliae* (1 × 10⁹ CFU ml⁻¹) @ 50 ml per 10 L water, and an untreated control receiving water spray. Two foliar applications were made with a knapsack sprayer at a spray volume of 500 L ha⁻¹. The initial application was carried out at the 50% flowering stage, followed by a second application 15 days after the first spray.

Grain yield

Grain yield was recorded at harvest from each experimental plot and expressed as q ha⁻¹. The yield obtained from each treatment was used for estimating additional yield and monetary returns over the untreated control.

Economic analysis

The economics of the treatments was assessed by considering the cost of bio-pesticide application, grain yield and the prevailing market price of chickpea grain. The total

plant-protection cost included the cost of the respective bio-pesticide and labour and spray-pump charges for two applications.

The value of increased yield over the untreated control was calculated using the prevailing grain price of Rs. 5,225 q⁻¹. Net gain over the control was calculated by deducting the additional treatment cost from the value of increased yield.

Incremental cost-benefit ratio

The incremental cost-benefit ratio (ICBR) was calculated to determine the economic advantage of each bio-pesticidal treatment over the untreated control using the following expression:

$$\text{ICBR} = \frac{\text{Net gain over control}}{\text{Additional treatment cost over control}}$$

The untreated control was considered the baseline for economic comparison; therefore, no ICBR was calculated for the control.

Results and Discussion

The economic performance of the evaluated bio-pesticidal treatments against *Helicoverpa armigera* on chickpea is presented in Tables 1 and 2 and illustrated in Fig. 1. Considerable variation was observed among the treatments with respect to plant-protection cost, grain yield, additional yield over the untreated control, value of increased yield, net gain and incremental cost-benefit ratio (ICBR).

Among the treatments, *Bt* commercial (Delfin) recorded the highest grain yield of 18.20 q ha⁻¹, compared with 9.69 q ha⁻¹ in the untreated control, resulting in an additional yield of 8.51 q ha⁻¹. The corresponding value of increased yield was Rs. 44,481.26 ha⁻¹. After accounting for the additional

treatment cost of Rs. 3,800 ha⁻¹, the treatment resulted in the highest net gain of Rs. 40,681.26 ha⁻¹ and an ICBR of 1:10.71, thereby ranking first economically.

PDKV SY-4 25% WP ranked second, recording a grain yield of 16.72 q ha⁻¹ and an additional yield of 7.02 q ha⁻¹ over the untreated control. The value of the increased yield was Rs. 36,707.52 ha⁻¹, which resulted in a net gain of Rs. 33,307.52 ha⁻¹ and an ICBR of 1:9.80. *HaNPV* followed closely, with a grain yield of 16.31 q ha⁻¹, additional yield of 6.62 q ha⁻¹, value of increased yield of Rs. 34,610.87 ha⁻¹ and net gain of Rs. 31,210.87 ha⁻¹, giving an ICBR of 1:9.18.

Among the botanical treatments, neem oil 2% recorded an ICBR of 1:8.65, with a grain yield of 14.20 q ha⁻¹ and net gain of Rs. 21,107.01 ha⁻¹. NSE 5% produced a relatively higher grain yield of 16.30 q ha⁻¹ and net gain of Rs. 30,364.10 ha⁻¹; however, its comparatively higher treatment cost of Rs. 4,150 ha⁻¹ resulted in a lower ICBR of 1:7.32. This indicates that higher yield alone did not necessarily translate into the highest economic efficiency, as treatment expenditure also influenced the final ICBR.

The entomopathogenic fungi recorded comparatively lower economic returns. *Beauveria bassiana* produced a grain yield of 13.89 q ha⁻¹, with an additional yield of 4.20 q ha⁻¹ and a net gain of Rs. 19,034.20 ha⁻¹, resulting in an ICBR of 1:6.56. *Metarhizium anisopliae* recorded the lowest economic performance among the treated plots, with a grain yield of 12.72 q ha⁻¹, additional yield of 3.02 q ha⁻¹, net gain of Rs. 12,905.52 ha⁻¹ and ICBR of 1:4.45. The untreated control recorded the lowest grain yield of 9.69 q ha⁻¹ and served as the basis for calculation of additional yield and economic returns; consequently, no ICBR was assigned to the control.

Table 1: Cost of plant protection under different bio-pesticidal treatments against *Helicoverpa armigera* on chickpea

Sr. No.	Treatment	Quantity of Pesticides (L or Kg/ha) for two sprays	Cost of Pesticides (Rs./ha)	Labour & Spray Pump Charges (Rs./Ha)	Total treatment cost (₹/ha)
T ₁	<i>HaNPV</i> (1 × 10 ⁹ POB's/ml)	1	2000	1400	3400
T ₂	<i>Bt</i> commercial (Delfin)	2	2400	1400	3800
T ₃	(PDKV– SY – 4 25% WP) <i>Bt</i> -strain	2	2000	1400	3400
T ₄	Neem oil 2%	0.8	1040	1400	2440
T ₅	NSE 5%	50	2750	1400	4150
T ₆	<i>Beauveria bassiana</i> (1 × 10 ⁹ CFU/ml)	5	1500	1400	2900
T ₇	<i>Metarhizium anisopliae</i> (1 × 10 ⁹ CFU/ml)	5	1500	1400	2900
T ₈	Control (water spray)	-	-	1400	1400

HaNPV Rs.2000/lit; *Bt* commercial Rs. 1200/Kg; PDKV *Bt* strain Rs. 1000/Kg; Neem Oil 2% Rs. 1300/lit; NSE 5% Rs. 50/Kg neem seed; *Beauveria bassiana* Rs.300/lit; *Metarhizium anisopliae* Rs.300/lit; Labour charge Rs. 300/day @2 labours/spray; spray pump charges Rs.50/day @2 pump/spray;

The comparative ICBR presented in Fig. 1 clearly showed that *Bt* commercial (Delfin) provided the greatest economic advantage, followed by PDKV SY-4 25% WP and *HaNPV*. The higher ICBR of these treatments can be attributed to the combination of effective crop protection and relatively favourable treatment expenditure, which resulted in greater returns per unit of additional investment. Conversely, the lower ICBR of *M. anisopliae* and *B. bassiana* indicates prevailing experimental conditions.

