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Monitoring of Tomato Leaf Miner (*Tuta absoluta*) and Assessment of Management Practices Adopted in Tanahun, Nepal

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ABSTRACT

Background and Objective: *Tuta absoluta,* a destructive invasive pest of tomato (Meyrick 1917), was first reported in Nepal in May, 2016. The study aimed to evaluate the prevalence, severity, and distribution of *Tuta absoluta* infestation in tomato crops in Tanahun, Nepal, and to assess the effectiveness of pest management practices to identify optimal control measures based on farmers' feedback. **Materials and Methods:** The 68 tomato cultivating farmers' were selected through purposive simple random sampling. A semi-structured questionnaire was used for the household survey. Descriptive statistics, scaling and indexing were used to analyze the data. The significance test was done at a 5% level. **Results:** The majority of the farmers' (82.4%) cultivated in open fields. Insect pests, particularly *Tuta absoluta*, were identified as the primary challenge. Trap captures of TLM ranged from 51 to 672, with the highest population observed in Aanbukhaireni-1, likely due to variations in management practices. The incidence peaked in May, lowered significantly in June, and then rose again towards the end of June. While nearly all farmers' recognized *Tuta absoluta*, only 14.7% understood its life cycle. However, due to the pest's damaging nature, most could identify its larval and adult stages. Encouragingly, 58.8% of the farmers' demonstrated a good understanding of IPM. **Conclusion:** Chemical pesticides were identified as the most effective method for managing *Tuta absoluta,* followed by pheromone traps, based on farmers' experiences. Enhancing tomato production requires strengthening extension services to improve farmers' knowledge of the pest's biology and promoting eco-friendly IPM strategies, including biological controls and resistant varieties. Adopting sustainable practices can mitigate the pest's impact on tomato yields and quality.

KEYWORDS

Tuta absoluta, tomato, monitoring, trap, management strategies

INTRODUCTION

Since its introduction in Nepal, *Tuta absoluta* has severely threatened tomato growers, causing 80-100% damage in open fields and greenhouses[1]. The pest has developed resistance against pesticides like Abamectin, Cartap, Methamidophos, Permethrin (Brazil), and Deltamethrin, Abamectin (Argentina) due to haphazard chemical use[2]. Dependency on chemical control measures in Nepal has induced resistance and increased tomato chemical residues. Misuse and overuse of pesticides have posed health risks, including serious poisoning cases. Non-chemical control measures, such as pheromone traps and cultural practices, have limited adoption among farmers'.

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The South American tomato leaf miner, *Tuta absoluta* (Meyrick) [Lepidoptera: Gelechiidae], is a notorious threat to tomato production worldwide[3]. It infests open fields and greenhouses, posing a severe agricultural pest problem in South America, Europe, the Middle East, and parts of Asia[4]. *Tuta absoluta* originated in South America and has spread to various countries, including Europe, Africa, and Asia[4]. This invasive pest attacks tomato plants, causing significant yield losses by feeding on leaves, stems, and fruits. The larvae create mines on leaves, leading to defoliation, reduced fruit quality, and yield[4].

In Nepal, *Tuta absoluta* was first officially recorded in May, 2016 in the Kathmandu Valley and has since been confirmed in 14 locations across five districts[5]. The highest infestation levels were observed in Ugrachandi Nala-2 and Panchkhal of Kavre. It is suspected that imported tomatoes from India introduced this pest to Nepal[1]. The presence of *Tuta absoluta* has resulted in significant losses, accounting for 25-30% of total tomato production in affected areas, with estimated loss of $7,200 ha[6]. In Nepal, the potential annual loss due to this pest could reach $50 million, amounting to 80-100% of the yield[6]. This recent introduction has caused ecological and economic imbalances, leading to severe crop damage.

The presence of *Tuta absoluta* on tomato plants is characterized by several distinct symptoms. Leaves exhibit blotch mines visible from both sides, containing dark excreta and sometimes the larva itself. These mines can cause leaf browning, necrosis, and eventual plant death, leading to significant yield losses in heavily infested fields. Larvae also bore into apical buds and stems, resulting in stunted growth and the presence of dark frass. Additionally, larvae tunnel into fruit near the calyx, creating galleries filled with excreta and causing fruit damage. Adult moths are often observed flying near the ground surface in heavily infested fields[1].

