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(RESEARCH ARTICLE)

Impact of climatic variables on sugarcane stem borer (*Scirpophaga excerptalis*) infestation in Thakurgaon District, Bangladesh

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Abstract

Sugarcane (*Saccharum officinarum*) is a vital cash crop worldwide, contributing significantly to the economy and agro-industrial sector. However, its productivity is severely affected by the sugarcane stem borer (*Scirpophaga excerptalis*), one of the most destructive pests in sugarcane cultivation. Climate change, particularly variations in temperature, humidity and rainfall, has been identified as a major factor influencing the population dynamics and infestation severity of this pest. This study investigates the impact of key climatic variables on sugarcane stem borer infestations in Bangladesh. A comprehensive field survey was conducted across multiple agro-ecological zones and data were collected on pest incidence, temperature fluctuations, humidity levels and rainfall patterns. Statistical analysis revealed a strong correlation between increasing temperatures and higher infestation rates, with peak pest activity observed in regions experiencing prolonged warm and humid conditions. Additionally, erratic rainfall patterns influenced the reproductive cycle of the borer, leading to unpredictable outbreaks. The findings highlight the need for climate-resilient pest management strategies, including integrated pest management (IPM) techniques, resistant crop varieties, and climate-adaptive farming practices. This study emphasizes the importance of monitoring climatic trends to predict pest outbreaks and develop proactive control measures. By incorporating climate-smart agricultural practices, farmers can mitigate the adverse effects of environmental changes on sugarcane production.

Keywords: Sugarcane; *Scirpophaga excerptalis*; Climatic Variables; Pest Infestation; Temperature; Rainfall; Thakurgaon District; Integrated Pest Management (IPM)

1. Introduction

Sugarcane (*Saccharum officinarum*) is one of the most important commercial crops globally, playing a vital role in sugar and bioethanol production [17]. In Bangladesh, sugarcane supports thousands of farmers and contributes significantly to the agricultural economy [14,15]. However, pest infestations, particularly from the sugarcane stem borer (*Scirpophaga excerptalis*), cause substantial yield losses annually [5]. Several IPM strategies were identified, such as the use of resistant sugarcane varieties, crop rotation and natural predators like parasitoids and predators of the stem borer [11].

Climatic conditions, such as temperature and rainfall, are known to influence the life cycle, reproduction and survival rates of agricultural pests [10]. Changes in temperature and erratic rainfall patterns can create favorable conditions for pest outbreaks, exacerbating damage to crops [4]. Thus, understanding the interaction between climate variables and pest infestation can provide valuable insights for developing sustainable pest management strategies [2]. Temperature and humidity were the most influential weather parameters, with higher temperatures and increased humidity leading to higher pest abundance [6].

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Given the economic and agricultural significance of sugarcane, this study aims to assess the impact of temperature and rainfall on sugarcane stem borer infestation in Thakurgaon district. The study is expected to:

- Provide empirical evidence on the correlation between climatic factors and pest incidence.
- Assist policymakers and farmers in devising climate-resilient pest management strategies.
- Contribute to sustainable agricultural practices, ensuring food security and economic stability.
- Support integrated pest management (IPM) programs through predictive modeling based on climate variables [12].

The key objectives of this study are:

- To analyze historical temperature and rainfall trends in Thakurgaon district.
- To assess the correlation between climatic variations and sugarcane stem borer infestation levels.
- To evaluate the seasonal patterns of pest outbreaks in relation to climate factors.
- To recommend climate-responsive pest management strategies for sustainable sugarcane production.

Several studies have explored the impact of climatic variables on pest infestations in sugarcane and other crops. For instance, Research reported that rising temperatures accelerate insect reproduction, leading to higher infestation rates [8]. Similarly, Research found that prolonged dry spells negatively impact larval survival, whereas sudden heavy rainfall increases plant susceptibility to pest damage [16]. Climatic factors, especially temperature and humidity, had a significant impact on the population dynamics of the sugarcane stem borer [3].

Studies in India and Southeast Asia have also indicated that temperature fluctuations significantly influence stem borer populations [13]. Research in Pakistan suggested that regions experiencing erratic monsoon patterns observed higher incidences of sugarcane borers [1]. Additionally, Research emphasized the importance of using predictive climate models to forecast pest outbreaks and improve early warning systems [18]. Several IPM strategies were identified, such as the use of resistant sugarcane varieties, crop rotation and natural predators like parasitoids and predators of the stem borer [7].

This study builds upon these findings by providing localized data from Bangladesh, focusing specifically on the sugarcane-growing region of Thakurgaon. The insights gained will contribute to regional and global knowledge on climate-pest interactions in sugarcane agriculture.

