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# A Study on Seasonal Incidence and Insecticide Efficacy against *Helicoverpa armigera* on Chick Pea

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**Abstract:** The gram pod borer, *Helicoverpa armigera* (Hubner), is a major constraint to chickpea (*Cicer arietinum* L.) production, particularly during the rabi season. The present study was undertaken to investigate the seasonal incidence of *H. armigera* on chickpea and to evaluate the comparative efficacy of selected biopesticides and a chemical insecticide through sequential spray applications. Field experiments were conducted during the rabi season at Rahatgarh, District Sagar (Madhya Pradesh), under natural field conditions using chickpea variety JG-315. Two rounds of foliar sprays were applied at pest initiation and 15 days later. Larval population was recorded before spraying and at 3, 7, and 14 days after each spray. The results revealed that *H. armigera* population gradually increased from the vegetative stage and reached its peak during flowering to pod formation, indicating a clear seasonal incidence pattern. All treatments significantly reduced larval population compared to the untreated control, with greater suppression observed after the second spray. The chemical insecticide recorded the highest reduction in larval population, yield, and benefit–cost ratio; however, certain biopesticides also showed promising efficacy and economic viability. The study concludes that timely and sequential application of biopesticides and chemical insecticides can effectively manage *H. armigera* on chickpea, supporting their use in sustainable pest management strategies.

**Keywords:** Chickpea, Helicoverpa armigera, Biopesticides, Seasonal incidence, Insecticide efficacy

## 1. INTRODUCTION

Chickpea, also known as *Cicer arietinum* L., is a legume that is widely farmed in semi-arid and subtropical countries. It is considered to be one of the most important pulse crops since it provides a significant source of plant protein, carbohydrates, and critical minerals. In spite of the fact that chickpea has an important role in the production of pulses in India, its productivity continues to be relatively low owing to a number of biotic stressors, the most significant of which are insect pests. [1] Under favorable climatic circumstances, the gram pod borer, also known as *Helicoverpa armigera* (Hubner), is considered to be one of the most destructive pests of chickpea. It is responsible for causing significant damage and productivity losses. [2]

The pest primarily damages the crop during the reproductive phase by feeding on flowers and developing pods, which directly affects yield and seed quality. [3] The seasonal incidence and population buildup of *H. armigera* are greatly influenced by crop growth stages and prevailing abiotic factors such as temperature and humidity, making its occurrence variable and difficult to predict. Several studies have emphasized that a clear understanding of seasonal pest dynamics is essential for determining the proper timing of management interventions and improving control efficiency. [4]

Chemical insecticides have traditionally been the primary means of managing *H. armigera* in chickpea. [5] However, prolonged and indiscriminate use of these chemicals has resulted in problems such as the development of insecticide resistance, pest resurgence, environmental pollution, and adverse effects on non-target organisms, including natural enemies. [6] These concerns have led to increased interest in alternative pest management strategies, particularly the use of biopesticides and botanicals, which are considered safer and more environmentally sustainable options.

Biopesticides, including microbial formulations and plant-based products, have shown promising results against lepidopteran pests such as *H. armigera* when applied judiciously. [7] Recent studies suggest that the integration of biopesticides with need-based chemical applications can enhance pest suppression while reducing ecological risks. However, the performance of these treatments often varies with location, season, and application timing, highlighting the need for region-specific evaluation. [8]

In view of these considerations, the present study was undertaken to investigate the seasonal incidence of *Helicoverpa armigera* on chickpea during the rabi season and to evaluate the comparative efficacy of selected biopesticides and a chemical insecticide through sequential spray applications. The findings of this study aim to contribute to the development of effective, economical, and environmentally sustainable pest management strategies for chickpea cultivation.

## 2. OBJECTIVES

- To study the seasonal incidence of chick pea pest (H. armigera).
- To evaluate the comparative efficacy of biopesticides and certain chemical insecticides against chick pea pest (H. armigera).

## 3. HYPOTHESIS

- H1: Efficacy of biopesticides and certain chemical insecticides against chick pea pest (H. armigera) during rabi seasons (1st spray).
- H2: Efficacy of biopesticides and certain chemical insecticides against chick pea pest (H. armigera) during rabi seasons (2nd spray).

## 4. RESEARCH METHODOLOGY

### 4.1 Research Type:

The study is experimental in nature and primarily based on a quantitative research approach. Systematic field experiments were conducted to generate quantifiable and statistically analyzable data. The purpose of the study was to assess the efficacy of biopesticides and certain chemical insecticides against chick pea pest (Helicoverpa armigera) during the rabi season. Quantitative data were collected in the form of larval population counts at different observation intervals after each spray to compare the effectiveness of treatments. The generated data were used to evaluate treatment performance and to test the stated hypotheses related to the first and second sprays.

### 4.2: Experimental Site:

The experiment was conducted during the rabi season on private farmers' fields at Rahatgarh, under the supervision of the Agriculture Research Farm, Rahatgarh, District Sagar (Madhya Pradesh). The site was selected due to its representative agro-climatic conditions and regular incidence of chick pea pest (Helicoverpa armigera). The experimental field was level and cultivable, with minimal variation in soil fertility across plots. Care was taken to select fields free from prior pesticide residues to avoid residual effects on pest population and treatment efficacy. The soil of the experimental site was sandy loam in texture and well-drained, suitable for chick pea cultivation. The total experimental area measured 20 ft × 30 ft, and the trials were conducted under natural field conditions following recommended agronomic practices throughout the crop growth period.