The study on monitoring tomato leaf miner and assessing management practices in Tanahun, Nepal is essential to address limited information, explore non-chemical options, identify the most susceptible stages of damage, and develop sustainable IPM strategies[7]. Its findings will enhance tomato production and support farmers' in Nepal. The study aimed to assess the prevalence, severity, and distribution of *Tuta absoluta* infestation in tomato crops in Tanahun, Nepal, as well as to evaluate the effectiveness of pest management practices based on farmers' feedback to identify optimal control measures[8,9].

MATERIALS AND METHODS

Selection of study sites: The study was conducted from February to June, 2023 in Tanahun District, which is one of the tomato-producing districts in Nepal. Aanbu Khaireni Rural Municipality was selected as a study site based on its tomato production levels and accessibility.

Preliminary survey: A preliminary survey was conducted to gather information on the current status of tomato production and management practices in the study sites. This involves interviews with key informants, including tomato farmers', extension workers, and agricultural officers.

Study design

- **Cross-sectional survey design:** The survey used a cross-sectional study design to collect data on tomato production, management practices, and the incidence of tomato leaf miner infestation in Tanahun District. A sample of tomato farmers' was selected from different locations in the district
- **Field observations:** Field observations were conducted to assess the severity of tomato leaf miner infestation and to observe the management practices adopted by farmers'

Sample and sampling technique: Aanbu Khaireni Rural Municipality was selected for the study. Specifically, the study was focused on all 6 wards of Aanbu Khaireni Rural Municipality that have tomato production areas allocated as vegetable zones by PMAMP-Gorkha/Tanahun. To gather data, a simple random method of sampling was utilized within these choosen areas.

By using Raosoft, the sample size for the study was calculated. The population involved in tomato cultivation in Aanbu Khaireni Rural Municipality is 400. Hence, a total of 68 households were selected by simple random sampling procedure (i.e., 5% margin of error, 95% level of confidence, 50% response distribution).

Whereas for monitoring of insect population, three commercial farms cultivating Srijana variety 30 days after transplanting were selected at Aanbu Khaireni Rural Municipality. The number of *T. absoluta* male moths captured in different traps was counted at weekly intervals and recorded.

Data collection

- **Survey questionnaire:** A structured questionnaire was used to find out the major problems in tomato production, and to collect data on management practices, socio-demographic characteristics, and tomato yield. The questionnaire was pretested before data collection to ensure its validity and reliability
- **Field observations:** Field observations were conducted to assess the severity of tomato leaf miner infestation by inspecting the number of insects, stage of insects and loss of fruits through the use of Wota-T-trap and sticky trap[10]
- **Data collection procedure:** The survey questionnaire was administered to the selected farmers' using face-to-face interviews. The field observation was conducted by trained field technicians

Data analysis: The information collected from the field was coded first and entered. Descriptive statistics such as mean, standard deviation, percentage, and frequency were used to analyze socio-economic and farm characteristics. Data entry and analysis were done by using computer software packages which are SPSS 20.0 and MS-Excel 16.78.3 at 95% level of confidence and 5% margin of error. The following analysis was performed.

Socio-economic and farm characteristics: Variables like gender, age group, education status of respondents, ethnicity, occupation, and area under tomato were analyzed by descriptive statistics such as mean, frequencies, percentages, and standard deviation.

Index of tomato production problems: The scaling technique provides the direction and attitude of the respondents towards propositions. A five-point Likert Scale was employed to assess farmers' perceptions of production problems. This scaling technique allowed for the quantification of respondents' attitudes, ranging from "most serious" to "least serious". Specifically, the scale assigned numerical values of 1, 0.8, 0.6, 0.4, and 0.2 to the respective categories[12].

