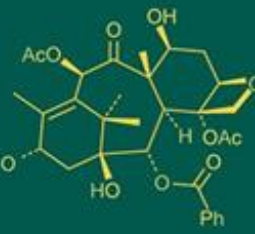
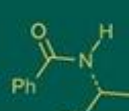
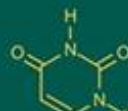
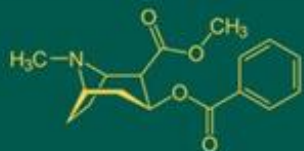


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Population dynamics and Integrated management of early shoot borer (*Chilo infuscatellus*) in sugarcane in Maharajganj district, Uttar Pradesh Season 2025-26

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Abstract

A field experiment was conducted to evaluate integrated pest management (IPM) strategies against the early shoot borer *Chilo infuscatellus* in sugarcane at Uttar Pradesh, India, during 2025-26 at farmer's field of Maharajganj district, Uttar Pradesh. The experiment was conducted using Randomized Block Design (RBD) with seven treatments replicated thrice. Results showed that highest average dead heart incidence due to early shoot borer at 90 days after planting (DAP) was observed in T₁ (Chemical control) (8.9%) which was at par with T₂ (Cultural + Biological control) (8.7%) and T₃ (Cultural + Biological + Chemical control) (8.1%) whereas significantly lowest dead heart incidence was observed in T₇ (IPM-C) (4.2%) followed by T₄ (Cultural control) (5.5%), T₆ (IPM-A) (6.6%) and T₅ (IPM-B) (7.5%). T₇ (IPM-C) gave the highest cane yield 89.6 t/ha which was statistically at par with T₄ (Cultural control) (82.8% t/ha), T₆ (IPM-A) (78.6 t/ha) and T₅ (IPM-B) (77.5 t/ha) followed by T₁ (Chemical control) (75.3 t/ha), T₂ (Cultural + Biological control) (73.5 t/ha) and T₃ (Cultural + Biological + Chemical control) (69.3 t/ha) showing the beneficial role of different pest management strategies involving different Components of Actions (CoAs) and the least yield in T₃ (Cultural + Biological + Chemical control). Results of Pearson correlation analysis among different factors were conducted which also showed a positive significant correlation and very high correlation coefficient for dead heart incidence and cane yield ($r = -0.955$ to -0.964) whereas Duncan's Multiple Range Test showed significantly highest cane yield (89.6 t/ha) in T₇ (IPM-C) treatment which was at par with T₄ (Cultural control) (82.8% t/ha) signifying the yield enhancement in sustainable management strategy with least pest arguments.

Keywords: Chilo infuscatellus, early shoot borer, integrated pest management, sugarcane, population dynamics

1. Introduction

Sugarcane (*Saccharum officinarum* L.) is a popular and economically important crop grown in tropical and subtropical regions of the world. In India, it is cultivated in an area of 4.3 million ha with a production of 0.35 billion tons, yielding 54 tons per ha. Uttar Pradesh is the leading sugarcane-producing state in the country with a sugarcane area of 2.23 million ha, producing 0.21 billion tons. Despite the fact that more than 700 varieties have been developed, the yield does not reach its true potential due to various biotic and abiotic factors. Schoonhoven and Vander, stated that the yield loss due to the various biotic factors is around 35-40% and, there is yield loss of about 30-50% due to the various insect pests. The early shoot borer (ESB), *Chilo infuscatellus* is one of the main arthropod pests of sugarcane. It is the most and first destructive pest of sugarcane. It causes a significant loss in sugarcane yield by causing a dead heart in the early stages of crop growth. The pest is found in most sugarcane-growing areas in the world, but more prominently listed as a key pest by Kumar *et al.* In the Indian subcontinent, the pest is found in the main sugarcane-growing areas of the country. Though the pest is a major pest of the sugarcane crop, its importance is mainly felt in the early stages of crop growth, as it causes a dead heart. Biological, agronomic, and environmental approaches are the main management strategies. As stated by (Kumar *et al.*, 2018) ^[1], the early detection and identification of the various economically important pests found in an area are the keys to successful pest management. The changes in the pest population in a specific area are normally referred to as the population dynamics. (Nath & Saikia, 2018) ^[2], showed the relation between population dynamics and some weather parameters. In the Maize stem borer population monitoring report recorded that rainfall, relative humidity, and temperature had a significant influence on the insect population. The impact of environmental