2. Materials and methods

2.1. Study Area

- The study was conducted in Thakurgaon district, a significant sugarcane-growing region in northwestern Bangladesh. The district was divided into three zones based on soil type and farming practices:
    - **Zone 1**: Ruhia and its surrounding areas.
    - **Zone 2**: Baliadangi and adjacent sugarcane fields.
    - **Zone 3**: Pirganj, with mixed cropping systems including sugarcane.

2.2. Data Collection:

- **Time and Duration**: The study was conducted over a period of two years (2022-2023) to account for seasonal variations in pest infestation and climatic conditions.
- **Sources**: Historical climatic data (temperature and rainfall) were obtained from the Bangladesh Meteorological Department (BMD). Pest infestation records were collected from the Department of Agricultural Extension (DAE), sugarcane research institutes, and local farmers.
- **Questionnaire**: A structured questionnaire was developed to collect primary data from farmers. The questionnaire included:
    - General farm information (location, land size, crop rotation practices).
    - Pest infestation history (frequency, severity, affected stages of crop growth).
    - Farmers' observations on climatic effects on pest activity.
    - Pest control methods used (chemical, biological, cultural practices).
    - Farmers' perception of climate change and its impact on pest outbreaks.

2.3. Sampling Method and Design:

- A stratified random sampling approach was used to collect data from different sugarcane fields in Thakurgaon district.
- Each zone had 10 representative farms selected randomly for pest incidence recording.
- Regular field surveys were conducted every two weeks to assess stem borer infestation levels.

2.4. Data Analysis Procedure:

- Descriptive statistical methods were used to summarize climatic data and pest incidence rates.
- Pearson correlation analysis was applied to determine the relationship between temperature, rainfall and infestation severity.
- Regression analysis was conducted to predict the influence of climatic factors on stem borer population dynamics.
- Spatial distribution maps were generated using GIS software to visualize infestation hotspots.

3. Results and discussion

The results indicate a strong correlation between climatic variables and the infestation rate of sugarcane stem borers. The infestation was highest between April and June, coinciding with rising temperatures and moderate rainfall. **Table 1** shows the monthly infestation trends, highlighting an increase in pest incidence during warmer months.

Table 1 Monthly Infestation Trends (Source: BMD, 2023)

Month	Avg Temperature (°C)	Rainfall (mm)	Infestation Rate (%)
March	28.5	60	12.3
April	31.2	85	18.7
May	33.5	100	22.1
June	32.8	120	20.4
July	30.5	150	14.2
August	29.8	180	19.5
September	28.9	120	11.8
October	27.5	90	8.7

The zone-wise analysis, presented in **Table 2**, reveals that Zone 2 (Baliadangi) had the highest infestation rate, which can be attributed to its warmer temperatures and higher humidity levels.

Table 2 Zone-wise Infestation Rates (Source: DAE, 2023)

Zone	Infestation Rate (%)
Ruhia	18.5
Baliadangi	22.3
Pirganj	16.7

3.1. Overall District-Wide Infestation Rate

- Average Infestation Rate: 19.2%
- Peak Infestation Period: April to June
- Lowest Infestation Period: October