Mathematically:

$$I_{imp} = \sum \frac{S_i f_i}{N}$$

Where:

I_{imp} = Index of importance
$\sum$ = Summation
S_i = ith scale value
F_i = Frequency of ith importance given by the respondents
N = Total number of respondents

RESULTS

Education level of the tomato growers: The study revealed that 52.9% of the respondents in the study area had a primary level of education followed by respondents having a secondary level of education i.e., 39.7%. Similarly, 1.5% had higher education and 5.9% of the respondents were illiterate (Table 1).

Total land holding of farmers': The table reveals variations in land holdings among the farmers'. The mean land holding suggests that, on average, farmers' in the sample possess around 12.63 ropani of land. However, there is a significant range, with some farmers' owning as little as 5 ropani and others owning up to 22 ropani. Regarding tomato cultivation, the mean land area dedicated to tomatoes is 4.61 ropani.

This indicates that, on average, farmers' allocate a substantial portion of their land to tomato production. The minimum and maximum values suggest that some farmers' cultivate tomatoes on a relatively small scale (1 ropani), while others allocate a larger portion of their land (up to 10 ropani) to this crop (Table 2).

Tomato cultivation

Tomato cultivation system: Most of the farmers' cultivated tomatoes in open fields (82.4%), whereas 13.2% of farmers' cultivated in both. Out of them, only 4.4% of the farmers' grew tomatoes in plastic houses (Table 3).

Tomato crops per year: The study result showed that 72% of total farmers' grow tomato crops in one season of the year while 28% of the farmers' grow only in two seasons in a year.

Varieties of tomato cultivated: Most of the tomato farmers' had more preference for the variety Srijana followed by Kabita and Local. A total of 35 of the respondents cultivated Srijana variety whereas Kabita variety was cultivated by 18 only. Likewise, out of the total respondents, Manisha, Aayush, and Local were cultivated by 6, 2 and 7 of the respondents, respectively (Table 4).

Srijana emerged as the most favored variety, accounting for 51.5% of the responses. Kabita followed closely with a preference of 26.5%. Local varieties garnered 10.3% of the votes, while Manisha and Aayush secured 8.8 and 2.9%, respectively. This data suggests a strong preference for commercial varieties over local ones, with Srijana being the clear frontrunner among the respondents.

Involvement of tomato growers in cooperative/farmers' group: Table 5 shows that about 70.6% of the tomato growers were involved in the cooperatives/farmers' groups whereas 29.4% were not involved in any cooperatives/farmers' group.

Problems in the production aspect of tomato

Production problem ranking in tomato: Farmers' have more than one problem at a time. Major problems seen in tomato cultivation in the study area were insects and diseases, unavailability of inputs lack of technical knowledge, labor shortage, and lack of irrigation (Table 6).

The findings highlight that the most significant problem is insect-related issues (Rank I, Index 0.956), followed by disease (Rank II, Index 0.812). The unavailability of input ranks 3rd (Index 0.636), while the lack of technical knowledge ranks fourth (Index 0.512). Labor shortage is ranked fifth (Index 0.45), and lack of irrigation is the least significant issue (Rank VI, Index 0.339).

Insect pest ranking based on severity in tomato production: The severity index showed that among insects, tomato leaf miner (*Tuta absoluta)* was the most severe affecting the profitability of tomatoes with

Table 1: Education level of tomato growers in the study area, 2023

Education level of the respondent	Number	Percentage (%)
Illiterate	4	05.9
Primary level	36	52.9
Secondary level	27	39.7
Bachelor	1	01.5
Total	68	100.0

Table 2: Total land holding and under tomato cultivation in the study area

Land (ropani)	Minimum	Maximum	Mean
Total land holding	5	22	12.63
Land under tomato cultivation	1	10	04.61

Table 3: Tomato cultivation system in the study area, 2023

Method	Frequency (n = 68)	Percentage (%)
Open field only	56	82.4
Plastic tunnel only	3	04.4
Both	9	13.2

Table 4: Varieties of tomato cultivated in the study area, 2023

Varieties of tomato	Frequency (n=68)	Percentage (%)
Aayush	2	02.9
Kabita	18	26.5
Local	7	10.3
Manisha	6	08.8
Srijana	35	51.5