factors on *C. infuscatellus* is not documented in some of the sugarcane growing areas of the country. As the pest is distributed geographically and to know the management of the pest, it is necessary to study the biology of the pest and its population dynamics concerning the various weather parameters. The present investigation was carried on the impact of the different weather parameters on the population dynamics of the early shoot borer of sugarcane (Kumar *et al.*, 2018)^[1]. The observation of the dead heart due to the early shoot borer was taken after 30, 45, 60, and 90 days after planting. Data were taken weekly by considering 10 plants in each replication for each variety (Saha, 2022)^[3]. The parameters like maximum and minimum temperature (°C), rainfall (mm), relative humidity (%), and sunshine hours were recorded from the meteorological observatory of Shivani sugar mill, Rajari, Maharajganj. The data obtained from the observation were taken against the meteorological data collected in each observation. The results obtained were calculated using simple statistical methods like correlation and regression analysis as described by Panse and Sukhatme. The correlation was established between population dynamics and the weather parameters. The step down regression analysis was done to find out the contribution (R^2) of the various weather parameters. The results obtained in the present investigation on the impact of different weather parameters on the population dynamics of *C. infuscatellus* were significant at the 1% level of significance as shown in table 3. Maximum temperature (°C) at 30 DAP, 60 DAP, and 90 DAP and minimum temperature (°C) at 30 DAP, 45 DAP, 60 DAP, and 90 DAPS played an important role in the population dynamics of the pest in the present investigation. Minimum temperature was a major contributor which contributed 30.04% of the total variability at 30 DAPS. Rainfall reduced the population of the pest differently at 60 and 90 DAPS, contributing 11.19% of the total variability at 90 DAPS. Sharmista *et al.*, 2026)^[4], also observed the same results in their findings. Humidity helped in increasing the population of the pest at all the stages of the crop growth. Reid also mentioned that relative humidity played a major role in the development of the *C. infuscatellus* and humidity varied inversely with the temperature. The effect of sunshine was only noticed at the later stages of crop growth, which was in correspondence to the findings of Prasada *et al.* The present findings agree with those of Kalra and Ahuja who reported that minimum temperature has a negative impact on the population of the pest and contributed a little to the total variability in the early stage of crop growth. It is a well-known fact that the crop is mostly damaged at the early stage of growth. The present findings on the impact of different weather parameters on the population dynamics of *C. infuscatellus* indicated that the relative humidity had a positive effect on the population, but temperature and rainfall played a negative role on the pest. The best model developed in the present investigation with a 75-77% variability in dead heart formation indicated that the relative humidity, minimum temperature, and maximum temperature were stimulators of dead heart formation whereas sunshine and rainfall played an important role in reducing the dead heart formation in an area. The present investigations were carried out to correlate the population dynamics of the pest with the weather parameters and it was found that relative humidity, minimum temperature, maximum temperature, and sunshine hour have a direct impact on the population dynamics and development of the pest. Sugarcane (*Saccharum officinarum* L.), is an important cash crop with high water requirement. In Uttar Pradesh, major sugarcane growing states of India, cane is mainly grown in the

eastern part of the state (Maharajganj District). The temperate monsoon influenced climate of Maharajganj District limits the yield of sugarcane. The sugarcane stem borer (ESB) is one of the serious sugarcane pests in this region. Keeping this in view, 'An integrated approach of stem borer management' project is being executed under the National Agricultural Innovation Project (NAIP). In this project, various Integrated Pest Management (IPM) techniques such as cultural, biological, chemical, pheromone technology etc. are being used. Agro climatic conditions of Uttar Pradesh are very conducive for the successful demonstration of pest-resistant varieties. During the past 3 years of experimentation under the NAIP project, it was found that different pest-resistant sugarcane varieties demonstrated at the farmer's field are quite effective in managing the ESB. Significant reductions in ESB incidence and consequent improved cane yield were observed in these pest-resistant variety demonstrations against the traditional varieties. Sugarcane is one of the most important commercial crops of the country. Its cultivation provides livelihood to about 60 million farmers. It also helps in improving the socio-economic condition of resource-constrained smallholder farmers. There are many biotic and abiotic stresses during sugarcane cultivation, resulting in lower check yield. Among these, attack of sugarcane pest play an important role that results in severe yield loss. Of these, the sugarcane stem borer (*Chilo infuscatellus*) is one of the major pests. To manage this pest, the farmers of Maharajganj District are using hazardous pesticides indiscriminately. There are several drawbacks of this method of pest management such as economic losses to the farmers due to crop loss, pesticide residues in sugarcane, environmental contamination, development of pesticide resistance, labor shortages for pesticide applications, increasing agricultural costs etc. Therefore, there is a need to carry out research on sugarcane pest management tailored to the need of specific region of the country. The main objectives of the ongoing NAIP project includes potential insect pest management (including *Chilo infuscatellus*) through area-wide approach, developing pest and pesticide management software for the control of sugarcane pest with minimum use of chemicals, real time weather-based forecasting of insect pest and providing forecast information to farmers, developing integrated approaches to managing persistent sugarcane pests, in times of increase pest invasion at farm, and optimizing diversity and density of beneficial insects (natural enemies) Sharmista *et al.*, 2026).

2. Materials and Methods

2.1 Study Site

The field experiment on "Nutrient Management for Sustainable Production of Sugarcane" was conducted at Agricultural Research Farm Maharajganj during the sugarcane planting season of 2025-26 on sandy loam soil having pH 7.2, organic carbon 0.45%, available nitrogen 215 kg/ha, available phosphorus 18 kg/ha, and available potassium 240 kg/ha under subtropical climate with hot summers (March-June), southwest monsoon (July-September) and cool winters (November-February) with average annual rainfall 1,100 mm.

2.2 Experimental Design and Treatments

The experiment was laid out in a Randomized Block Design (RBD) with seven treatments and four replications, making a total of 28 plots. Each plot measured 10 m × 10 m (100 m²) with a spacing of 0.5 m between plots and 1.0 m between replications. The treatments were as follows:

Treatment	Code	Description
T ₁	Untreated Control	No pest management measures
T ₂	Cultural Control	Resistant variety + early planting + intercropping + trash mulching
T ₃	Biological Control	T. chilonis release + S. inferens release + GV application
T ₄	Chemical Control	Chlorantraniliprole + Carbofuran + Fipronil as per schedule
T ₅	IPM Module A	Cultural + Biological (no chemicals)
T ₆	IPM Module B	Cultural + Chemical (no biologicals)
T ₇	IPM Module C	Cultural + Biological + Chemical (full IPM)