The findings of the present investigation are in close conformity with the reports of earlier workers, Patel *et al.* (2025)^[3] reported that *Bacillus thuringiensis* 1% WG @ 2 g l⁻¹ recorded the highest protection cost-benefit ratio (1:3.85) among all the tested biopesticides, followed by azadirachtin 10,000 ppm (1:3.38). The treatment also contributed significantly to enhanced seed yield and was found more economical than *HaNPV*, neem oil, *Metarhizium anisopliae*, and *Beauveria bassiana*, thereby proving to be the most cost-effective biopesticide for the management of *H. armigera* in chickpea.

Overall, the economic analysis demonstrated that *Bt* commercial (Delfin), PDKV SY-4 25% WP and *HaNPV* were the most economically efficient treatments, recording ICBRs of 1:10.71, 1:9.80 and 1:9.18, respectively. These treatments therefore showed greater economic advantage

over the untreated control and appear promising for incorporation into economically sustainable management

programmes for *H. armigera* in chickpea under conditions similar to those of the present investigation.

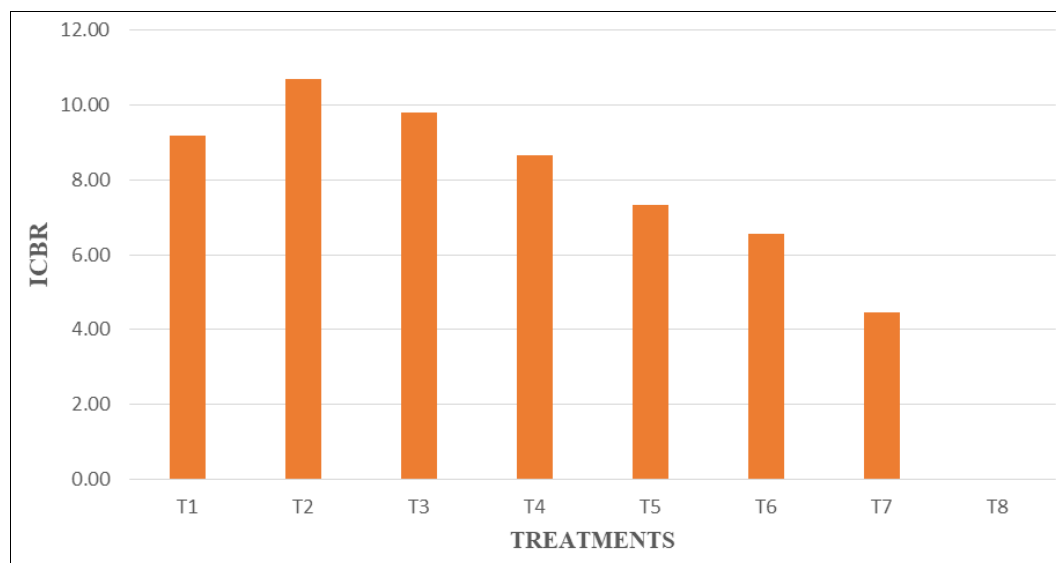


Fig 1: Incremental cost-benefit ratio (ICBR) of different bio-pesticidal treatments against *Helicoverpa armigera* on chickpea.

Table 2: Incremental Cost Benefit Ratio of Various Treatments

Sr. No.	Treatments	Grain yield of chickpea (q/ha)	Increase in yield over control (q/ha)	Value of increased yield over control(rs/ha)	Net gain over control (rs/ha)	Icbr	Rank
T ₁	HaNPV (1×10^9 POB's/ml)	16.31	6.62	34610.87	31210.87	1:9.18	III
T ₂	Bt commercial (Delfin)	18.20	8.51	44481.26	40681.26	1:10.71	I
T ₃	(PDKV– SY – 4 25% WP)	16.72	7.02	36707.52	33307.52	1:9.80	II
T ₄	Neem oil 2%	14.20	4.51	23547.01	21107.01	1:8.65	IV
T ₅	NSE 5%	16.30	6.60	34514.10	30364.10	1:7.32	V
T ₆	<i>Beauveria bassiana</i> (1×10^9 CFU/ml)	13.89	4.20	21934.20	19034.20	1:6.56	VI
T ₇	<i>Metarhizium anisopliae</i> (1×10^9 CFU/ml)	12.72	3.02	15805.52	12905.52	1:4.45	VII
T ₈	Control (water spray)	9.69	-	-	-	-	VIII

Rate of chickpea/q: Rs. 5225

Conclusion

The present study demonstrated that economic performance varied substantially among the evaluated biopesticides and was influenced by the balance between treatment expenditure and yield response. *Bt* commercial (Delfin), PDKV SY-4 25% WP and HaNPV emerged as the most economically promising options, providing a favourable return on investment under the prevailing experimental conditions. The findings emphasize that selection of biopesticides should consider not only their pest-management potential but also their economic feasibility. These treatments may therefore serve as promising components of an economically viable and comparatively safer management strategy for *Helicoverpa armigera* on chickpea. Further multi-location and multi-season evaluation is warranted to confirm their economic stability under varying production conditions before wider recommendation.

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