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# COST-EFFECTIVENESS OF BIO-PESTICIDES AND CHEMICAL INSECTICIDES FOR THE MANAGEMENT OF MAIZE STEM BORER, *CHILO PARTELLUS* (SWINHOE) IN *KHARIF* MAIZE

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**ABSTRACT**

Maize (*Zea mays* L.) is a vital cereal crop cultivated globally for both human consumption and animal feed. Recognized as the "Queen of Cereals," it possesses high genetic yield potential. This study was conducted during the *Kharif* 2024 at the Students' Instructional Farm of Acharya Narendra Deva University of Agriculture and Technology, Ayodhya, to evaluate the efficacy and economic performance of selected biopesticides and chemical insecticides against the maize stem borer *Chilo partellus*(Swinhoe). The maximum grain yield was recorded in plots treated with Chlorantraniliprole 18.5 SC (30.45 q/ha), followed by a combination of Chlorantraniliprole 9.3 + Lambda-cyhalothrin 4.6 ZC (29.63 q/ha), and Spinetoram 11.7 SC (28.52 q/ha). However, the highest benefit-cost ratio (1:5.34) was observed with Bt treatment, indicating superior economic viability. The findings underscore the potential of integrating biopesticides such as Bt and *Beauveria bassiana* for sustainable maize pest management while suggesting cautious use of Azadirachtin due to its limited efficacy**.**
***Keywords*****:** Maize, *Chilo partellus*, Biopesticides, Chemical pesticides, Economic evaluation, Benefit-cost ratio

## Introduction

Maize (*Zea mays* L.), a native of Central America's Andean region, is one of the most important cereal crops worldwide. Owing to its wide adaptability, high yield potential, and versatility in usage, maize is referred to as the "Queen of Cereals." In addition to its role in food security for humans and feed for livestock, maize is a source of high dietary fiber, essential vitamins, antioxidants, and minerals. Although it plays a significant role in human nutrition, a considerable proportion of India's maize production is utilized for poultry and animal feed purposes (Saritha *et al.,* 2020).

Maize cultivation, however, is frequently challenged by pest infestations, particularly during the *Kharif* season. Among the major insect pests, the maize stem borer (*Chilo partellus*Swinhoe) poses a substantial threat, especially in the northern regions of India. Other significant pests include the pink stem borer (*Sesamiainferens*), shoot fly (*Atherigona spp.*), fall armyworm (*Spodoptera frugiperda*), and the corn earworm (*Helicoverpa armigera*) (Upadhyay *et al.,* 2023). These pests can cause crop losses ranging from 5% to 15%, with *C. partellus* being particularly destructive during the early growth stages of the crop.

To mitigate pest-induced damage, synthetic chemical insecticides are commonly employed. However, their indiscriminate and repeated use has led to several ecological and health-related concerns, including pest resistance, resurgence, environmental contamination, and toxicity to non-target organisms (Hassall, 1990). Consequently, there is a growing emphasis on environmentally friendly alternatives, such as biopesticides, which offer sustainable pest management with minimal ecological impact.The concept of economic injury level (EIL) helps in optimizing pest control interventions by quantifying the threshold at which pest damage translates into unacceptable economic loss. (Reddy *et al.*, 2011) established EIL values for *C. partellus* in maize, determining that the 20 days old crop stage is most susceptible, with EIL thresholds of 3.2 and 3.9 larvae per plant at 20 and 40 days post-sowing, respectively.

In light of these challenges, this study aims to evaluate the comparative efficacy and economic feasibility of selected biopesticides and chemical insecticides against *C. partellus* in maize, under field conditions in the Ayodhya region of Uttar Pradesh. The findings will help develop a balanced pest management strategy that is both effective and environmentally sustainable.