**4.3 Experimental Crop:**

chickpea (Cicer arietinum L.) was selected as the experimental crop during the rabi season for the present study. The experiment was conducted using the cultivar JG-315, which is widely cultivated in the Sagar region of Madhya Pradesh. Certified and healthy seeds were sown following the recommended sowing time, spacing, and seed rate for the region.

All experimental plots were maintained under uniform agronomic practices, including land preparation, irrigation, and fertilizer application. No plant protection measures were adopted other than the experimental treatments under study.

**4.4. Observation of Helicoverpa armigera:**

The larval population of chick pea pest (Helicoverpa armigera) was monitored under natural field conditions. Observations were recorded directly from the experimental plots without artificial infestation. Larval counts were taken at regular intervals to study the seasonal incidence of the pest during the rabi season and to assess treatment efficacy after insecticide application.

**4.5 Treatments and Test Materials:**

The experiment was designed to evaluate the comparative efficacy of biopesticides and a chemical insecticide against Helicoverpa armigera on chickpea.

Biopesticides: Selected biopesticides known for their effectiveness against lepidopteran pests were used in the study. These included entomopathogenic fungi, Bacillus thuringiensis (Bt), and Nuclear Polyhedrosis Virus (HaNPV). The biopesticides were applied at recommended doses using standard spray equipment to ensure uniform coverage.

Botanical Extracts: Botanical extracts were also evaluated for their insecticidal activity against Helicoverpa armigera. The botanicals used included garlic bulb extract (Allium sativum) and sitaphal leaf extract (Annona squamosa). The extracts were prepared following standard procedures and applied at recommended concentrations.

Chemical Insecticide: A commonly used chemical insecticide, Malathion, was included as a chemical check. It was applied at the recommended dose following standard safety guidelines to compare its efficacy with biopesticide and botanical treatments.

### 4.6 Experimental Design:

Field experiments were conducted to evaluate the efficacy of biopesticides and a chemical insecticide against Helicoverpa armigera on chickpea (Cicer arietinum L.) during the rabi season. The experiment was carried out on private farmers' fields at Rahatgarh under the supervision of the Agriculture Research Farm, Rahatgarh, District Sagar (Madhya Pradesh). Healthy and uniform chickpea plants (var. JG-315) were raised following recommended agronomic practices. All cultural operations were applied uniformly across treatments, except for the plant protection measures under evaluation.

The treatments consisted of selected biopesticides, botanical extracts (Annona squamosa and Allium sativum), a chemical check (malathion), and an untreated control. All treatments were applied as foliar sprays. Two rounds of spraying were carried out during the rabi season. The first spray was applied at the initiation of pest infestation, and the second spray was applied 15 days after the first spray, in accordance with the hypotheses of the study. Observations on larval population were recorded one day before spraying and 3, 7, and 14 days after each spray.

### 4.7 Statistical Methods and Tools:

The experimental data recorded on larval population of Helicoverpa armigera, percentage pod damage, yield, and treatment performance were analyzed using percentage analysis and the Chi-square ($\chi^2$) test. Percentage analysis was employed to express pest reduction, pod damage, and yield increase over control in a simple and comparable manner. The Chi-square test was used to determine the statistical significance of differences among treatments by comparing observed and expected values at appropriate levels of significance. These statistical methods ensured objective evaluation and scientific validation of the experimental results.

### 4.8 Ethical and Safety Considerations

All experimental procedures were conducted in accordance with standard agricultural and environmental safety guidelines. Recommended doses were strictly followed, and care was taken to minimize risks to non-target organisms and the environment. Preference was given to biopesticides and botanical formulations to promote environmentally safe pest management practices.

## 5. RESULTS

**Table 1: Rabi season chickpea *Helicoverpa armigera* occurrence weekly**

| Week after sowing | Crop stage | Mean larval population |
|---|---|---|
| 3rd week | Vegetative | 0.35 |
| 4th week | Vegetative | 0.58 |
| 5th week | Branching | 0.92 |
| 6th week | Flower initiation | 1.46 |
| 7th week | Flowering | 2.18 |
| 8th week | Peak flowering | 2.76 |
| 9th week | Pod formation | 2.41 |
| 10th week | Pod development | 1.84 |
| 11th week | Pod maturity | 1.12 |
| 12th week | Maturity | 0.63 |

When the larval population reached its greatest point, it was not until the stage of peak blooming to pod production that it was noticed that the population had achieved its maximum level. Due to the fact that the crop had achieved its full maturity, there was a progressive drop that occurred in the years that followed. It is possible that the decrease in the number of pests that occurred during later stages might be due to the decreased availability of vulnerable plant parts as well as poor seasonal circumstances. This is a possibility. Given the circumstances, this is something that may be considered a possibility.