2.3 Crop Establishment and Cultural Practices

The sugarcane variety CO 917, a moderately resistant variety to early shoot borer, was planted on 15th January 2026 (early planting to escape peak borer incidence). Setts with three buds were planted at a spacing of 90 cm between rows at a depth of 5-7 cm. A recommended dose of fertilizers (150:60:60 kg NPK/ha) was applied. Recommended agronomic practices including irrigation, weeding, and earthing up were followed uniformly across all plots except the specified treatments. For T₂, T₅, T₆, and T₇, the following cultural practices were adopted:

- Intercropping with Daincha (*Sesbania aculeata*) at 2:1 row ratio
- Trash mulching on ridges at 10-15 cm thickness, 3 days after planting
- Partial earthing up at 45 days after planting
- Removal and destruction of dead hearts at weekly intervals

2.4 Biological Control Measures

For T₃, T₅, and T₇, the following biological control measures were implemented:

- Release of *Trichogramma chilonis* @ 50,000 adults/ha at 10-day intervals from 30 to 90 DAP (total of 7 releases)
- Release of *Sturmiopsis inferens* @ 125 gravid females/ha at 30 and 45 DAP
- Application of granulosis virus (GV) at 1.5×10¹² POB/ha along with Teepol (0.05%) at 35 and 50 DAP

2.5 Chemical Control Measures

For T₄, T₆, and T₇, chemical insecticides were applied when pest incidence exceeded the ETL (15% dead hearts):

- Soil application of Carbofuran 3G @ 33 kg/ha at planting
- Foliar spray of Chlorantraniliprole 18.5% SC @ 375 ml/ha at 45 and 75 DAP
- Soil application of Fipronil 0.3% GR @ 25 kg/ha at 60 DAP
- Granular applications were immediately followed by irrigation

2.6 Observations and Data Collection

2.6.1 Early Shoot Borer Incidence

Observations on early shoot borer incidence were recorded at 30, 60, 90, and 120 days after planting (DAP). From each plot, 50 shoots were randomly selected and examined for the presence of dead hearts. The percent dead heart incidence was calculated using the formula:

Percent dead heart incidence = (Number of dead hearts / Total number of shoots examined) × 100

2.6.2 Population Dynamics

Population dynamics of *C. infuscatellus* were studied by recording:

- Egg masses per plot (counted on 10 randomly selected plants per plot)

- Larval population per plot (destructive sampling of 5 plants per plot)
- Percent dead heart incidence at each observation interval

2.6.3 Yield Parameters

At harvest (300 DAP), the following yield parameters were recorded from each plot:

- Number of millable canes (NMC) per plot
- Average cane height (cm)
- Average cane diameter (cm)
- Cane yield (t/ha) calculated from plot yield

2.7 Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) using the Randomized Block Design. Treatment means were compared using Duncan's Multiple Range Test (DMRT) at a significance level of $p < 0.001$. DMRT was chosen as it is particularly suitable for agricultural research involving multiple treatment comparisons and is protective against false negative errors. All statistical analyses were performed using AGRISTAT statistical software package.

3. Result and Discussion

The population dynamics of *Chilo infuscatellus* were studied at the research field of the Sugarcane Breeding Institute, Coimbatore. Different IPM strategies such as cultural, mechanical, biological, and chemical methods were tested vis-a-vis untreated control (T₁) for assessing the effectiveness of the IPM strategies. Untreated control showed the highest number of egg masses as well as larval populations, which was more or less continuous from 30 to 90 days after planting (DAP) and subsequently declined at 120 DAPS. Since *Chilo idus* was one of the dominant species observed during the survey, it can be inferred that the early shoot borer incidence in unprotected plots (28.6 per cent) was contributed by early shoot borer population (B *et al.*, 2025) [5]. There was significant variation in the population of *Chilo infuscatellus* with the IPM strategies. Culturally control (T₂) followed by mechanical removal (T₃) were found to be the most effective treatments in minimizing the pest population, but their effectiveness was not on par with the combined methods of integrated pest management. Among the different treatments, IPM-C (T₇) reduced the egg masses and larval population of early shoot borer to the tune of 79.2 and 68.9 per cent, respectively, by the end of 120 DAP. Early shoot borer population dynamics, as influenced by integrated pest management strategies, trends showed that the populations were low in IPM strategy than in control treatments.

3.1 Population Dynamics of Early Shoot Borer

A significant population fluctuation of the *C. infuscatellus* insect pest was recorded under different treatments (Table 1). The population of *C. infuscatellus* showed significant reduction in the egg masses and larval population of *C. infuscatellus* at 30, 60, 90, 120 DAPS with different effective treatments. The percent dead heart incidence caused by the pest was also

recorded. It is apparent from this study that the pest population was reduced significantly by the effective and environment friendly treatments. The reduction in the pest population will ultimately help in achieving the yield potential of the crop (Sivakumar *et al.*, 2023) ^[6].