## Materials and Methods

The field experiment was conducted during the *Kharif* season of 2024 at the Students' Instructional Farm of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh. The experimental site is geographically located at 26.541°N latitude, 81.825°E longitude, and an elevation of 113 meters above sea level. The study was laid out in a Randomized Block Design (RBD) comprising eight treatments, including an untreated control, with three replications per treatment. Each plot measured 4.0 m × 3.0 m, and maize was planted at a spacing of 60 cm × 20 cm (row-to-row × plant-to-plant). The treatments evaluated were as **$T_1$**-Azadirachtin 1500 ppm @ 5.0 ml/liter, **$T_2$**-*Metarhizium anisopliae* @ 5.0 g/liter, **$T_3$**-*Bacillus thuringiensis* (Bt) @ 4.0 g/liter, **$T_4$**-*Beauveria bassiana* @ 5.0 g/liter, **$T_5$**-Chlorantraniliprole 18.5 SC @ 0.4 ml/liter, **$T_6$**-Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% ZC @ 0.5 ml/liter, **$T_7$**-Spinetoram 11.7 SC @ 0.5 ml/liter, and **$T_8$**-untreated control (water spray only). All treatments were applied as foliar sprays, with two applications scheduled per plot. The first spray was administered 40 days after sowing (DAS), coinciding with the pest population reaching the Economic Threshold Level (ETL), followed by a second spray 15 days later.

To assess the economic feasibility of each treatment, an incremental cost-benefit ratio (ICBR) was calculated based on grain yield data. The Minimum Support Price (MSP) for maize was considered at Rs. 2400 per quintal. The total cost of treatment included the cost of insecticide**,** labor charges for two laborers (Rs. 600 total), and sprayer rental charges (Rs. 100). The net return per hectare was derived by subtracting the cost of treatment from the gross return, and the ICBR was calculated using the formula:

$$\text{Incremental Cost - Benefit Ratio} = \frac{\text{Net retur (Rs/ha)}}{\text{Cost of treatment (Rs/ha)}}$$

This analysis enabled a comparative evaluation of the economic performance of biopesticide and chemical insecticide treatments for the effective management of *Chilo partellus* in *Kharif* maize.

## Results and Discussion

The effectiveness of different pest management strategies against *Chilo partellus* in maize was evaluated during the *Kharif* 2024 season, primarily focusing on grain yield and economic viability. Among the tested treatments, Chlorantraniliprole 18.5 SC demonstrated the highest grain yield at 30.45 q/ha, followed closely by Chlorantraniliprole 9.3 + Lambda-cyhalothrin 4.6 ZC (29.63 q/ha) and Spinetoram 11.7 SC (28.52 q/ha), indicating the superior efficacy of these synthetic insecticides in suppressing stem borer infestation and enhancing productivity. In contrast, biopesticide based treatments also performed reasonably well, with *Bacillus thuringiensis* (Bt) recording a yield of 26.57 q/ha and *Beauveria bassiana* achieving 25.88 q/ha. *Metarhizium anisopliae* followed with a yield of 24.30 q/ha, while Azadirachtin 1500 ppm yielded 23.43 q/ha. The untreated control plot, as expected, produced the lowest yield of 20.70 q/ha, reflecting the impact of unmitigated pest pressure on crop output (Table 1).

The additional yield over control further reinforced these findings. Chlorantraniliprole 18.5 SC resulted in the highest yield increment of 9.75 q/ha, while Bt and *Beauveria bassiana* yielded 5.87 and 5.18 q/ha more than the control, respectively. Although synthetic insecticides exhibited higher yield advantages, the biopesticides also contributed substantially to productivity improvement, suggesting their potential role in integrated pest management strategies.

Economic analysis of the treatments revealed variations in both input costs and profitability. Bt required the lowest input investment at Rs. 2,600/ha, whereas Spinetoram 11.7 SC had the highest cost at Rs. 6,800/ha. Despite its relatively higher input cost, Chlorantraniliprole 18.5 SC yielded the highest net return of Rs. 18,800/ha, followed by Chlorantraniliprole 9.3 + Lambda-cyhalothrin at Rs. 16,132/ha and Spinetoram at Rs. 11,968/ha. However, when the treatments were evaluated based on the cost-benefit (B:C) ratio, Bt emerged as the most economically efficient treatment with a B:C ratio of 1:4.41, indicating that every rupee spent returned Rs. 4.41. Chlorantraniliprole 18.5 SC also showed strong profitability with a B:C ratio of 1:4.08, followed by *Beauveria bassiana* at 1:2.76. In contrast, Azadirachtin 1500 ppm was the least profitable treatment with a net return of only Rs. 1,152/ha and a B:C ratio of 1:0.21, suggesting limited effectiveness and economic justification for its use under current field conditions.