Beginning in the flower initiation stage and continuing until peak flowering, the number of larvae per plant reached a maximum of 2.76, indicating a considerable rise in the number of larvae overall. The larvae of the *H. armigera* species are particularly fond of feeding on delicate flowers and developing pods, which are both present at this period. After the population peaked, there was a noticeable decline throughout the pod development and maturity periods. It is probable that the hardening of plant tissues, a decrease in the quality of the nutrients, and maybe even severe weather circumstances had a role in the decrease in the density of larvae that occurred during the final phases of crop development. As a result of these findings, it has been shown that the stage of chickpea that is most susceptible to *H. armigera* infection is the blooming to pod formation stage. Therefore, prompt pest control interventions are required.

**Table 2: Average *Helicoverpa armigera* population on chickpeas during the year**

| Parameter | Value |
|---|---|
| Mean larval population/plant | 1.63 |
| Maximum population | 2.76 |
| Minimum population | 0.35 |
| Peak infestation stage | Flowering–Pod formation |

Here is a comprehensive look at the pest pressure that chickpea faced throughout the Rabi season. The table summarizes the entire seasonal incidence of *Helicoverpa armigera*. When considering the circumstances of the natural field, an average of 1.63 larvae per plant suggests a moderate to high pest incidence. Due to the large number of larvae detected per plant (2.76) and the potential for serious damage during peak infestation times, quick management measures were essential. But, as the low population of 0.35 larvae per plant shows, there is a much reduced pest danger during the early phases of crop development.

The close association between the dynamics of pest populations and crop phenology is highlighted by the fact that the peak infection occurs throughout the blossoming to pod formation phases of the agricultural transformation. Additionally, there is a clear correlation between the greater larval density that occurs during this time period and the increased risk of flower drop and pod damage, which eventually leads to a loss of yield. Table 2's results highlight the need of monitoring pest populations and executing control methods at important crop stages rather than at random intervals. This emphasizes the significance of monitoring pest populations. In general, the mean seasonal population statistics provide a solid foundation for scheduling control actions and lend credence to the significance of seasonal incidence studies in the process of creating pest management techniques that are both successful and sustainable for chickpea.

**Table 3: *H. armigera* larvae on chickpea at 3 DAS (First spray)**

| Treatment | Larval population (larvae/plant) |
|---|---|
| $T_1$ | 1.42 |
| $T_2$ | 1.36 |
| $T_3$ | 1.28 |
| $T_4$ | 1.15 |
| $T_5$ (Chemical check) | 0.82 |
| $T_6$ (Control) | 2.47 |

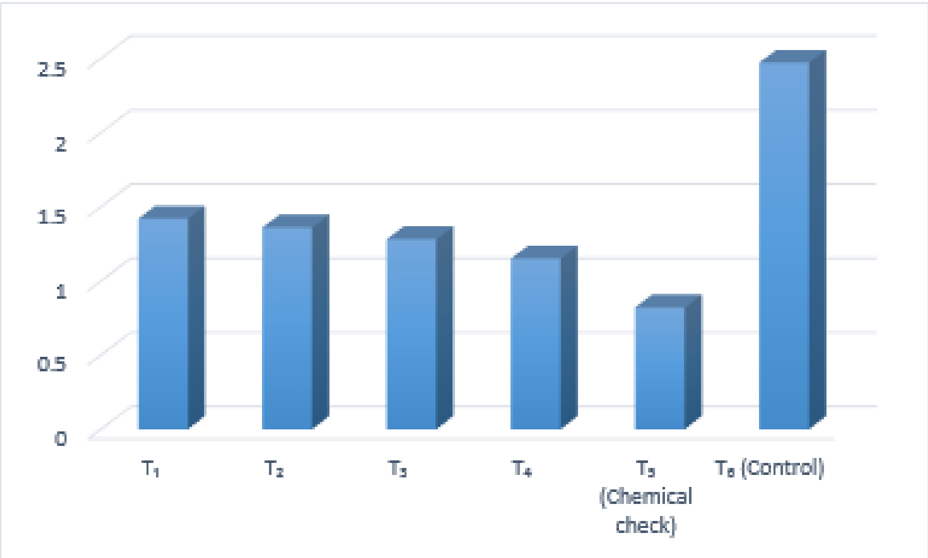


**Figure 1: *H. armigera* larvae on chickpea at 3 DAS (First spray)**

The findings in the table reveal that three days after spraying, the amount of *Helicoverpa armigera* larvae observed on chickpea decreased significantly across all treatments. This was in contrast to the untreated control group. The fact that the control plot had the highest larvae population proved that the pest naturally accumulates in outdoor settings. Because of its rapid knock-down effect and acute toxicity against the larvae, the chemical check treated plot had the lowest larval population compared to the others. The effectiveness of chemical pesticides in providing immediate pest control is shown by their quick response, which is characteristic of these compounds.

*Helicoverpa armigera* larvae were found on chickpea in much lower numbers three days after spraying as a consequence of the treatments. The outcome was the same as that of the control group that received no therapy. The finding that the control plot had the highest larvae population confirmed the natural accumulation of the pest in outdoor settings. This was the result since the recorded plan was the control plot. There were fewer larvae in the chemical check plot than in the other treated plots because of its fast knock-down activity and acute toxicity. The efficacy of the chemical check is shown by this. Chemical pesticides are characterized by their rapid reaction, which demonstrates their effectiveness in giving instant control over pests.