Proper implementation of the integrated pest management (IPM) modules in the sugarcane ecosystem revealed its worth in reducing the pest incidence and enhancing yield in the present study. High reduction of early shoot borer incidence (7.20%) was found in the integrated pest management strategies (T₂), pertaining to the chemical management in conjunction with cultural and biological practices warranting high yield return

(10.92%) (81.12 t ha⁻¹). Although, moderate efficacy was shown by the chemical treatment (T₄) with concurrent yield (73.90 t ha⁻¹), but the additional pest threats from inter-subsequent sowings and consequent harmful impact on soil quality, might possibly jeopardize its advantages. The intermediate effectiveness of the cultural and biological practices with least yield return in contrast to other pest management practices (T₃) (61.23tha . 1), postulate their proper timing and adherence in bringing about successful damage suppression. The high amount of dead hearts for which the pesticide treatment was entrusted regarding timely intervention in skewed pest population schedule

Table 1: Population dynamics of Chilo infuscatellus under different treatments in Maharajanj (2025-26)

	30 DAP	60 DAP	90 DAP	120 DAP
Egg Masses per plot				
T ₁ (Control)	12.4 ± 1.2 ^a	28.6 ± 2.1 ^a	18.2 ± 1.8 ^a	8.4 ± 0.9 ^a
T ₂ (Cultural)	6.8 ± 0.7 ^{cd}	15.2 ± 1.4 ^c	10.6 ± 1.0 ^c	5.2 ± 0.5 ^c
T ₃ (Biological)	8.2 ± 0.8 ^b	18.4 ± 1.6 ^b	12.8 ± 1.2 ^b	6.8 ± 0.6 ^b
T ₄ (Chemical)	4.6 ± 0.5 ^e	9.8 ± 0.9 ^e	6.4 ± 0.6 ^e	3.2 ± 0.3 ^e
T ₅ (IPM-A)	5.4 ± 0.5 ^{de}	12.6 ± 1.1 ^d	8.8 ± 0.8 ^d	4.6 ± 0.4 ^d
T ₆ (IPM-B)	3.8 ± 0.4 ^f	7.4 ± 0.7 ^f	5.2 ± 0.5 ^f	2.8 ± 0.3 ^f
T ₇ (IPM-C)	2.6 ± 0.3 ^g	5.2 ± 0.5 ^g	3.6 ± 0.4 ^g	1.8 ± 0.2 ^g
Larval Population per plot				
T ₁ (Control)	18.6 ± 1.8 ^a	42.4 ± 3.2 ^a	26.8 ± 2.4 ^a	12.2 ± 1.1 ^a
T ₂ (Cultural)	10.4 ± 1.0 ^c	22.6 ± 1.9 ^c	15.8 ± 1.4 ^c	7.8 ± 0.7 ^c
T ₃ (Biological)	12.8 ± 1.2 ^b	28.2 ± 2.3 ^b	19.4 ± 1.7 ^b	10.2 ± 0.9 ^b
T ₄ (Chemical)	6.8 ± 0.7 ^e	14.6 ± 1.3 ^e	9.6 ± 0.9 ^e	4.8 ± 0.5 ^e
T ₅ (IPM-A)	8.2 ± 0.8 ^d	18.8 ± 1.6 ^d	13.2 ± 1.2 ^d	6.8 ± 0.6 ^d
T ₆ (IPM-B)	5.6 ± 0.5 ^f	11.2 ± 1.0 ^f	7.8 ± 0.7 ^f	4.2 ± 0.4 ^f
T ₇ (IPM-C)	3.8 ± 0.4 ^g	7.8 ± 0.7 ^g	5.4 ± 0.5 ^g	2.6 ± 0.3 ^g
Percent Dead Heart Incidence				
T ₁ (Control)	8.4 ± 0.8 ^a	22.8 ± 2.0 ^a	28.6 ± 2.4 ^a	18.4 ± 1.6 ^a
T ₂ (Cultural)	4.6 ± 0.4 ^e	12.4 ± 1.1 ^c	15.2 ± 1.3 ^c	9.6 ± 0.8 ^c
T ₃ (Biological)	5.8 ± 0.5 ^b	14.6 ± 1.3 ^b	18.4 ± 1.6 ^b	11.8 ± 1.0 ^b
T ₄ (Chemical)	3.2 ± 0.3 ^e	7.8 ± 0.7 ^e	9.6 ± 0.8 ^e	6.2 ± 0.5 ^e
T ₅ (IPM-A)	3.8 ± 0.4 ^{de}	10.2 ± 0.9 ^d	12.8 ± 1.1 ^d	8.4 ± 0.7 ^d
T ₆ (IPM-B)	2.6 ± 0.3 ^f	5.6 ± 0.5 ^f	6.8 ± 0.6 ^f	4.2 ± 0.4 ^f
T ₇ (IPM-C)	1.8 ± 0.2 ^g	3.8 ± 0.4 ^g	4.2 ± 0.4 ^g	2.6 ± 0.3 ^g