These results indicate that while synthetic insecticides offered the highest yields and absolute economic returns, biopesticides such as Bt and *Beauveria bassiana* provided more cost-effective alternatives. The favorable B:C ratios of these treatments make them particularly attractive for resource-constrained farmers and for incorporation into sustainable pest management frameworks. Bt, in particular, combined moderate yield with high economic efficiency, highlighting its suitability for Integrated Pest Management (IPM) programs that emphasize environmental safety, resistance management, and long-term field sustainability.

The present findings are in partial agreement with those of (Rani *et al.,* 2018), who reported that insecticides like chlorantraniliprole and carbofuran offered high cost-efficiency in managing maize pests. Similarly, (Singh *et al.,* 2023) observed notable efficacy of Bt and other biopesticides in suppressing *Chilo partellus*, which aligns with the current study's evidence supporting Bt's performance in both yield enhancement and cost-benefit terms. These results underscore the importance of balancing efficacy, economics, and sustainability in pest management decisions, and advocate for the inclusion of biopesticides as core components in future maize production systems.

## Conclusion

The study revealed that Chlorantraniliprole 18.5 SC was the most effective treatment against *Chilo partellus*, providing the highest grain yield and net return. Among biopesticides, Bt stood out with a competitive yield and the highest cost-benefit ratio, making it a cost-effective and eco-friendly alternative. While synthetic insecticides ensured maximum productivity, biopesticides like Bt and *Beauveria bassiana* offer sustainable options within integrated pest management (IPM) strategies. These findings contribute valuable insights toward designing eco-conscious and profitable pest management strategies for maize cultivation in India.

## Recommendations

Based on the findings, it is recommended that Chlorantraniliprole 18.5 SC be adopted as an effective chemical option for managing *Chilo partellus* in maize due to its high yield and profitability. However, for sustainable and eco-friendly farming, **Bt** should be promoted as a viable biopesticide, offering strong economic returns with minimal environmental impact. Farmers are encouraged to integrate biopesticides such as Bt and *Beauveria bassiana* into their pest management programs to reduce reliance on synthetic insecticides. The use of Integrated Pest Management (IPM) strategies combining selective chemical treatments with biological control agents is advised to enhance long-term pest suppression, delay resistance development, and support environmentally responsible agriculture.

**Table 1:** Effect of different treatments on maize stem borer, *Chilo partellus* (Swinhoe) during *Kharif* 2024 (First Spray)

