Research Article:

POPULATION DYNAMICS OF TOMATO LEAF MINER, *Tuta absoluta* (Meyrick, 1917), IN VARIOUS LOCATIONS OF SURKHET, NEPAL

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ABSTRACT

The tomato leaf miner, *Tuta absoluta* (Meyrick, 1917), is a destructive pest of tomatoes and other solanaceous plants, inflicting severe yield losses globally. A population dynamics study of *T. absoluta* in tomato provides an opportunity to understand interactions among biotic and abiotic factors, which are useful to develop a pest management strategy. The population dynamics was observed for a year from May 2024 to May 2025 at nine sites of Surkhet spread across 598 to 724 masl. The study focused on five popular tomato varieties and two growing conditions (plastic house and open-field). Male adult populations was found to have declined by 33.33% over an elevation increase of 126 m, with infestation intensity inversely correlated ($r = -0.45$). Adult population peaked at temperatures between 25-35 °C ($r = +0.71$, $p < 0.0001$), whereas rain greater than 10 mm suppressed population growth by physically washing off eggs and larvae from host plants, increasing mortality through direct impact, and contributing to environmental conditions less favorable for population proliferation. Tomato variety VL 443 exhibited the tolerance (only 41% infestation) while Heemsohna showed the preference (100% infestation) variety. Furthermore, plastic house tomato had a significant reduction in male adult leaf miner by 49% compared to open field growing conditions.

सारांश

गोलभेंडाको पात खन्ने कीरा, टुटा अब्सुलुटा (मेयरिक, १०१७) गोलभेंडा लगायत अन्य सोलानासियस परिवार अन्तर्गतका बालीहरूको एक प्रमुख बिनाशकारी कीरा हो । गोलभेंडा बालीमा गोलभेंडाको पात खन्ने कीराको जनसंख्या गतिशीलताको अध्ययनले जैविक र अजैविक कारक तत्त्वहरूको अन्तरक्रिया बुझ्ने अवसर प्रदान गर्दछ, जुन शत्रुजीव ब्यवस्थापनको रणनीति विकास गर्नमा उपयोगी हुन्छ । जनसंख्या गतिशिलताको अध्ययन मे २०२४ देखि मे २०२५ एक बर्षासम्म सुर्खेतको ५९८-७२४ मिटर उचाइका नौ वटा स्थानमा गरिएको थियो। यो अध्ययन पाँचवटा गोलभेंडाको प्रजातिहरू र दुई वटा खेती (प्लास्टिक घर र खुला खेती) प्रणालीमा केन्द्रित थियो । अध्ययनको प्रमुख निष्कर्ष अनुसार, उचाइ १२६ मीटरले बढ्दै जाँदा कीराको पुरुष वयस्क जनसंख्या ३३.३३% ले घटेको पाईयो । २५-३५°C को तापक्रममा जनसंख्या सबैभन्दा बढी ($r = +०.७१, p<०.०००१$) भएको पाईयो भने १० मिमिभन्दा बढी वर्षाले कीराका अण्डाहरू र लार्भालाई भौतिकरुपले असर पूर्‍याउँदा र वृद्धि विकासको लागी वातावरण प्रतिकुल हुँदा पुरुष कीराको जनसंख्या घटेको पाईयो । VL ४४३ जातमा ४१% मात्र क्षति भएको देखियो भने हिमसोहनामा १००% क्षति देखियो । खुला खेती प्रणालीको तुलनामा प्लास्टिक घरमा पुरुष कीराको जनसंख्या ४९% ले कम भएको देखियो ।

Keywords: Climatic factors, pest monitoring, pheromone traps, varietal tolerance

INTRODUCTION

Tomato leaf miner, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae), is one of the most devastating and severely destructive pest of tomato and other solanaceous crops globally (Desneux et al., 2010; Tarusikirwa et al., 2020). This pest is native to Peru (South America) and has spread to more than 60 countries in Europe, Africa, and Asia (Campos et al., 2014; Biondi et al., 2018). The pest equally infests other solanaceous crops such as potato (*Solanum tuberosum* L.), eggplant (*Solanum melongena* L.), pepper (*Capsicum annuum* L.), and tobacco (*Nicotiana tabacum* L.) (Mawcha et al., 2025).