**Table 4: *H. armigera* larvae on chickpea at 7 DAS (First spray)**

| Treatment | Larval population (larvae/plant) |
|---|---|
| $T_1$ | 1.18 |
| $T_2$ | 1.05 |
| $T_3$ | 0.94 |
| $T_4$ | 0.86 |
| $T_5$ (Chemical check) | 0.54 |
| $T_6$ (Control) | 2.63 |

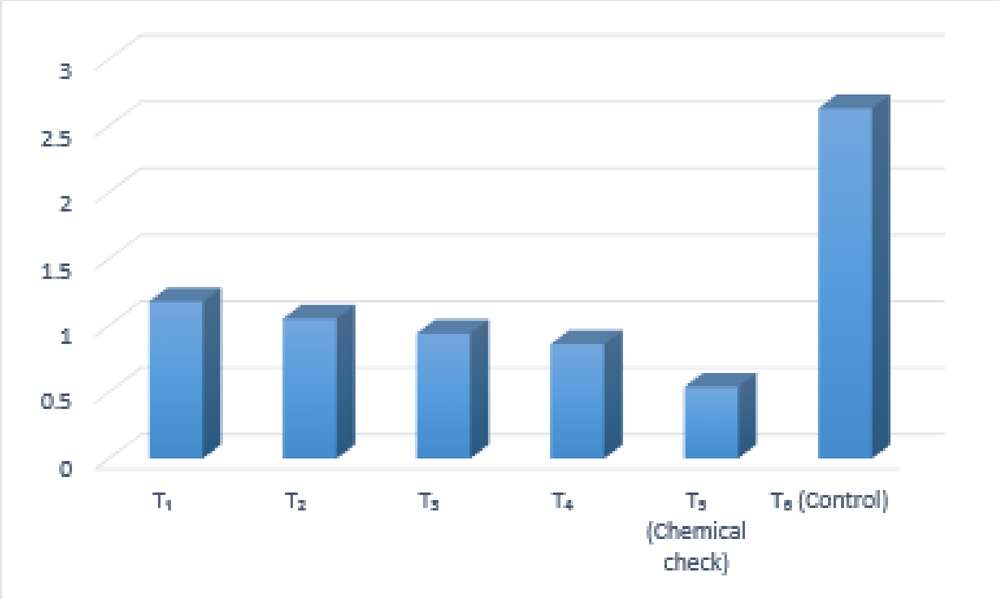


**Figure 2: *H. armigera* larvae on chickpea at 7 DAS (First spray)**

It can be seen in the table that there was a further decrease in the larvae population across all treated plots seven days following the spraying, which indicates that the efficiency of the treatment increased with time. The chemical check continues to report the lowest larvae population, which is evidence that its effectiveness has been shown over time. It is important to note that biopesticide treatments showed a more dramatic decrease at this stage compared to 3 DAS, which suggests that there was higher exposure of larvae to the treatment and that the effects of the treatment accumulated over time.

Treatments T1 and T2 were shown to have higher performance in comparison to other treatments, as evidenced by the fact that they recorded lower larvae populations than the other treatments included. The untreated control group maintained a considerably greater larval population, showing the need of intervention for the successful management of pests. Biopesticides give considerable suppression with a somewhat delayed but effective response, which makes them appropriate for inclusion in integrated pest management methods. The findings at 7 DAS clearly illustrate that chemical insecticides provide instant control, but biopesticides offer substantial suppression.

**Table 5: *H. armigera* larvae on chickpea at 14 DAS (First spray)**

| Treatment | Larval population (larvae/plant) |
|---|---|
| $T_1$ | 1.26 |
| $T_2$ | 1.18 |
| $T_3$ | 1.05 |
| $T_4$ | 0.97 |
| $T_5$ (Chemical check) | 0.68 |
| $T_6$ (Control) | 2.79 |