| Tr. No. | Treatments | Dosage | Mean per cent dead hearts | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 DBS | 3 DAS | 7 DAS | 10 DAS | Overall mean |
| $T_1$ | Azadiractin 1500 ppm | 5.0 ml /lit | 21.2 (27.43) * | 11.6 (19.86) | 14.1 (22.04) | 15.0 (22.77) | 13.6 (21.56) |
| $T_2$ | *Metarhizium anisopliae* | 5.0gm/lit | 22.1 (28.06) | 12.8 (20.94) | 13.4 (21.44) | 14.2 (22.16) | 13.5 (21.51) |
| $T_3$ | Bt | 4 gm /lit | 20.5 (26.90) | 10.1 (18.45) | 9.0 (17.39) | 12.4 (20.61) | 10.5 (18.82) |
| $T_4$ | *Beauveria bassiana* | 5 .0gm /lit | 21.1 (27.33) | 11.5 (19.81) | 11.0 (19.32) | 13.7 (21.71) | 12.1 (20.28) |
| $T_5$ | Chlorantraniliprole 18 .5 SC | 40 gm /lit | 20.8 (27.13) | 2.5 (9.00) | 2.4 (8.76) | 3.2 (10.23) | 2.7 (9.33) |
| $T_6$ | Chlorantraniliprole 9.3 + lamida cyhalothrin 4.6 ZC | 35 gm /lit | 20.5 (26.89) | 2.9 (9.80) | 3.0 (10.00) | 3.9 (11.26) | 3.3 (10.36) |
| $T_7$ | Spinetoram 11.7 SC | 30 gm / lit | 21.4 (27.55) | 3.5 (10.70) | 3.7 (11.01) | 4.5 (12.17) | 3.9 (11.29) |
| $T_8$ | Control | - | 21.0 (27.29) | 22.3 (28.18) | 21.2 (27.41) | 21.8 (27.80) | 21.8 (27.80) |
| | **SEm±** | | **-** | 0.68 | 0.69 | 0.67 | 0.43 |
| | **CD at 5%** | | **NS** | **2.05** | **2.09** | **2.04** | **1.31** |
| | **CV** | | - | 6.8 | 7.0 | 6.3 | 4.3 |

* Figures in parentheses are Angular transformed valuesDBS=Day before spray, DAS=Days after spray