The pest was first reported in Nepal in Kathmandu and its vicinity in 2016 (Bajracharya et al., 2016). The route of invasion remains unclear; however, it is most likely invaded to Nepal was invaded from India through tomato imports (Venkatramanan et al., 2020). The pest is now spread to almost all tomato-growing districts and different ecological regions of the country. It was first detected in Kathmandu, Lalitpur, Bhaktapur, Kavrepalanchowk, and Dhading, causing severe losses, especially in major production areas like Nawalparasi and other mid-hills and Terai pockets (Pandey et al., 2023).

The larval instars are the most damaging stage, causing up to 100% losses in the tomato crop if control measures are not applied (Aynalem, 2018). The larvae attack almost all aerial parts of tomato plants, most preferably the leaves and fruits of the tomato. The larval feeding on fruit creates pin holes that reduce quality and induce secondary infection by other microbes, rendering them unfit for consumption. The pest has a short life cycle (3-4 weeks) and completes 10–12 generations in a year, and is prone to gaining insecticide resistance in a short period (Guedes & Picanço, 2012). Trade and transport of tomato fruits serve as a primary pathway in the invasion and dispersal of *T. absoluta* globally (Venkatramanan et al., 2020).

Tuta absoluta is now the major challenge of tomato production across the country, including Surkhet. The farmers of tomato growing in this region are facing heavy losses due to this pest. They are losing a great quantity of tomatoes every summer and rainy growing seasons. Farmers are applying toxic chemical insecticides to manage this menace. Further, the pest problem is exacerbated through haphazard use of chemical pesticides, resulting in pest resistance, pest resurgence, including the risk to human health and the environment. However, there is limited research focusing on the population dynamics of the pest across agro-ecological zones, considering climatic factors such as temperature, humidity, and rainfall, including tomato varieties, and crop growing conditions. This study, carried out in Surkhet, reports the effects of abiotic factors, crop varieties, and growing conditions on the population dynamics of this pest. The findings of the study help to understand infestation peaks and dynamics of pest populations, which as important in designing an IPM program for the sustainable management.

RESEARCH METHODS

The research was conducted from May 2024 to May 2025 at nine major tomato growing sites of Surkhet district: Birendranagar-4 (Naretapper, 724 m), Birendranagar-3 (Uttarganga, 628 m), 2 sites in Birendranagar-9 (Tilpur, 639 m), Birendranagar-9 (Parseni, 696 m), 3 sites in Bheriganga-4 (Muralikhola, 703 m), and in Gurvakot-13 (Salamidanda, 598m). Five varieties, which were farmers' cultivated, were randomly allocated to nine altitudes and two growing conditions (Inside a plastic house and open field). The sites were spread across a small elevational gradient (126 m) from (Salamidanda) to 724 m (Naretapper).

Daily temperature (maximum, minimum), relative humidity, and rainfall data were collected from the Hydrology and Meteorology Department located in Banke district. These data represented the river basin, hill, and mountain agro-ecological areas of Karnali Province. The reference data used for this study were the data recorded at the Meteorological Station of Surkeht Airport. So, this data reflects all nine selected locations. The populations of *T. absoluta* were monitored by using Tomato Leaf Miner lure (TLM) and Wota-T-Trap (developed by Revolution Company, India), which were installed in tomato fields across all the sites, both in plastic house and open-field growing conditions. Two TLM lures per plastic house were installed and adjusted according to the growing stages of tomato plants. Similarly, two TLM lures per open field growing conditions were installed. The traps were established immediately after transplanting, when the seedling height was 15 cm, and the height of the traps was adjusted along with the crop growth and the plant height.

The pests in the trap were collected and counted each week. The Tomato Leaf Miner lures were replaced in 30 days; however, the water used in the traps was replaced each week immediately after counting the adult moths, which will help understand the infestation peaks and dynamics of the pest population in those particular sites. The most popular tomato varieties under farmer's field conditions: Gaurabh 555, Manisha, Nabin, VL 443 (farmer-preferred varieties), and Heemsohna (susceptible check) were chosen to monitor *T. absoluta*. While growing the tomato crop, the row-to-row and plant-to-plant spacing was maintained at a spacing of about 0.75 m × 0.45 m by the farmers. Farmers grew tomatoes more than a ropani to about one hectare. There was no specified plot size maintained during carried out this research because the design of this research was a survey type. Standard and recommended irrigation and weed management practices were followed, and jute ropes were used for staking. and 3G pruning (cutting) was practiced in all the tested varieties and in both plastic house and open-field growing conditions.