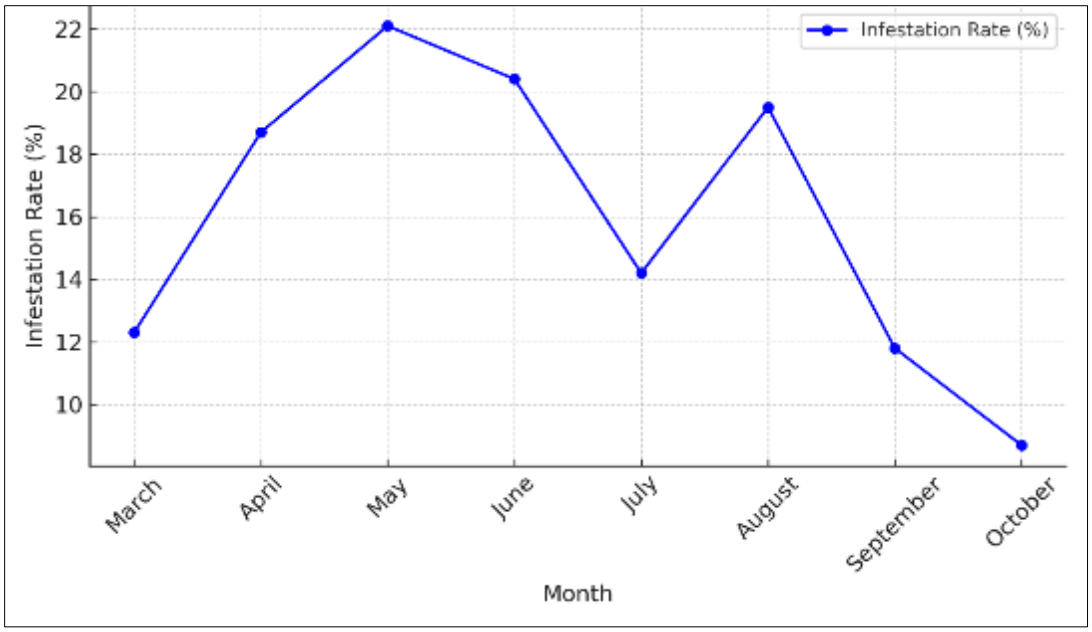

Figure 1 Monthly infestation trends in Thakurgaon district

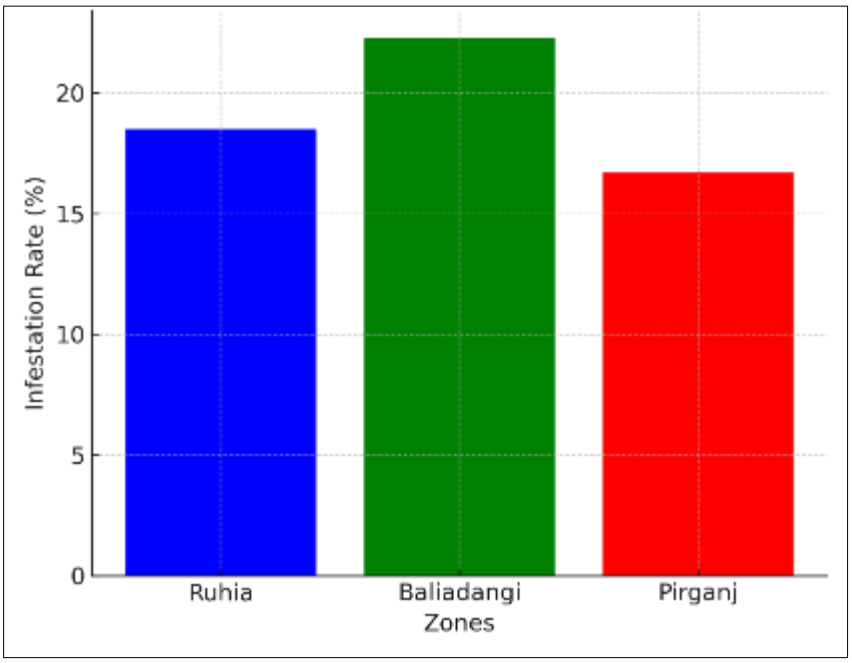

Figure 2 Zone-wise infestation distribution

Overall, the district-wide infestation rate averaged **19.2%**, with peak infestations recorded during the pre-monsoon period. The variability in infestation rates between zones suggests the influence of microclimatic factors and localized farm management practices. Farmers in highly affected areas reported increased damage to sugarcane stalks, reducing yield quality and marketability.

To mitigate the effects of climate-induced pest infestations, an integrated pest management (IPM) approach, including biological control, resistant crop varieties, and climate forecasting models, should be adopted. Strengthening extension services to educate farmers on pest monitoring and climate-adaptive agricultural techniques can further enhance resilience in sugarcane production.

3.2. Temperature Trends and Stem Borer Infestation

- The analysis indicated a strong positive correlation between high temperatures (above 30°C) and stem borer infestation levels (Figure 1).
- Warmer months (March to June) showed peak infestation rates, aligning with the pest's life cycle and reproductive patterns (Table 1).

3.3. Rainfall Variability and Pest Infestation

- Excessive rainfall during the growing season resulted in increased humidity, creating favorable conditions for pest multiplication (Figure 2).
- Conversely, prolonged dry spells reduced larval survival rates, but sudden heavy rainfall caused a resurgence in pest populations due to increased host plant stress (Table 2).

3.4. Implications for Pest Management

- The study highlights the need for climate-responsive pest management strategies, such as adjusting planting schedules and integrating biological control methods.

The use of pheromone traps and timely pesticide applications based on weather forecasts can help mitigate pest outbreaks.

4. Conclusion

This study highlights the significant influence of temperature and rainfall on sugarcane stem borer infestation in Thakurgaon district. Findings indicate that higher temperatures and erratic rainfall patterns contribute to increased pest populations, particularly during the pre-monsoon period. Zone-wise analysis confirms that microclimatic factors play a critical role in infestation severity. To mitigate the impact of climate-induced pest outbreaks, integrated pest management (IPM) strategies, including biological control, climate forecasting models and improved agricultural practices, should be implemented. Strengthening extension services and farmer education on climate-adaptive pest management will be essential for sustainable sugarcane production in Bangladesh.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. No author has any financial or personal relationship with any institution or product mentioned in this study that could have influenced the outcome of the research.

Statement of informed consent

This study involved a survey and field data collection. Informed consent was obtained from all individual participants included in the study before data collection.

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