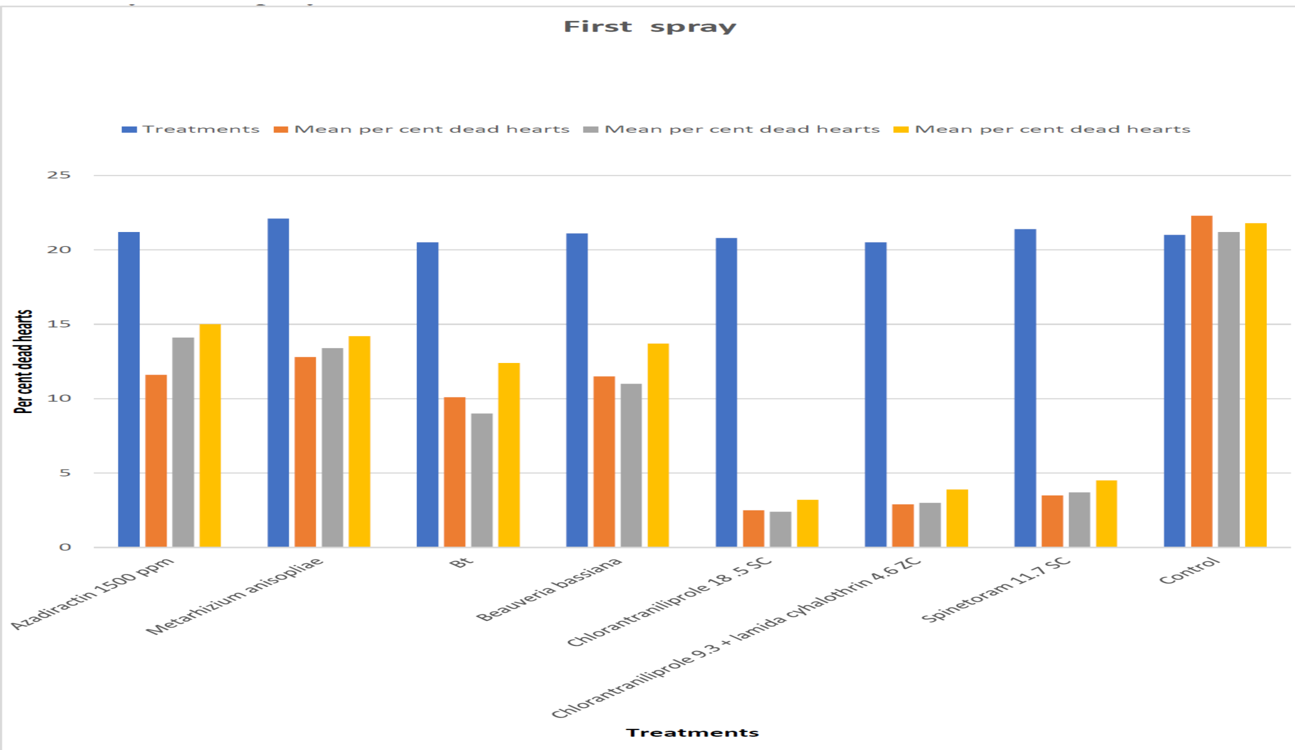


**Fig. 1:** Effect of different treatments on maize stem borer, *Chilo partellus* (Swinhoe) during *Kharif* 2024 (First Spray)

**Table 2:** Effect of different treatments on maize stem borer, *Chilo partellus* (Swinhoe) during *Kharif* 2024 (Second Spray)

| Tr. No. | Treatments | Dosage | Mean per cent dead hearts | | | | |
|---|---|---|---|---|---|---|---|
| | | | **1 DBS** | **3 DAS** | **7 DAS** | **10 DAS** | **Overall mean** |
| $T_1$ | Azadiractin 1500 ppm | 5.0 ml / lit | 19.3 (26.02) * | 12.1 (20.37) | 13.0 (21.12) | 14.0 (21.12) | 13.0 (21.14) |
| $T_2$ | *Metarhizium anisopliae* | 5 .0 gm /lit | 19.2 (26.00) | 11.9 20.20 | 12.4 20.58 | 13.3 20.58 | 12.5 (20.72) |
| $T_3$ | Bt | 4 gm /lit | 18.1 (25.14) | 10.7 (19.06) | 9.9 (18.32) | 11.0 (18.32) | 10.5 (18.92) |
| $T_4$ | *Beauveria bassiana* | 5 .0gm /lit | 18.4 (25.37) | 11.1 (19.40) | 10.5 (18.89) | 11.6 (18.89) | 11.0 (19.38) |
| $T_5$ | Chlorantraniliprole 18 .5 SC | 40 gm /lit | 16.3 (23.77) | 1.3 (6.44) | 1.5 (6.83) | 1.8 (6.83) | 1.5 (6.99) |
| $T_6$ | Chlorantraniliprole 9.3 + lamida cyhalothrin 4.6 ZC | 35 gm /lit | 17.5 (24.72) | 1.9 (7.98) | 2.4 (8.900 | 2.7 (8.90) | 2.4 (8.77) |
| $T_7$ | Spinetoram 11.7 SC | 30 gm / lit | 18.2 (25.23) | 2.1 (8.09) | 2.8 (9.54) | 3.4 (9.54) | 2.8 (9.41) |
| $T_8$ | Control | - | 19.4 (26.12) | 19.9 (26.51) | 19.4 (26.15) | 19.0 (26.15) | 19.5 (26.16) |
| | **SEm±** | | **-** | 0.72 | 0.60 | 0.74 | 0.59 |
| | **CD at 5%** | | **NS** | **2.18** | **1.83** | **2.25** | **1.78** |
| | **CV** | | - | 7.8 | 6.4 | 7.5 | 6.2 |

* Figures in parentheses are Angular transformed values
DBS=Day before spray, DAS=Days after spray