Data collection and analysis

Tomato leaf miner (TLM) lure was used to monitor populations of adult males of *T. absoluta*. Adult males trapped in TLM lures were counted every week from both the plastic house and open-field tomato plots spread across nine locations at different elevations, as mentioned above. In case of a high number of insects trapped in per trap, daily counting was done and then averaged in a weekly basis. Regular weekly water replacement was done for the reduction of insect decomposition. The pest count data were analyzed in Microsoft Excel by descriptive statistics, including means and deviations across the fields and varieties. The abundance of tomato leaf miners in plastic house and open-field tomato plots was compared by t-test comparisons.

RESULTS AND DISCUSSION

Role of elevations on the population dynamics of *T. absoluta*

The study revealed a trend of decline in the *T. absoluta* male adult population with an increase in altitude (Table 1). The mean density of *T. absoluta* adults at the lowest elevation (598 masl) was 159, and at the highest elevation (724 masl) was 106 individuals, i.e., a difference of 33.3% in a 126 m increase in elevation. There was a gradual decline of the male adult population with an increase in altitude from the base 598 masl to the highest altitude 724 masl location by 9.43%, 10.06%, 15.72%, 29.55 and 33.33%, respectively (Table 1). The result shows variability in weekly captures of male *Tuta absoluta* adults, with averages ranging from 106 to 159 per trap. The standard deviations indicated significant fluctuation in captures. Thus, there is an inconsistent *Tuta absoluta* presence across the observed period.

A moderate negative correlation was found between elevation and infestation intensity (r = -0.45). There was a significant decline in adult population density with increasing

altitude. Elevation influences 20% of the variation of *T. absoluta* adult population fluctuation (R^2 = 0.20), and the rest 80% variance is attributable to other ecological and management factors, like temperature, humidity, agronomic practices, and varietal tolerance. The correlation between the elevation and population dynamics of *Tuta absoluta* is also shown in a graph.

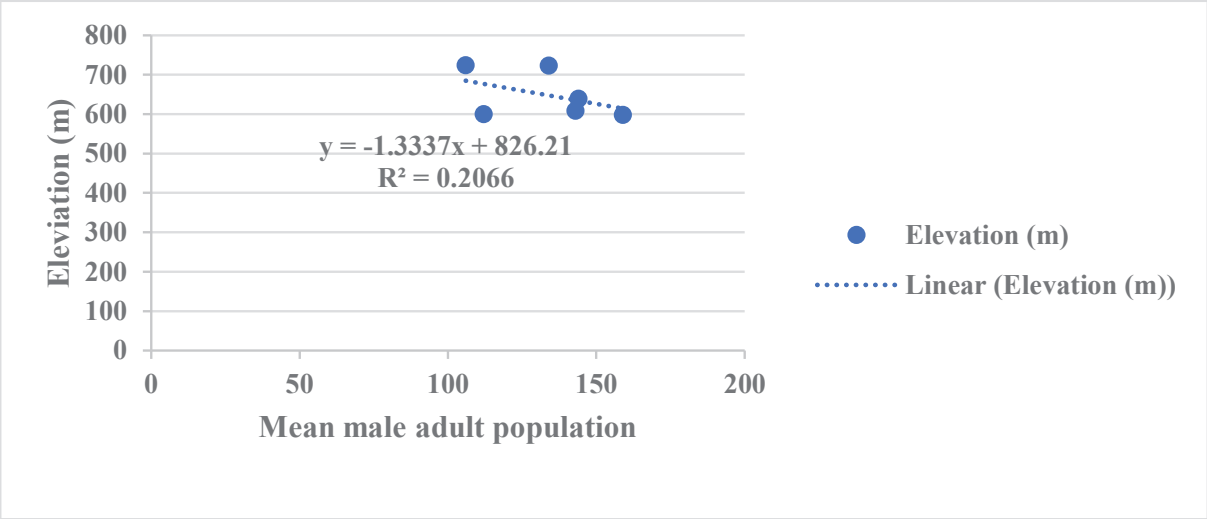

Fig. 1. Correlation between the elevation and population dynamics of *Tuta absoluta*