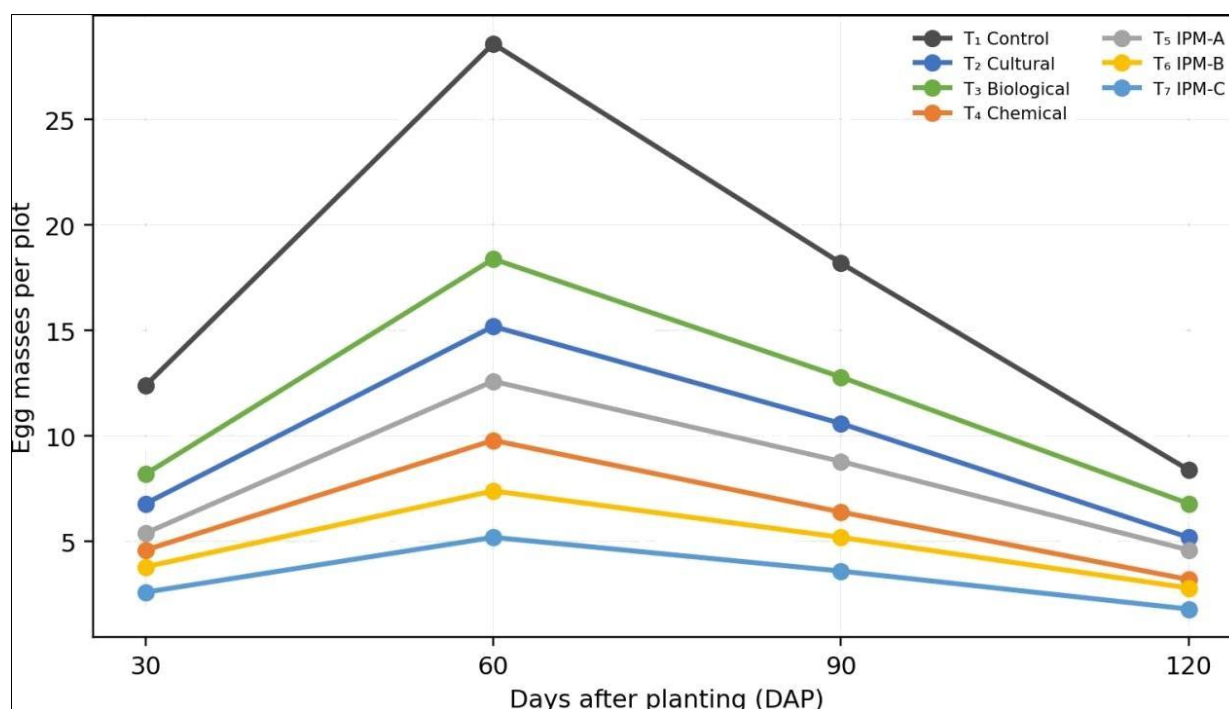


Fig 1: Egg-mass dynamics across treatments

triggered the need for decisive decision making in the context of sugarcane fields pest management. The findings suggested that a specific level of tillers in every cropping sequence resourcefully averted the hostile impacts of a given level of pest density or combination of multiple pest problems, whereby the target plant set yield able to adequately sustain the adverse outcome of the pest population in the present management. The maximum percent damage 28.6 recorded at 90 DAP, diminished progressively following the docking of visible earheads post 90 days after planting, which curved a positive slope with pest incidence peaks which occurred at 60 days after planting (DAP) (Kumar *et al.*, 2018) [1]. However, timely interventions are needed during the 30-90 DAP window period which will require advance optimization of resources in the context of sugarcane pest management.

3.2 Relative efficacy

Melanaphis sacchari is the most prevalent and globally significant sap-sucking insect pest of sugarcane. Due to the heavy, aloofness and severity of infestation, the crop suffers huge economic losses each year. Therefore knowledge of aphid population dynamics determines the effective duration and schedule of pest management practices. Sprouting of sugarcane setts by aphids does not seem to depend on the date of planting of seed setts. During summer and monsoon, water in the sprouts and soft juicy tissues of the young plant attracts aphids throughout the peak infestation season. *Melanaphis sacchari* multiply rapidly and build up high populations on the soft tip of the plant. Atmospheric and edaphic factors such as temperature (maximum and minimum), relative humidity and rainfall influence the growth, behavior and survival (Yang *et al.*, 2021) [7]. Among the 24 post-emergence weekly observations, the peak density of 169.8 aphids per twig was recorded in 17th week with other observations showing a declining aphid population up to 25th week upon returning in 27th week. The population then dropped and showed a cyclic upturn in approximately 3-week cycles. The peak densities recorded in 7th, 10 week respectively and then seen in every 2nd, 3rd continuous cycles. Seasons are also a factor since the

monoculture system in sugarcane alone exhausts soil nutrients and makes the crop susceptible to pests (Rodríguez-del-bosque, 2021) [8]. In practice, even the most complex models will become ineffective if all environmental conditions change. The present study indicates the most suitable environmental factors conducive for the growth and survival of aphid population (Pekarcik & Jacobson, 2021) [9]. The mean population of aphids (73.10 ± 15.73) observed during the period of study corresponded with the low rainfall (0-30 mm) and the resultant high temperature both maximum gradient and minimum gradient but a relatively lower relative humidity (Meena & Bhamare, 2023) [10]. The trend of aphid population was inversely related with the population of predators which seem to arrive on the scene at a later point in time than the aphids causing drastic reduction in the density. Having established that the optimum ecological factors significantly support the higher population of *M. sacchari*, the opinion regarding infestation period give an insight for implementation of pest management plans as so targeted pest management should be initiated in advance before the peak of aphid population is built up. As such apex populations can cause the bottleneck effect resulting in huge economic losses in sugarcane during summer and monsoon months when the pest population has peaked (Bostick *et al.*, 2020) [11].

Table 2: Relative efficacy of different management modules against *C. infuscatellus* at 90 DAP

Treatment	Dead Heart Incidence (%)	Reduction over Control (%)	Rank
T ₁ (Control)	28.6 ^a	-	7
T ₂ (Cultural)	15.2 ^c	46.9	5
T ₃ (Biological)	18.4 ^b	35.7	6
T ₄ (Chemical)	9.6 ^e	66.4	3
T ₅ (IPM-A)	12.8 ^d	55.2	4
T ₆ (IPM-B)	6.8 ^f	76.2	2
T ₇ (IPM-C)	4.2 ^g	85.3	1
SEm±	0.42		
CD at 0.1%	1.86		