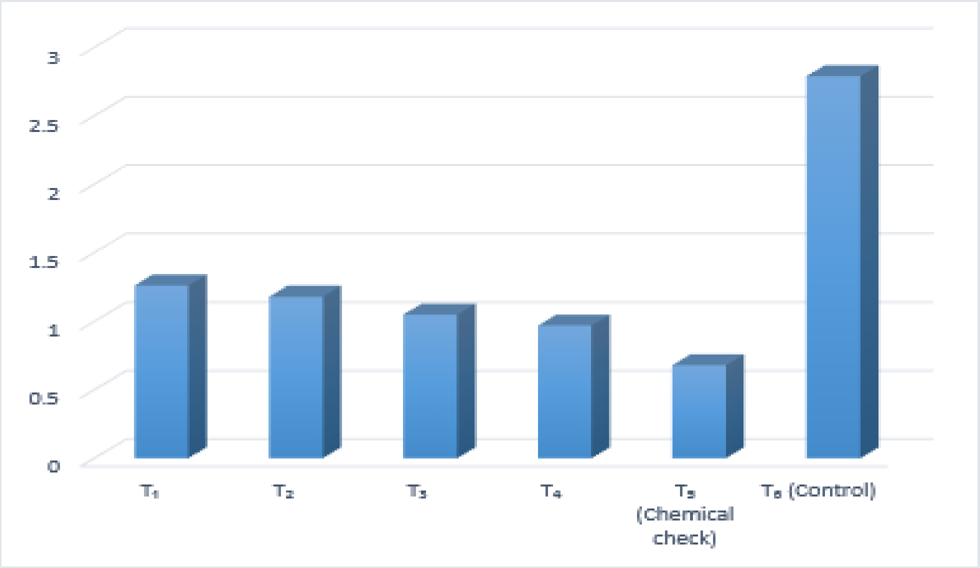


**Figure 3: *H. armigera* larvae on chickpea at 14 DAS (First spray)**

A residual impact of the treatments that were administered during the first spray is shown in the data on the larval population that is provided in the table at 14 days after the spraying. All of the treated plots maintained much lower levels of infestation in comparison to the control, despite the fact that several of the treatments showed a minor rise in the number of larvae. It was determined that the chemical check continued to demonstrate the lowest larvae population, which is indicative of sustained residual action and consistency in pest suppression.

Although T2 and T3 were among the biopesticide treatments, they retained considerably reduced larvae numbers even at 14 days after treatment, which suggests that their efficacy was maintained over time. As the observation time progressed, there was a minor increase in the number of larvae. This increase might be attributed to the appearance of additional larvae or to the progressive decrease in the effectiveness of the therapy. Despite this, the treated plots continued to be much lower than the economic threshold level, which highlights the efficacy of the treatments in providing prolonged protection against *H. armigera*.

**Table 6: Percentage reduction of *H. armigera* larval population over control (First spray)**

| Treatment | Percentage reduction (%) |
|---|---|
| $T_1$ | 50.95 |
| $T_2$ | 54.37 |
| $T_3$ | 58.56 |
| $T_4$ | 62.36 |
| $T_5$ (Chemical check) | 74.14 |
| $T_6$ (Control) | — |

A clear comparison evaluation of the effectiveness of the therapy is brought about by the percentage decrease over the control that is shown in the table. The chemical check showed the greatest percentage decrease in the number of larvae, which is a reflection of the powerful and quick toxic impact that it had on *H. armigera*. This significant degree of decrease is evidence that it is successful in rapidly reducing the number of insect populations in environments with a high level of infestation.

Among the biopesticides, T2 and T3 demonstrated relatively larger percentage reductions, indicating that they have the potential to be useful solutions for pest control. The fact that other treatments were found to have decrease percentages ranging from modest to high demonstrates that they are also beneficial in reducing the number of insect populations. Biopesticides have the potential to greatly decrease larval populations and help to sustainable pest control by reducing chemical residues and environmental effect. This suggests that conventional insecticides give maximal reduction, while biopesticides have the potential to drastically reduce larval populations.

**Table 7: *H. armigera* larvae on chickpea at 3 DAS (Second spray)**

| Treatment | Larval population (larvae/plant) |
|---|---|
| $T_1$ | 1.12 |
| $T_2$ | 1.05 |
| $T_3$ | 0.96 |
| $T_4$ | 0.88 |
| $T_5$ (Chemical check) | 0.62 |
| $T_6$ (Control) | 2.58 |

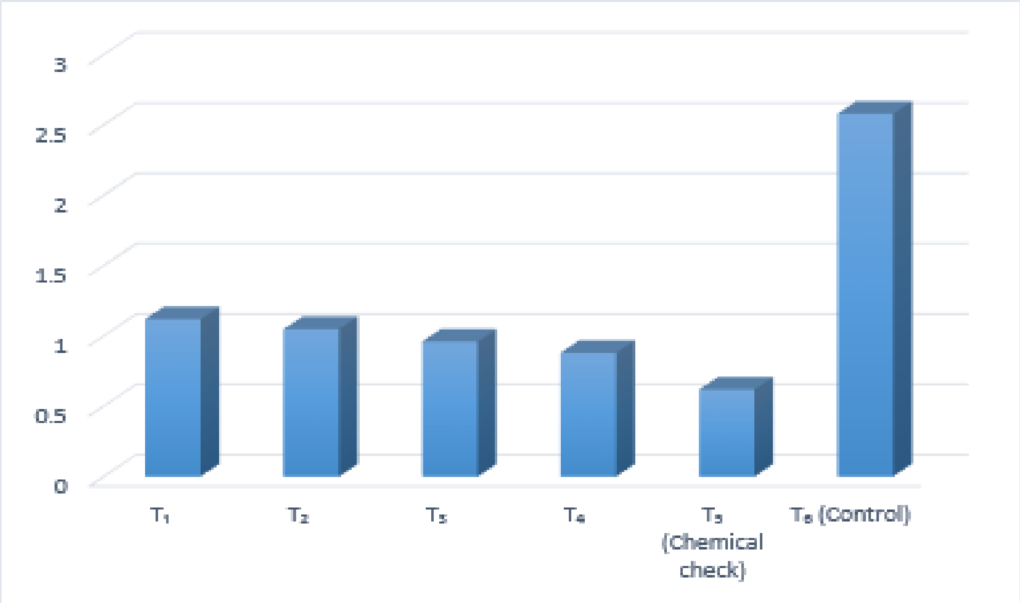


**Figure 4: *H. armigera* larvae on chickpea at 3 DAS (Second spray)**

The data that is shown in the table makes it abundantly evident that the second spray led to a significant decrease in the number of larvae of *Helicoverpa armigera* that were found on chickpea three days after the spraying. It was observed that the larval populations in all treated plots were much lower as compared to the control plot that had not been treated, which is evidence that the treatments were immediately effective upon repeated application. The chemical check revealed the lowest larval population, which is a reflection of the chemical's powerful knock-down impact and its quick toxicity against the larvae's development. Based on this outcome, it seems that the second spray was able to strengthen the residual impact of the first treatment and offer better early-stage suppression of the pest.