Elevation can lower *T. absoluta* populations dramatically; however, it cannot solely predict pest distributions. Similar studies in Colombia and Peru at cooler high-altitude zones (>800 m) reported a 27% population decline of *T. absoluta* per 100 m rise in altitude, and the cooler temperatures at higher than 1,500 m inhibited *T. absoluta* multiplication (Biondi et al., 2018).

Table 1. *Tuta absoluta* male adults trapped at research locations across elevational gradients

Elevation of the sites (m)	Elevational gradient (m) across the sites	Male adults of *Tuta absoluta* (Per trap/week) (Mean ± SD)	Percentage decline over the base elevation (598 m)
598	0	159 ± 149.4	0.0
628	30	144 ± 85.2	9.43
639	11	143 ± 126.2	10.06
696	57	134 ± 133.3	15.72
703	7	112 ± 125.6	29.55
724	21	106 ± 87.6	33.33

Note: SD denotes Standard Deviation

Relationship between temperature, moisture, and abundance of *T. absoluta*

Maximum temperature had a strong positive relationship with adult *T. absoluta* population ($r = +0.71$, $p < 0.0001$), with the maximum activity at a temperature range of 25-35°C (Table 2). The relationship for minimum temperature had a moderate positive correlation ($r = +0.52$, $p < 0.0001$), and the male adult populations increased at the minimum temperature above 15°C. Similarly, relative humidity had a weak positive correlation ($r = +0.39$, $p = 0.0012$), with the optimal abundance of male adult *T. absoluta* at 60-80% relative humidity. While rainfall had a strong negative correlation ($r = -0.63$, $p < 0.0001$), indicating rainfall greater than 10 mm per week reduced adult abundance (Table 2).

The findings are consistent with previous studies that have shown strong temperature dependence for *T. absoluta* growth and population increase (optimal activity at 25–30°C) (Ghaderi et al., 2017; Proffit et al., 2011). Above 15°C is optimal for adult survival and reproduction, and 60–80% relative humidity is a favorable condition for *T. absoluta* moth emergence (Krechemer & Foerster, 2015). The optimum temperature for *T. absoluta* was 30 °C, with upper and lower developmental thresholds of 34.6 °C and 14 °C, respectively (Martins et al., 2016). Similarly, *T. absoluta* required 416.7-degree days to complete the cycle from egg to adult, and the lower temperature threshold was estimated to be 8.0°C. The upper temperature threshold estimated for the egg-adult cycle was 37.3°C (Krechemer et al., 2015).

Table 2. Relationship between temperature, moisture conditions, and abundance of *T. absoluta*

Factors	Correlation (r)	p-value	Optimal range
Maximum temperature	+0.71	<0.0001***	25–35°C
Rainfall	-0.63	<0.0001***	>10 mm/week
Relative humidity	+0.39	0.0012**	60–80 %
Minimum temperature	+0.52	<0.0001***	>15°C

Note: In statistical results, ** denotes a p-value between 0.01 and 0.001 (moderate significance), while *** denotes a p-value < 0.001 (high significance), °C denotes temperature in degrees centigrade.

Abundance of *T. absoluta* across tomato varieties

There was a variation in the abundance of *T. absoluta* across tomato varieties (Table 3). The variety Heemsohna was the most preferred (100% infestation) variety and with 568 male adults observed. All the leaves and fruits were damaged by the *Tuta absoluta*. Conversely, VL 443 was the most tolerant (41% infestation) with 287 male adults. The other highly preferred varieties: Gaurabh 555 (82%; 466 male adults) and Manisha (79%; 449 male adults) captured almost twice as the adults as that of VL 443, while Nabin was the other preferred variety (68% infestation) with 386 male adults observed.