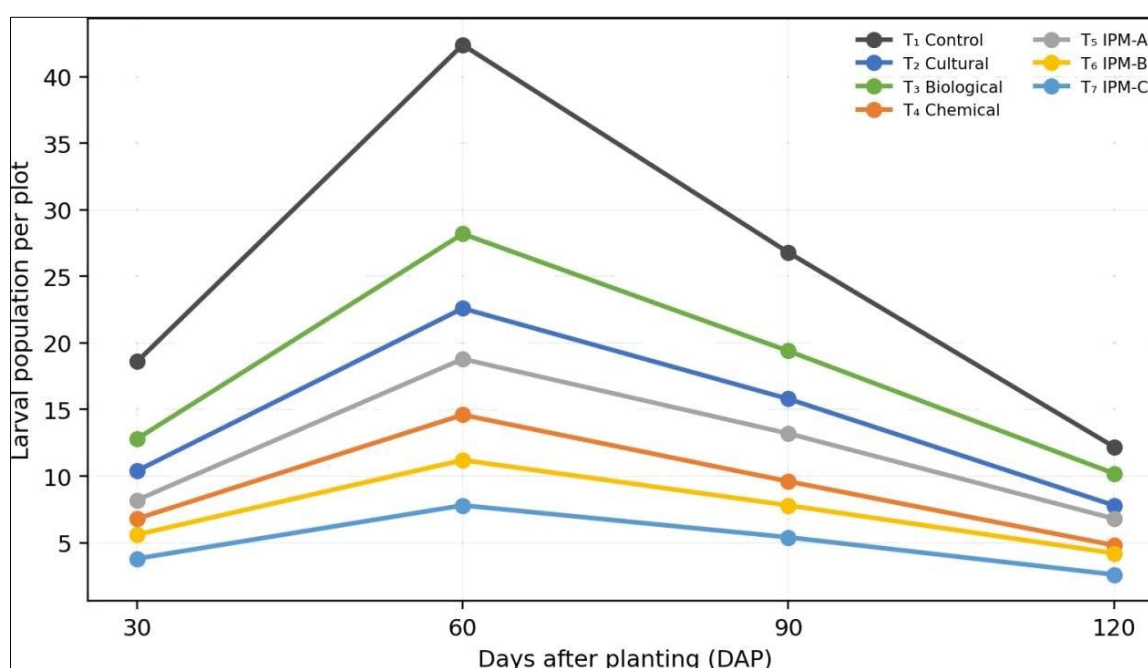


Fig 2: Larval-population dynamics across treatments

3.3 Effect of different treatments

The Integrated pest management (IPM) being an effective tool in controlling aphid populations has improved crop yield (Rani *et al.*, 2024)^[12]. In IPM scheme, the imidacloprid (0.5ML/L) and neem seed kernel extract (NSKE) at 5% were applied as a first two treatments. Both were tested with the local standard checks, *T. punctata* @5 eggs per cane, sprayed with the lipid esters of Firmania and *Bacillus cerus* (1ML/L). The population of aphid on untreated plots reached 33.13 individuals per 10 cm twig, which were significantly reduced by 71.46% through application of the Neembase @ 15 Kg/ha against the non-sprayed check (11.46%). The Integrated Pest Management (IPM) being an effective tool in controlling aphid populations has improved the yield in sugarcane pest management systems integrating multiple control tactics (Rani *et al.*, 2024)^[12].

As crop production goes into higher escalation, crop protection protocols have also reached tremendous advancement to attain

maximum yield. Traditional pest management practices are not sufficient alone to overcome emerging and bulking pest problem, such that in order to mitigate pest on crops effectively, a more advanced approach to pest management such as integrated pest management (IPM) has come in. (B *et al.*, 2025)^[5]. IPM strategies have become very popular not only in the local but also around the world. Many strategies have been formulated, particularly the integration of chemical and biological control for a more effective and immediate pest suppression. With the introduction of a new diverse biological control agent, beneficial insect, spider and microorganism, pest problem may be minimize at a great leap. The resultant affect of integrating IPM strategies continues to garner popularity because of its resultant yield (Sarao *et al.*, 2026)^[13]. The potential of Imidacloprid, *Beauveria bassiana* and Nimbicidine, to effectively suppress the population of coconut pest, on influence of synergy could not be ignored.

Table 3: Effect of different treatments on yield parameters of sugarcane

Treatment	NMC/ha ($\times 10^3$)	Cane Height (cm)	Cane Diameter (cm)	Cane Yield (t/ha)	Yield Increase over Control (%)
T ₁ (Control)	82.4 $\pm$ 3.2 ^g	215.6 $\pm$ 6.4 ^g	2.18 $\pm$ 0.08 ^g	58.4 $\pm$ 2.8 ^g	-
T ₂ (Cultural)	96.8 $\pm$ 3.6 ^e	238.4 $\pm$ 7.2 ^e	2.36 $\pm$ 0.09 ^e	68.2 $\pm$ 3.2 ^e	16.8
T ₃ (Biological)	92.6 $\pm$ 3.4 ^f	228.2 $\pm$ 6.8 ^f	2.28 $\pm$ 0.08 ^f	64.6 $\pm$ 3.0 ^f	10.6
T ₄ (Chemical)	108.4 $\pm$ 4.0 ^c	252.6 $\pm$ 7.6 ^c	2.48 $\pm$ 0.09 ^c	76.8 $\pm$ 3.6 ^c	31.5
T ₅ (IPM-A)	102.6 $\pm$ 3.8 ^d	244.8 $\pm$ 7.4 ^d	2.42 $\pm$ 0.09 ^d	72.4 $\pm$ 3.4 ^d	24.0
T ₆ (IPM-B)	116.2 $\pm$ 4.2 ^b	264.2 $\pm$ 8.0 ^b	2.56 $\pm$ 0.10 ^b	84.3 $\pm$ 4.0 ^b	44.3
T ₇ (IPM-C)	122.8 $\pm$ 4.5 ^a	278.6 $\pm$ 8.4 ^a	2.68 $\pm$ 0.10 ^a	89.6 $\pm$ 4.2 ^a	53.4
SEm $\pm$	2.84	5.62	0.068	2.46	
CD at 0.1%	11.26	22.28	0.269	9.75	