Table 5: Involvement of the tomato growers in cooperative/farmers' group in Tanahun, Nepal

Involvement	Number	Percentage (%)
Yes	48	70.6
No	20	29.4
Total	68	100.0

Table 6: Production problem ranking in tomatoes in the study area, 2023

Problems	Index	Rank
Unavailability of input	0.636	III
Lack of technical knowledge	0.512	IV
Insect	0.956	I
Disease	0.812	II
Labor shortage	0.450	V
Lack of irrigation	0.339	VI

an index value of 0.9. Whitefly and tomato fruit borer were found 2nd and 3rd most severe insects with an index value of 0.72 and 0.64, respectively. Similarly, Aphid was found as the least severe with an index value of 0.59 (Table 7).

***Tuta absoluta*:** *Tuta absoluta* has been the major problem in tomato cultivation in this area. As the study revealed 80-100% of yield loss occurred due to this pest and more than USD 50 million.

Knowledge level on the life cycle of *Tuta absoluta*: Out of 68 respondents, only 10 farmers' revealed that they knew the life cycle of *Tuta absoluta*. Almost 85.3% of the farmers' were ignorant about the pest life cycle (Table 8).

Infestation of *Tuta absoluta*: The study revealed that 76.5% of total farmers' had problems with *Tuta absoluta* in their tomato fields. So, *Tuta absoluta* is one of the most important and serious pests of tomatoes in Tanahun (Table 9).

Table 7: Insect pest impact on tomato: Ranking the most significant threats

	Intensity of problems								
Insects	1	0.80	0.6	0.4	0.2	Total	Weight	Index	Rank
Tomato leaf miner	46	12	10	0	0	68	61.6	0.90	I
Tomato fruit borer	12	20	15	13	8	68	43.8	0.64	III
Whitefly	8	35	15	10	0	68	49.0	0.72	II
Aphid	5	15	30	10	8	68	40.6	0.59	IV

Table 8: Knowledge regarding the lifecycle of *Tuta absoluta* in the study area, 2023

Responses of farmers'	Frequency	Percentage (%)
Yes	10	14.7
No	58	85.3
Total	68	100

Table 9: Infestation of *Tuta absoluta* in the study area, 2023

Responses of farmers'	Frequency	Percentage (%)
Yes	52	76.5
No	16	23.5
Total	68	100

Table 10: Level of infestation/crop damage by *Tuta absoluta* in the study area, 2023

Level of infestation/crop damage	Number	Percentage (%)
Low (0-10%)	8	11
Medium (10-20%)	14	20
High (20-40%)	28	42
Very high (40-60%)	16	24
Extreme level (60% above)	2	3
Total	68	100

Knowledge of damage symptoms of *Tuta absoluta*: Damage symptoms of *Tuta absoluta* were seen in the leaves, stem and fruit of the tomato. Larvae of insects damage leaves, stems, and fruit of tomatoes by mining into them. They feed on the green part of leaves and form whitish and irregular spots and black droppings and larvae can be seen inside leaves. They make holes in the fruit and enter inside. Mining damage of the stems causes malformation of the plant. In severe conditions, leaves dry out completely and flying moths can be seen around the plant.

Almost all of the respondents were aware of the damage symptoms of *Tuta absoluta* in leaves, twigs, and fruits. Out of 68 tomato growers, 62% of the respondents reported damage on leaves, 23% reported white spot blotch on leaves and 15% reported both symptoms. On twigs, almost all reported cessation of twigs growth resulting in lower plant height. On fruits, 76% reported the damage symptoms as small holes in fruits, 8% reported black fecal matter on fruits and 16% reported both symptoms.

Stage of plant mostly affected: The pest affects all the stages of the plant. According to the survey result, 41.17% of farmers' responded that the fruiting stage was the most affected while 35.29% reported the seedling stage as the infested stage. And 23.53% of the respondents reported that the fruit formation stage was the least affected stage by *Tuta absoluta* (Fig. 1).