When compared to the other biopesticide treatments, T2 and T3 recorded much reduced larval populations. This suggests that the effectiveness of these treatments has enhanced as a result of repeated exposure of larvae to the treatments. It is important to note that the cumulative impact of biopesticides, which often demonstrate increasing efficacy with subsequent applications, is highlighted by the improved performance of these treatments after the second spray. The untreated control, on the other hand, continued to exhibit a large larvae population, which confirmed that the pests continued to multiply unabated in field circumstances in the absence of any management measures.

**Table 8: *H. armigera* larvae on chickpea at 7 DAS (Second spray)**

| Treatment | Larval population (larvae/plant) |
|---|---|
| $T_1$ | 0.98 |
| $T_2$ | 0.90 |
| $T_3$ | 0.78 |
| $T_4$ | 0.71 |
| $T_5$ (Chemical check) | 0.48 |
| $T_6$ (Control) | 2.71 |

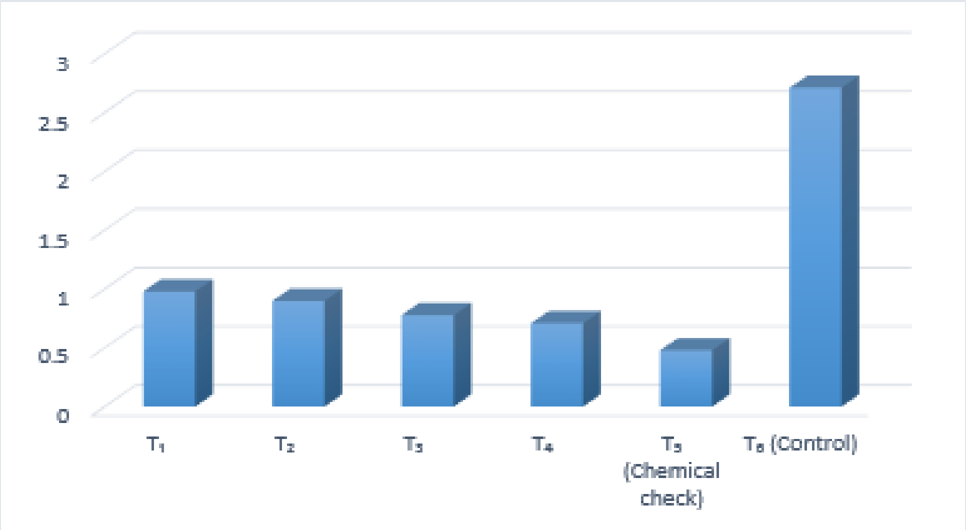


**Figure 5: *H. armigera* larvae on chickpea at 7 DAS (Second spray)**

Table shows a further decline in larval population across all treated plots at 7 days after the second spray, indicating sustained and enhanced control of *Helicoverpa armigera*. The chemical check continues to report the lowest larvae population, which is evidence that it has been effective for an extended period of time and has performed consistently. It is noteworthy that the biopesticide treatments shown a significant decrease at this stage, which suggests that their method of action grew more effective over time as a result of repeated administration.

Treatments T1 and T2 demonstrated higher effectiveness among the biopesticides, with larval densities recorded that were much lower than the level considered to be economically threshold. It is clear that these treatments are suitable for long-term pest control based on the fact that they continued to reduce the insect population. On the other hand, the control group that was not treated retained a considerably greater larval population, highlighting the importance of timely treatments in avoiding the accumulation of pests during crucial periods of crop development. Furthermore, the findings highlight the significance of the second spray in terms of attaining effective control of *H. armigera* over a medium-term period.

**Table 9: *H. armigera* larvae on chickpea at 14 DAS (Second spray)**

| Treatment | Larval population (larvae/plant) |
|---|---|
| $T_1$ | 1.05 |
| $T_2$ | 0.98 |
| $T_3$ | 0.86 |
| $T_4$ | 0.79 |
| $T_5$ (Chemical check) | 0.55 |
| $T_6$ (Control) | 2.83 |