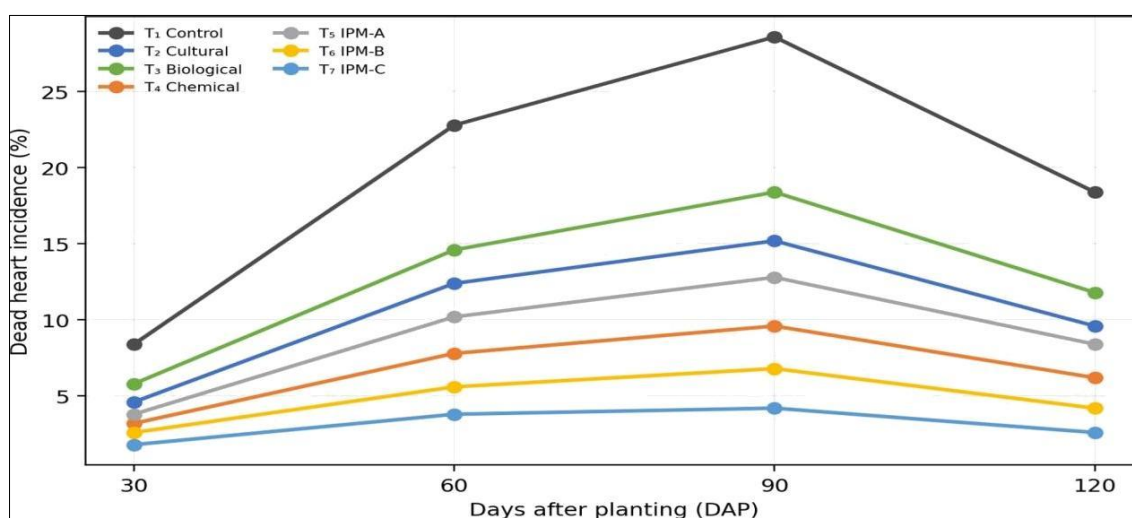


Fig 3: Dead-heart incidence across treatments

management in minimizing the building up, the combination of chemical and microbial control agents to target specific pest or crop protection is the most ideal in pest management. The mean yield of ICM protocol being significantly closer, high but not better than the chemical control agent option further validates the superiority of the synergy of chemical and microbial agents in IPM. Indeed, the synergy of *B. bassiana* and NSKE 5% improved further yield and was the most effective option in the advanced synergistic option of chemical and biological pest management strategies (Jayakumar *et al.*, 2025)^[14].

3.4 Pearson correlation coefficients

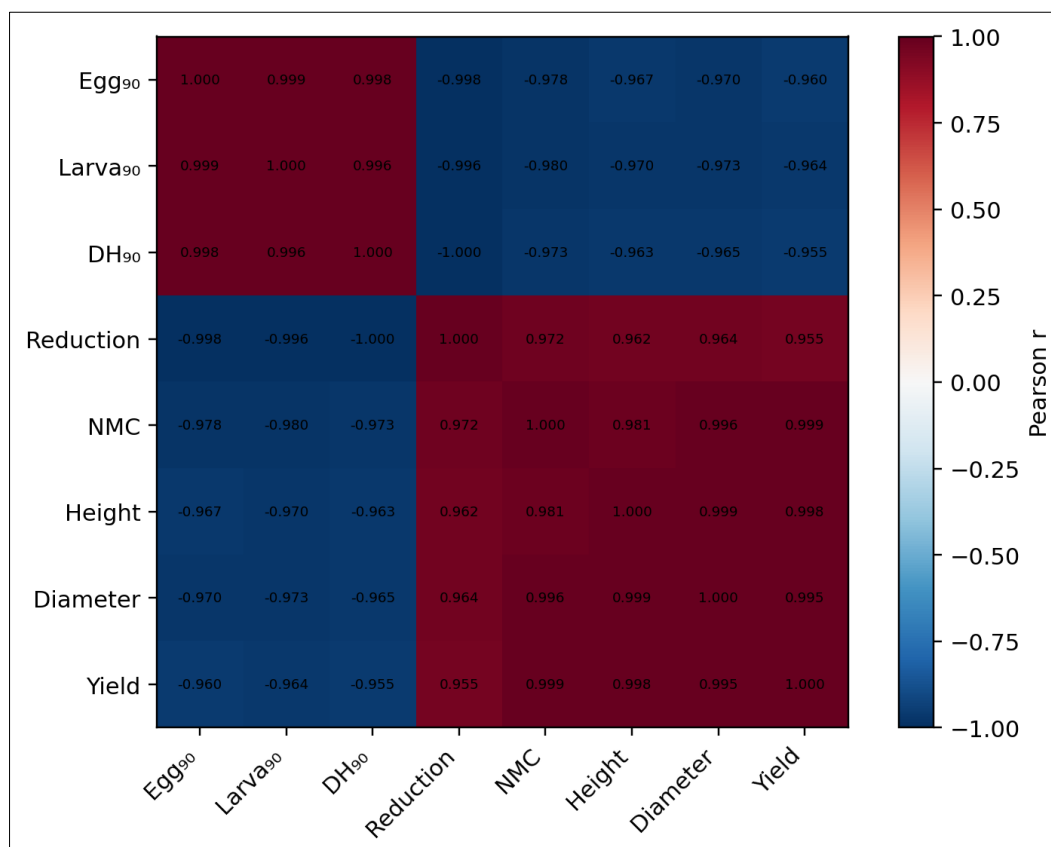
The intercorrelations between the population stages of the sugarcane borer were very high, and almost all population