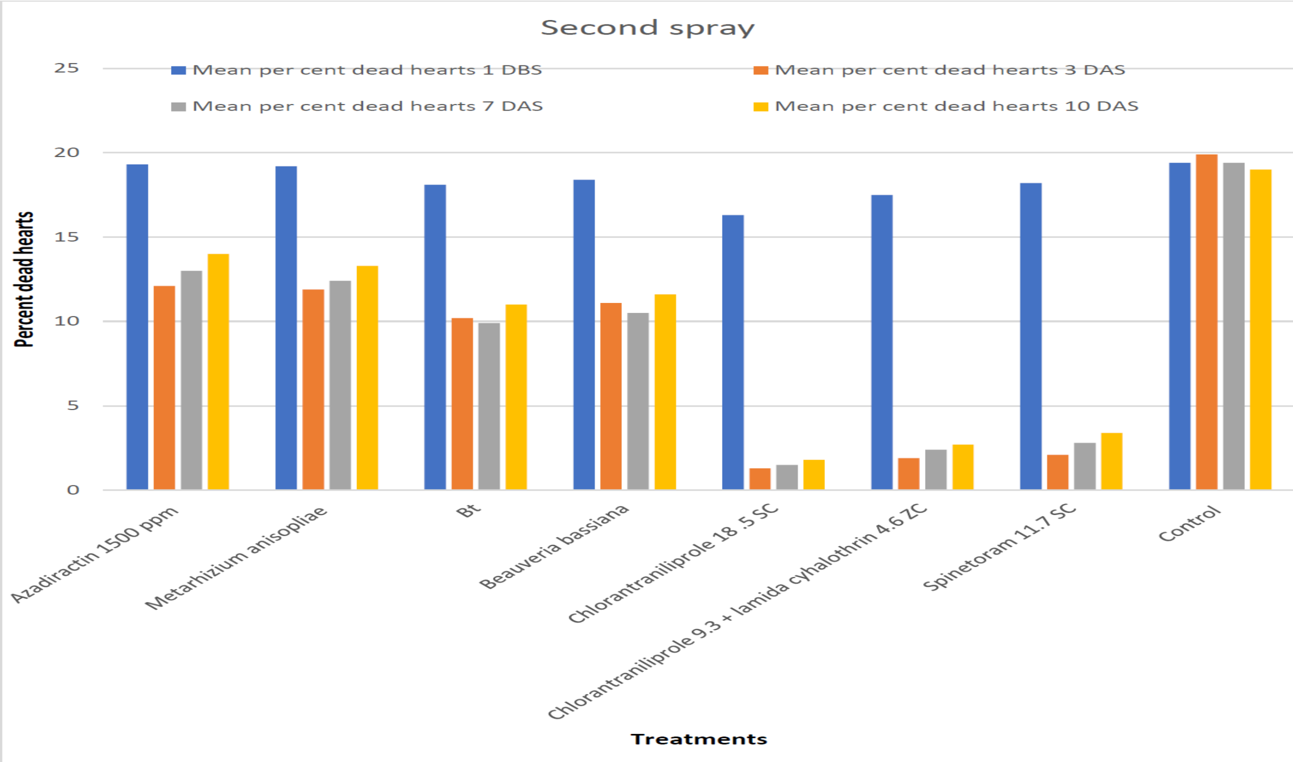


**Fig. 2:** Effect of different treatments on maize stem borer, *Chilo partellus* (Swinhoe) during *Kharif* 2024 (Second Spray)