Level of infestation/yield loss by *Tuta absoluta*: A significant portion of the surveyed population reported high levels of *Tuta absoluta* infestation. Specifically, 42% experienced high-level infestation, 24% a severe infestation and 19% a mild infestation. A smaller proportion reported low (11%) and extreme (3%) levels of infestation (Table 10).

Control measures: *Tuta absolutas*' damage is significant because it has already been introduced to the study's area. Control methods are therefore the most crucial component. It is impossible to completely

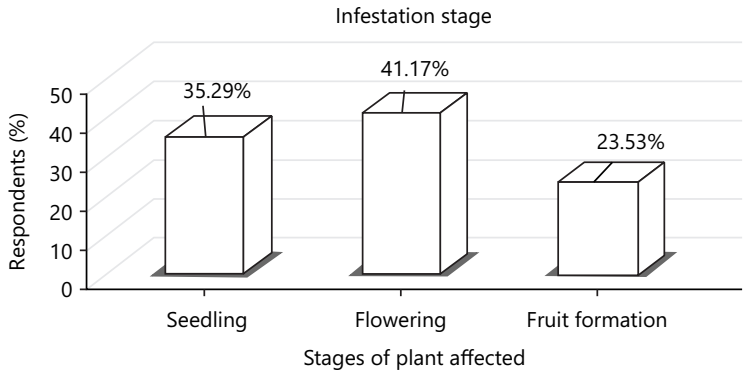

Fig. 1: Most affected stage by *Tuta absoluta*

Table 11: Methods of TLM control adopted by farmers' in the survey area

Method of control	Techniques/materials/chemicals
Mechanical control	TLM lure, netting, hand picking, use of sticky traps
Cultural method	Crop rotation, clean cultivation, pruning, removal of infested plant
Chemical control	King star, abamectin, arrow, spinosad, king killer

Table 12: Farmers' perception of the effectiveness of the mechanical method in controlling TLM

Level of effectiveness	Frequency (%)
Less effective	32 (47.1)
Moderately effective	34 (50)
Highly effective	2 (2.9)

eradicate this pest. However, a lot of farmers' use various control strategies. If yield declines, there will ultimately be economic loss since consumers won't pay for inferior items.

Idea about control measures and their adoption: Out of 68 farmers', 49 had ideas about control measures for this pest, and all the farmers' were found to be adopting these measures. The 19 farmers' were unaware of the control measures of TLM.

Current management practices adopted in Tanahun: The main means of control were cultural, chemical, and physical techniques. No one used the biological way of control because it wasn't available. Due to their ignorance of chemical methods, farmers' continue to use insecticides like King Killer and Arrow, which have little effect on pests. Sanitation, TLM lures, light traps, and sticky traps were among the many control methods. They learned how to use homemade traps during training on *Tuta absoluta* management tactics (Table 11).

Mechanical control and its effectiveness: The effectiveness of the mechanical methods varied with farmers'. About 47.1% of the farmers' found mechanical methods to be less effective while 50% of the farmers' found mechanical methods to be moderately effective. Similarly, 2.9% of the farmers' found mechanical methods to be highly effective for TLM control (Table 12).

Cultural control and its effectiveness: The cultural control method was well practiced in the survey area. The effectiveness of the cultural method was assessed on the basis of farmers' perceptions. 42.6% of the farmers' found cultural methods to be less effective. The remaining 57.4% of farmers' found cultural methods to be moderately effective. None of the farmers' found the cultural method highly effective (Table 13).

Table 13: Farmers' perception on the effectiveness of cultural methods in controlling TLM

Level of effectiveness	Frequency (%)
Less effective	29 (42.6)
Moderately effective	39 (57.4)
Highly effective	0

Table 14: Farmers' perception of the effectiveness of chemical methods in controlling TLM

Level of effectiveness	Frequency (%)
Less effective	5 (7.4)
Moderately effective	21 (30.9)
Highly effective	42 (61.8)

Chemical control and its effectiveness: One hundred percent of the infested farmers' were found to be using chemical methods. The effectiveness of the chemical method based on the farmers' perception was studied. 7.4% of the farmers' found chemical methods to be less effective while 30.9% of the farmers' found chemical methods to be moderately effective. And 42% of the farmers' found chemical methods to be highly effective (Table 14).