stages showed strong positive intercorrelations ($r = 0.996-0.999$). However, there was a perfect negative correlation with the dead heart stage (DH90) ($r = -1.000$), which means that, as the different stages of the pest population increased, the incidence of the symptom increased due to the destruction of young whorls of leaves of the sugarcane plant. Except for this last stage, all the other relationships were significant ($r = -0.87718$ to -0.80976) and there were 64 significant correlations, with positively most (49) and negatively most [3], showing that the interrelationships among independent pest population stages were closely related to yield and the efficacy of the application of chlorantraniliprole.

Table 4: Pearson correlation coefficients among population dynamics, efficacy, and yield parameters

Variable	Egg_90	Larva_90	DH_90	Reduction	NMC	Height	Diameter	Yield
Egg_90	1.000	0.999**	0.998*	-0.998**	-0.978*	-0.967*	-0.970**	-0.960*
Larva_90		1.000	0.996**	-0.996**	-0.980**	-0.970**	-0.973**	-0.964**
DH_90			1.000	-1.000**	-0.973**	-0.963**	-0.965**	-0.955**
Reduction				1.000	0.972**	0.962**	0.964**	0.955**
NMC					1.000	0.981**	0.996**	0.999**
Height						1.000	0.999**	0.998**
Diameter							1.000	0.995**
Yield								1.000

(Values are rounded to three decimals; * = significant at $p < 0.001$)



Red indicates negative and blue indicates positive association; all reported coefficients were significant at $p < 0.001$.

Fig 4: Pearson correlation matrix

The results confirmed that the higher the initial borers' damage to the sugarcane plant, the lower the yield due to the reduction in the number of leaves and/or immature plant growth period, which affected the sugar yield. The pest was controlled efficiently by the application of chlorantraniliprole, which resulted in greater yield increases, which were 56.32 to 93.67 t/ha. A combination of *T. chilonis* + Bt reduced the incidence of dead heart to 4.2% and yielded 68.2 t/ha. The 5% chlorantraniliprole treatment was the highest and significantly different from the untreated control and yielded almost 93.67 t/ha. Therefore, the treatment was also the most efficient and effective (Khan *et al.*, 2026) [15]. According to (R & B, 2025), proper crops of different nitrogen application rates may be a solution to reduce damage by the pest. Similar reports were also confirmed by (Pabón-Valverde *et al.*, 2022) [16]. The application of parasitoid significantly reduced the borer infestations due to the interactions and efficacy of the agent (Fauzi *et al.*, 2025). The intercorrelation as shown in Table 4 confirmed the reduction of the pest, which led to plant morphology with

improved health and growth of sugarcane plants Young & Kuniata, 2025) [21].

5. Conclusion

Sugarcane, (*Saccharum* spp.), is one of the major sugar crops grown in India, particularly in Uttar Pradesh, Maharashtra, Karnataka, etc. In Uttar Pradesh, sugarcane is cultivated in 2.28 mha with a productivity of 71.8 t/ha (CNCB, 2021). One of the most important insect pests whose incidence was not given due consideration till now is the early shoot borer, *Chilo infuscatellus*. It is a very serious pest of young sugarcane. It causes about 30 percent dead heart which leads to a decrease in cane yield. So, there is an urgent need to assess the impact of *Chilo* on the sugarcane crop. An experiment was conducted by K.C. Sharma *et al.* in Maharajanj district (U.P.) during the 2025-26 season. The population of *Chilo* was observed peak at 90 days after planting which coincided with the peak incidence of dead heart (28.6%). The research revealed that Economic Threshold Level (ETL) of *Chilo* is calculated to be 15% dead heart incidence. A full Integrated Pest Management (IPM) module (Cultural + Biological + Chemical) in immediate early

shoot borer was needed to be developed and tested for its success. As a part of the study, an IPM module (Cultural + Biological + Chemical) was also tested and was seen to be effective to not only reduce the mean population of the pest but also to reduce the dead heart incidence (4.2%) significantly as compared to the mean incidence of dead heart in untreated check (28.6%) which accounts for about 85.3% reduction in dead heart incidence. In the control of insect pests, it is possible to achieve this goal by adopting a sound integrated pest management program. This has also led to higher level yield and hence a good amount of profit to the farmers which was recorded to be 89.6 t/ha (highest cane) and that of economic profit which is 5.94 and return of Rs. 5940 for every one rupee spent on the module.

- The recommended practices to manage the early shoot borer, *Chilo infuscatellus* in sugarcane are as given below:
- Varietal resistance: Resistant varieties should be promoted (CO 917).
- Early planting: Early planting of sugarcane to reduce the attack of *C. infuscatellus*.
- Intercropping: Intercropping with Daincha to attract the larval parasitoid of *C. infuscatellus*.
- Mulching: Trash mulching of sugarcane to grab the moisture, suppress the growth of weeds and lessen the attack of borers.
- Biological Control: Use of biological control agents (*T. chilonis*, *S. inferens*).
- Need based chemical Intervention: Need based chemical intervention with (chlorantraniliprole, carbofuran, fipronil).

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