Morphological and biochemical traits of the tomato variety determine infestation and damage by *T. absoluta* (Aynalem, 2018). The softer leaves with lower trichome density in Heemsohna could have favored oviposition, and the leaves were more palatable to larvae. On the other hand, the higher trichome density, tougher leaves, and deterrent secondary metabolites in VL 443 caused tolerance to TLM infestation (Ghaderi et al., 2017). The secondary metabolites produced in the leaves could have repelled adults and reduced larval survival (Proffit et al., 2011). The tomato variety VL 443 can be recommended in *T. absoluta*-infested areas (Shiberu & Getu, 2017).

Table 3. *Tuta absoluta* male adult abundance across tomato varieties

Variety	Relative tolerance (%)	Peak male adult population (No.)
Heemsohna (The most preferred)	100	568
Gaurabh 555	82	466
Manisha	79	449
Nabin	68	386
VL 443	41	232

Influence of tomato growing conditions on *T absoluta* abundance

The number of adult *T. absoluta* males captured in the TLM lure varied with the growing conditions. The abundance of *T. absoluta* adults in the plastic house (118.2 ± 38.4) was lower (49%) as compared to the open-field condition (231.7 ± 38.4) ($t = 4.32$, $p < 0.01$), as shown in Table 4.

Table 4. Abundance of adult male *Tuta absoluta* in plastic-house and open-field conditions

Cultivation condition	Number of *T. absoluta* (± SD)	p-value (t-test)
Plastic houses	118.2 ±38.4	0.0032*
Open-field	231.7 ±62.1	-

The result showed that adult male *Tuta absoluta* is significantly more abundant in open-field conditions (231.7 ± 62.1) compared to plastic houses (118.2 ± 38.4), with the difference being statistically significant ($p = 0.0032$). The lower *T. absoluta* adult abundance in plastic houses could be a microclimatic effect and a movement barrier to the pest (Urbaneja et al., 2012; Tiwari et al., 2024).

CONCLUSION

Tuta absoluta abundance influenced across different cultivation practices, elevation, varieties, temperature, relative humidity, and amount of rainfall. Growing tomato crops at higher elevations suppressed pest populations, but additional control measures could be adopted in lowland areas. Similarly, the weather variables were also likely to either encourage or hinder pest abundance and dynamics based on major contributing factors of temperature, rainfall, and humidity, which indicates that climate-based forecasting can improve the timing of interventions. Differences in varietal resistance were observed, with VL 443 being the most tolerant variety to *T. absoluta*, while Heemsohna was the most preferred. Other varieties, Gaurabh 555 and Manisha, were highly preferred, and Nabin was also preferred.

Identifying tolerant varieties provides a safer means for smallholder farmers to mitigate pest pressure at the lowest cost. Growing tomato inside plastic houses with crop rotation decreased adult populations to nearly half, benefiting from pest exclusion and microclimate stabilization. The findings of this research will provide prior information to the farmers about carrying out the management measures against *Tuta absoluta* in Surkhet-based agro-climatic conditions.

The five varieties selected represent a spectrum of traits. This suggests that farmers should select varieties based on the host preferences of herbivorous. Male trap catch data is a proven population index. While it doesn't count females or larvae, trends in male catches directly correlate with overall population activity and breeding cycles. It provides an early warning. Similarly, monitoring males via sex pheromone traps is simultaneously a monitoring tool and a direct control tactic by mass trapping. This dual benefit is highly efficient. Reducing the number of males directly lowers mating success and subsequent egg-laying. The goal is not to eradicate *Tuta absoluta* but to manage it below an economically damaging threshold with the least cost and environmental impact.

Thus, this research supports the basis of an integrated pest management (IPM) approach based on a combination of tolerant varieties, growing tomato inside plastic houses, high altitude nurseries, and climate-aware monitoring to effectively manage *T. absoluta* in the tomato production system.

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AUTHOR CONTRIBUTIONS

Author A: Investigation, Conceptualization, Software, Data Curation, Formal Analysis, investigating resource, Writing Original Draft, Writing Review & Editing.
Author B: Conceptualization, Methodology design, Supervision, Writing Review & Editing, and Validation.
Author C: Methodology design, Supervision, Validation, Writing Review & Editing.
Author D: Investigation, Supervision, Visualization, Writing Review & Editing, and Validation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS APPROVAL

This research did not involve any regulated materials, and therefore, ethical approval or permits is not necessary.

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