Knowledge about Integrated Pest Management (IPM) practices: Among the total farmers', 41.2% of the farmers' were unaware of IPM practices whereas 58.8% of the farmers' knew IPM. The level of IPM knowledge was relatively better.

Source of knowledge/information: The 38% of the farmers' received information or knowledge regarding control measures from agrovets. Similarly, 46, 7, and 9% received information from government agencies, NGO/INGOs, and friends/families, respectively.

Monitoring tomato leaf miner (*Tuta absoluta)* using TLM lure

Weekly observation of *Tuta absoluta* in three locations of Tanahun: Based on observation of traps in 3 locations of Tanahun, the population of male moth trapped in a Wota-T-trap ranges from 51 to 672. A maximum of 672 male moths per week were noted on 30 May, 2023 in Aanbukhaireni-1 whereas in Aanbukhaireni-2 and 3, the maximum number of pests recorded was 426 on 4 July, 2023 and 292 on 23 May, 2023, respectively. The population of male moths reached its peak during May, and remarkably low population during June, which again increased during July (Table 15).

Population of *Tuta absoluta* during the monitoring period: Based on the observation of traps in 3 locations during the entire counting period, the maximum number of adult populations of TLM was found at 3479 in Aanbukhaireni-1, 2319 in Aanbukhaireni-2 and 1276 in Aanbukhaireni-3 from May to July. The lowest number of the pest in Aanbukhaireni-3 as compared to Aanbukhaireni-1 and 2 during the same counting period might be due to the use of pesticides (Emamectin benzoate) from the initial stage of cultivation as reported by the farmers'. Also, the farm of Aanbukhaireni-3 was well maintained following appropriate sanitation measures like removal of infested plant parts and host plants like *Solanum nigrum,* etc which may have influenced the least number of *Tuta absoluta* than other farms (Fig. 2).

Statistical difference in population of *Tuta absoluta* in three locations of Tanahun: Among the three locations (Aanbukhaireni-1, 2 and 3), the *Tuta absoluta* population per trap significantly varied during most of the observation. A higher population was recorded at Aanbukhaireni-1 as compared to other 2 locations except on 4 July and it was highest at Aanbukhaireni-2 on that date. The lower TLM population at Aanbukhaireni-3 is due to the application of insecticides; Emamectin benzoate (EMAR) as reported by the farmers'.

On 16 and 30 May, the highest TLM population was recorded at Aanbukhaireni-1 and the lowest at Aanbukhaireni-3. The number of insects recorded at these 3 locations was significantly different.

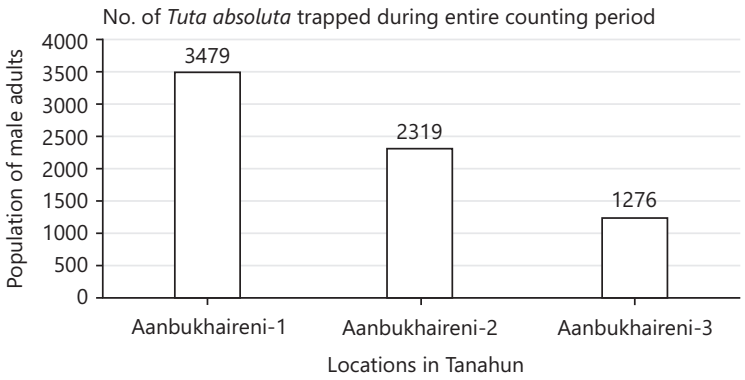

Fig. 2: Average total population of male adults of TLM trapped in 3 locations in Tanahun (May-July, 2023)

Table 15: Weekly observation data of *Tuta absoluta* trapped

	Number of TLM trapped		
Date of collection	Aanbukhaireni-1	Aanbukhaireni-2	Aanbukhaireni-3
16 May, 2023	595	321	194
23 May, 2023	607	328	292
30 May, 2023	672	316	208
6 June, 2023	430	234	177
13 June, 2023	251	230	198
20 June, 2023	233	161	51
27 June, 2023	465	303	55
4 July, 2023	226	426	101