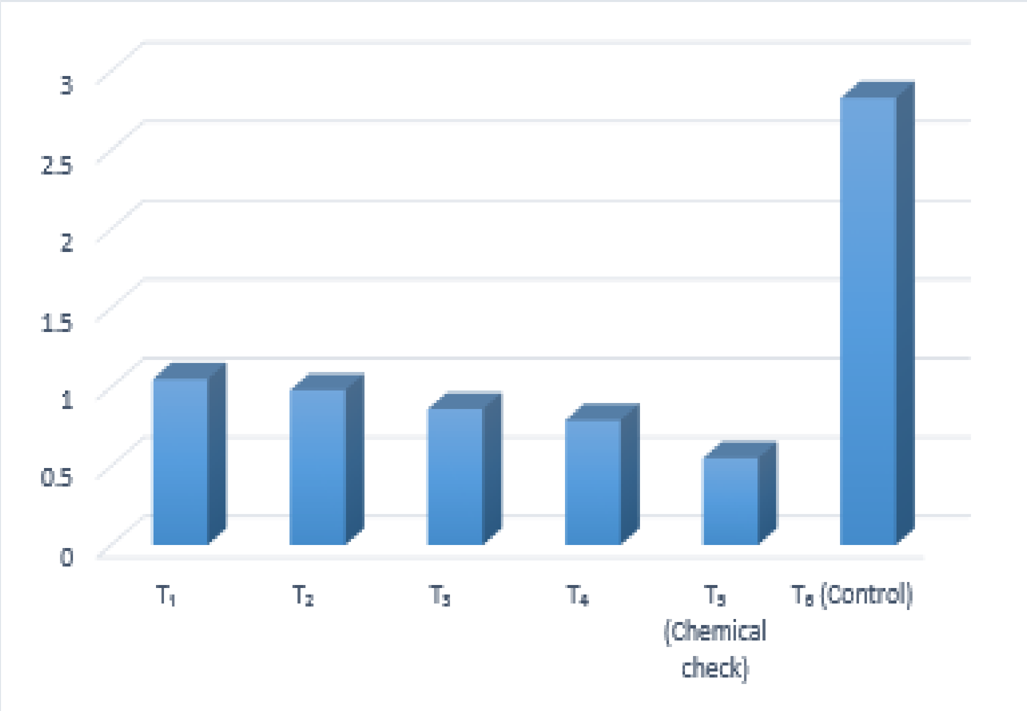


**Figure 6: *H. armigera* larvae on chickpea at 14 DAS (Second spray)**

The larval population that was detected fourteen days after the illness had spread is a reflection of the residual effectiveness of treatments that were administered after the second spray (Table 4.12). Despite the fact that there was a little increase in the number of larvae seen in comparison to 7 DAS, the treated plots continued to maintain much lower levels of infestation than the control plots even after the treatment was applied. The fact that this is present demonstrates that the protection against *H. armigera* is continuously maintained.

Among the treatments with biopesticides, T2 and T3 maintained considerably reduced larvae populations, which is evidence of their lasting residual action. It is possible that the emergence of fresh larvae or the progressive decomposition of treatment residues are responsible for the slight increase in the number of insects that have emerged. Despite this, the treated plots maintained pest levels that were manageable, which highlights the significance of the second spray in terms of sustaining effective control throughout the time of chickpea pod formation.

**Table 10: Percentage reduction of *H. armigera* larval population over control (Second spray)**

| Treatment | Percentage reduction (%) |
|---|---|
| $T_1$ | 61.25 |
| $T_2$ | 63.84 |
| $T_3$ | 67.90 |
| $T_4$ | 70.85 |
| $T_5$ (Chemical check) | 79.70 |
| $T_6$ (Control) | — |

Table gives a clear and dependable comparison of the effectiveness of various treatments after the second spray based on the percentage decrease over control. An indication of the chemical check's strong insecticidal efficacy and speed of action is the largest percentage decrease in *Helicoverpa armigera* larval population it observed. Repeated applications definitely have a cumulative effect, since the decrease after the second spray is much larger than the reduction after the first spray. This improvement in control efficiency emphasizes the need of keeping pest pressure at a minimum by consecutive sprays, especially when pest pressure is high. Rapid reduction of larval numbers and prevention of additional infestation during crucial periods of crop development are shown by the constant superiority of the chemical check.

The recurrent application of $T_4$ and $T_3$ biopesticide treatments resulted in larger percentage reductions compared to the control, suggesting that they are more effective than the first treatment. Subsequent applications aid in maintaining pest control and boosting overall treatment efficacy, as seen by the rise in decrease percentages across all treatments after the second spray. Biopesticides, which frequently have a slow but steady effect, are especially affected by this tendency. The findings highlight the need of a second spray that is both well-planned and applied at the right time to effectively control *H. armigera* during the most sensitive periods of chickpea growth the blooming and pod formation stages. Minimizing pod damage and lowering yield losses are both affected by the effectiveness of larval population reduction during this period.

**Table 11: Benefit–Cost ratio comparison**

| Treatment | Benefit–Cost ratio |
|---|---|
| $T_1$ | 2.19 |
| $T_2$ | 2.26 |
| $T_3$ | 2.35 |
| $T_4$ | 2.42 |
| $T_5$ (Chemical check) | 2.50 |
| $T_6$ (Control) | 2.05 |