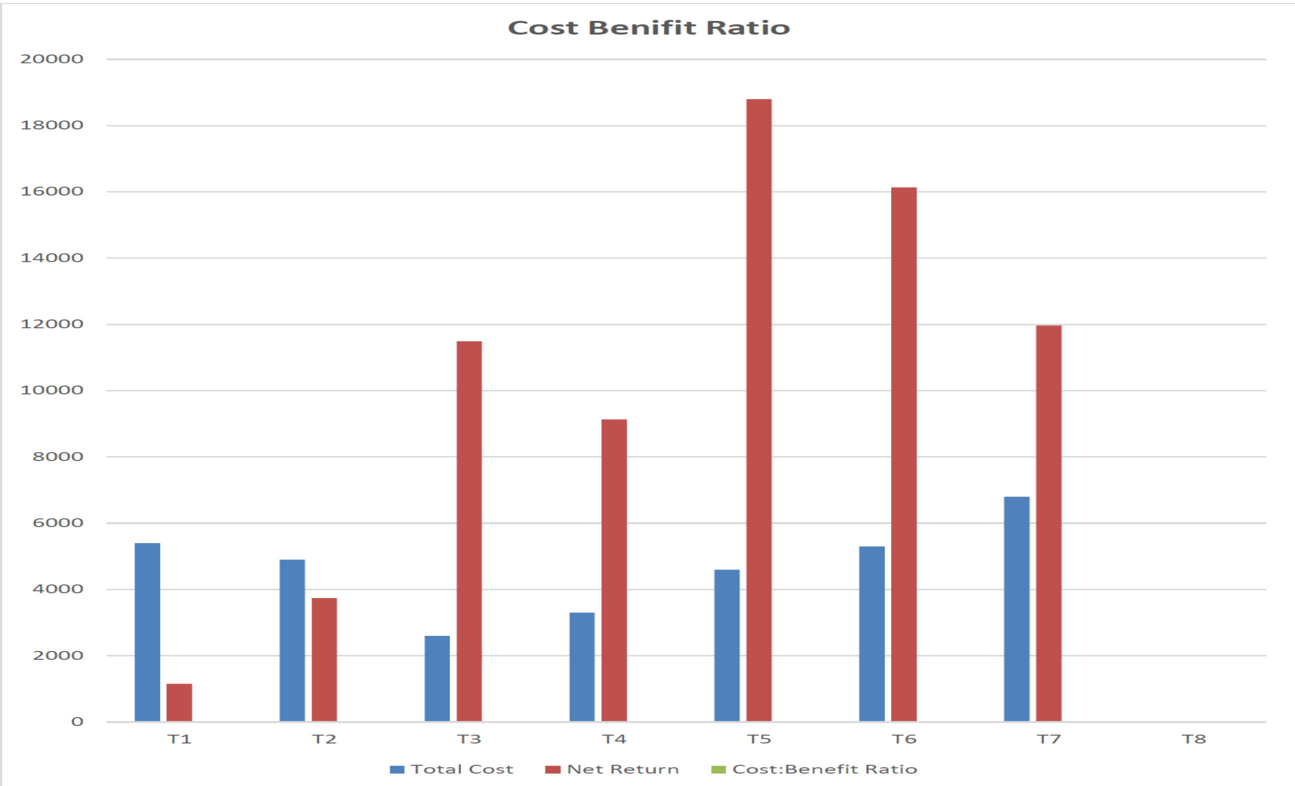


**Fig. 3:** Economics of pest management strategies against maize stem borer, *Chilo partellus* (Swinhoe) during *Kharif* 2024

**Table 3 :** Economics of pest management strategies against maize stem borer, *Chilo partellus* (Swinhoe) during *Kharif* 2024

| Tr. No. | Treatments | Dosage | Cost of Two Spray (labour+ Sprayer+ insecticide/ha) | Yield (q/ha) | Additional yield over control (q/ha) | Total return/ha (Rs.) | Net return/ha (Rs.) | Cost: Benefit ratio |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | Azadiractin 1500 ppm | 5.0 ml / lit | 5400 | 23.43 | 2.73 | 6552 | 1152 | 1:0.21 |
| $T_2$ | *Metarhizium anisopliae* | 5 .0 gm /lit | 4900 | 24.30 | 3.60 | 8640 | 3740 | 1:0.76 |
| $T_3$ | Bt | 4 gm /lit | 2600 | 26.57 | 5.87 | 14088 | 11488 | 1:4.41 |
| $T_4$ | *Beauveria bassiana* | 5 .0gm /lit | 3300 | 25.88 | 5.18 | 12432 | 9132 | 1:2.76 |
| $T_5$ | Chlorantraniliprole 18 .5 SC | 0.4 ml/lit | 4600 | 30.45 | 9.75 | 23400 | 18800 | 1:4.08 |
| $T_6$ | Chlorantraniliprole 9.3 + lamida cyhalothrin 4.6 ZC | 0.5 ml/lit | 5300 | 29.63 | 8.93 | 21432 | 16132 | 1:3.04 |
| $T_7$ | Spinetoram 11.7 SC | 0.5 ml/lit | 6800 | 28.52 | 7.82 | 18768 | 11968 | 1:1.76 |
| $T_8$ | Control | - | - | 20.70 | - | - | - | - |

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