Table 16: Population fluctuation of *Tuta absoluta* in 3 locations of Tanahun, May-July, 2023

Location	16 May	23 May	30 May	6 June	13 June	20 June	27 June	4 July
1	85 (1.92)^{a}	86.71 (1.93)^{a}	96 (1.98)^{a}	61.42 (1.78)^{a}	35.86 (1.54)	33.28 (1.52)^{a}	66.43 (1.82)^{a}	32.29 (1.51)^{a}
2	45.86 (1.65)^{b}	46.86 (1.66)^{b}	45.14 (1.65)^{b}	33.43 (1.5)^{b}	32.86 (1.5)	23 (1.36)^{a}	43.29 (1.64)^{a}	60.86 (1.78)^{a}
3	27.71 (1.42)^{c}	41.71 (1.62)^{b}	29.86 (1.46)^{c}	25.29 (1.35)^{b}	28.29 (1.43)	7.29 (0.83)^{b}	7.86 (0.85)^{b}	14.43 (1.05)^{b}
F test	***	***	***	**	NS	***	***	**
SEM (±)	4.36	4.47	3.51	4.62	3.69	3.24	2.93	3.76
LSD (0.05)	13.44	13.77	10.80	14.23	11.37	10	9.03	11.59
CV (%)	21.83	20.25	16.28	30.5	30.20	40.5	19.78	27.76
Grand Mean	52.86	58.43	57	40	32.33	21.19	39	35.86

SEM: Standard Error of Mean, LSD: Least Significance Difference, CV: Coefficient of Variation, *** Represent Significant at 0.1% level, ** Represent Significant at 1% level, and same letters in superscript indicates the similar effects

On 23 May and 6 June, the highest TLM populations were recorded at Aanbukhaireni-1 which was significantly higher than those recorded on Aanbukhaireni-2 and 3. Statistically, a similar number of insects were recorded at Aanbukhaireni-2 and 3.

On 13th June, the highest TLM populations were recorded at Aanbukhaireni-1 and the lowest at Aanbukhaireni-3 but are not significantly different.

But at 20th June and 27th June, the highest population was recorded in Aanbukhaireni-1 which was statistically similar to that of Aanbukhaireni-2. The lowest population was recorded on Aanbukhaireni-3 which significantly differs from these 2 locations.

On 4th July, the highest population was recorded in Aanbukhaireni-2 and the lowest in Aanbukhaireni-3 (Table 16).

The data shows significant variation across the locations and dates, with location 1 consistently higher in measurement, peaking on 30 May (96) and then declining. Location 2 exhibited a similar trend, though

with a lower overall range, reaching a peak on 4 July (60.86). Location 3 showed the lowest values, with a peak on 23 May (41.71) and a marked drop on 20 June (7.29). Statistical tests indicated significant differences (***) on most dates except for 13 June (NS). The overall variability (CV%) was highest on 20 June (40.5%) and lowest on 30 May (16.28%).

DISCUSSION

This study monitors the TLM and assesses the management practices adopted in Tanahun, Nepal. The study findings aligned with the previous studies that have highlighted the devastating impact of TLM in tomato cultivation. The TLM emerged as the most detrimental pest, significantly impacting profitability, particularly affecting crops at the seedling and flowering stages. Limited awareness among Nepalese farmers' regarding integrated pest management strategies, combined with favorable environmental conditions for *Tuta absoluta*, contributes to significant infestations in tomato fields[11]. *Tuta absoluta* infestation was evident on the leaves, stems, and fruits of tomato plants. The damage was caused by larval activity, which involved mining into these plant parts. Due to its biological characteristics, *Tuta absoluta* presents a significant challenge for conventional pest management strategies. Pest is known to infest both open-field and protected cultivation environments and its rapid spread significantly reduces crop yield and quality[7]. *Tuta absoluta* infestation leads to direct plant tissue damage (leaves, flowers, stems, and fruits) and potential secondary pathogen infection via larval wound[7]. While farmers' acknowledged the use of mechanical, cultural, and chemical control methods, chemical pesticides were perceived as the most effective approach. Based on their experiences, the most effective management strategy involved the application of chemical pesticides followed by the use of pheromone traps. These findings suggest that improved *Tuta absoluta* management practices in Tanahun, particularly focusing on the seedling and flowering stages and prioritizing chemical pesticides, are crucial for increased tomato production. Integrated Pest Management strategies, including mass trapping with pheromone traps, biological control with predators and parasitoids, and cultural practices, have been demonstrated to be effective in controlling this specific pest[8].