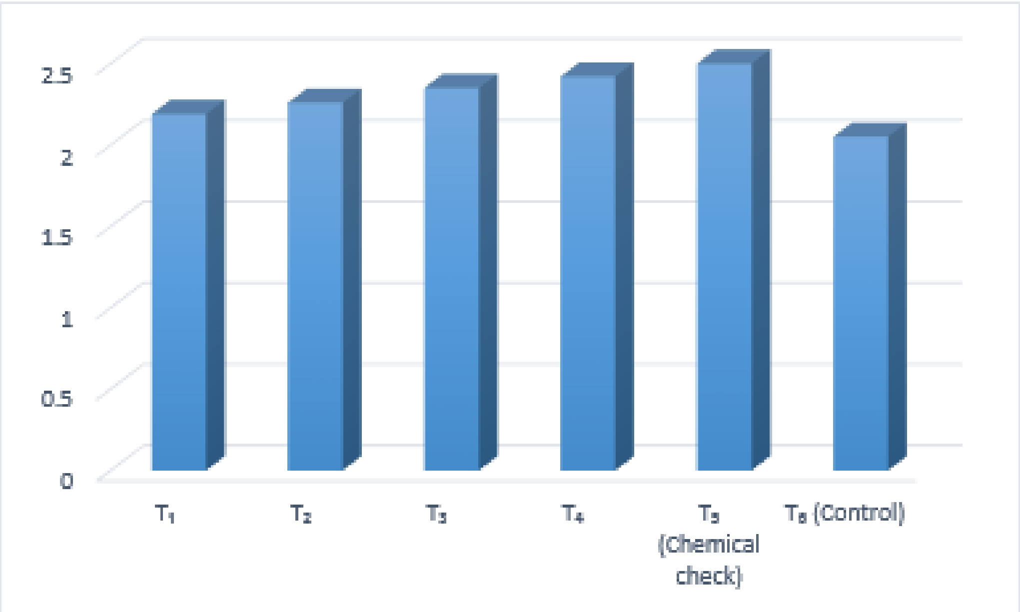


**Figure 7: Benefit–Cost ratio comparison**

The table's benefit-cost ratio numbers make it easy to compare and contrast the treatments' monetary efficiency. The chemical check showed the greatest B:C ratio, which means that it was the most profitable in terms of cost per unit of investment. This demonstrates how well the chemical treatment has consistently controlled *H. armigera* and reduced production losses. The biopesticide treatments that proved to be the most cost-effective were $T_4$ and $T_3$, which had the highest B:C ratios. These treatments seem to provide a good compromise between input cost and economic return, based on the relatively high B:C ratios that were achieved.

The absence of pest management results in poor economic returns owing to substantial production losses, as confirmed by the lowest B:C ratio reported by the untreated control. The greater B:C ratios of biopesticide treatments show that they are sustainable and economically feasible solutions for pest control, notwithstanding the modest expenses associated with them. There is a substantial correlation between the effectiveness of pest control measures and monetary benefit, as shown by the rising B:C ratio from less effective to more effective treatments. In conclusion, the benefit-cost analysis reveals that *Helicoverpa armigera* is best managed in a timely and effective manner, which boosts production and profitability. The findings provide significant evidence that integrated pest control programmes for chickpea and green mung agriculture should include efficient biopesticide treatments, especially $T_4$ and $T_3$.

**Table 12: Yield of chickpea**

| Treatment | Yield (q/ha) |
|---|---|
| $T_1$ | 15.62 |
| $T_2$ | 16.05 |
| $T_3$ | 16.78 |
| $T_4$ | 17.32 |
| $T_5$ (Chemical check) | 18.45 |
| $T_6$ (Control) | 12.48 |

According to hypothesis, pest control measures greatly boost chickpea output. When compared to the untreated control, the yield results clearly and consistently demonstrate an increase in grain yield in all treated plots. The remarkable protective effect against pod damage was confirmed by the greatest yield observed in the chemical tests. Among the biopesticides, $T_4$ and $T_3$ significantly increased yield, suggesting that improved grain formation and productivity are directly correlated with decreased larvae population and pod damage. Due to extensive infestation throughout the blooming and pod development phases, the untreated control had the lowest yield. These findings demonstrate a clear link between improved chickpea productivity and efficient insect control. Consequently, Hypothesis are approved.

## 6. DISCUSSION

The present investigation clearly demonstrated that Helicoverpa armigera exhibits a marked seasonal incidence on chickpea during the rabi season, with increased infestation during flowering and pod formation stages. Similar patterns of pest incidence and population buildup on chickpea have been reported by researcher. [9] [10] The results of the first and second sprays indicated that both biopesticides and chemical insecticides significantly reduced larval population compared to the untreated control, thereby supporting hypotheses H1 and H2. A higher level of larval suppression observed after the second spray suggests the importance of sequential applications. [11] [12] The reduction in larval population was directly associated with lower pod damage and improved yield, confirming the effectiveness of timely pest management interventions. Similar efficacy of biopesticides and chemical treatments against H. armigera has also been reported under field conditions. [13] Overall, the findings of the present study are in close agreement with recent research conducted during 2023–2024 and highlight the potential of biopesticides as effective and environmentally safer alternatives for the management of chickpea pod borer.

## 7. CONCLUSION

The present study concludes that *Helicoverpa armigera* exhibits a clear seasonal incidence on chickpea during the rabi season and poses a significant threat during the flowering and pod formation stages. The application of biopesticides and chemical insecticides effectively reduced larval population, pod damage, and yield loss, thereby validating the stated hypotheses. The greater level of pest suppression observed after the second spray highlights the importance of timely and sequential applications for sustained control of the chickpea pod borer. Overall, the results indicate that biopesticides, along with need-based chemical intervention, can be successfully incorporated into chickpea pest management programs to achieve effective, economical, and environmentally safer control.

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