Sex pheromone-based methods, including mass-trapping and mating disruption, offer a potential avenue for sustainable control of this invasive pest population[10]. The TLM lure emerged as the most effective, safe, and practical option among other methods[6]. The adoption of IPM strategies is crucial for mitigating substantial crop losses and fostering a reduction in reliance on chemical pesticides in sustainable agricultural practices. Integrated pest management strategies of *Tuta absoluta* control in tomatoes benefit from combining pheromone traps with insecticide application[9].

The primary benefit of the current study lies in its practical implications for farmers' in the Tanahun District, Nepal. By identifying the most detrimental pest and the preferred management practices, farmers' can make informed decisions to minimize crop losses. However, the current study has certain limitations. The sample size was relatively small, and the study was conducted in a specific region of Nepal. Further research is needed to assess the prevalence of TLM and the effectiveness of different control strategies in other regions. Despite these limitations, our findings have significant implications for farmers' in Tanahun. By identifying the most detrimental pest and the preferred management practices, farmers' can make informed decisions to minimize crop losses. To enhance TLM management, several strategies can be implemented: Promoting IPM combining cultural, biological and chemical controls; using pheromone traps for monitoring and mass trapping; conducting regular field monitoring for early detection; rotating crops with non-host plants; exploring biological control through natural enemies; promoting judicious use of chemical pesticides to mitigate resistance and environmental impact; and strengthening extension services to keep farmers' informed on the latest management practices[10-12].

Further research is needed to evaluate the long-term efficacy of different control methods and to develop more sustainable and environmental friendly approaches to TLM management. By addressing these recommendations, farmers' in Tanahun can mitigate TLM damage and improve tomato production.

CONCLUSION

Tomato leaf miner, *Tuta absoluta,* presents a significant challenge to tomato cultivation in Nepal, including Tanahun District. This invasive pest has been observed in tomato-growing regions throughout the year, with varying levels of infestation depending in implemented management strategies. The majority of farmers' (82.4%) cultivated in open fields and faced challenges from *Tuta absoluta*, with trap captures ranging from 51 to 672, peaking in May. While most farmers' identified its damaging stages, only 14.7% understood its life cycle, though 58.8% showed good knowledge of IPM. While cultural practices and pheromone traps are employed by many farmers', chemical insecticides remain a prevalent control method.

To achieve sustainable TLM management, integrating non-chemical approaches, such as biological control (e.g., parasitism), is essential. A community-based approach, promoting awareness and adoption of Integrated Pest Management (IPM) strategies, holds promise for mitigating TLM damage and ensuring long-term tomato production sustainability. To enhance tomato production in Tanahun, Integrated Pest Management (IPM) strategies should be prioritized, combining chemical control with biological and cultural practices, such as pheromone traps and crop rotation, to minimize pesticide resilience and environmental impact.

SIGNIFICANCE STATEMENT

The study monitors the infestation levels of *Tuta absoluta* on tomato crops in Tanahun, Nepal, and evaluates the effectiveness of different management practices adopted by local farmers'. Through field observations and data analysis, findings revealed high infestation rates with varying success among control methods, highlighting the urgent need for Integrated Pest Management (IPM) strategies tailored to local conditions. This research enhances pest management approaches, supports tomato yield stability, and promotes sustainable agricultural practices against *Tuta absoluta* in Nepal.

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