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Seasonal Incidence of Invasive Tomato Pinworm, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on Tomato

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Abstract

***Tuta absoluta* (Meyrick) is creating havoc for tomato growers in Himachal Pradesh. The present study was conducted at Sundernagar, Mandi, Himachal Pradesh, during the tomato cropping seasons of 2023 and 2024 to record its seasonal incidence. The maximum number of eggs, live mines, and mines/3 leaves was recorded in July, *i.e.*, 10.04 eggs, 8.03 live mines, and 11.24 mines/3 leaves during 2023, and 12.53 eggs, 9.48 live mines, and 12.75 mines/3 leaves in 2024. The highest number of adults trapped coincided with maximum egg and larval density. Leaf and fruit damage (%) varied between 3.05-22.41 and 1.95-10.25 per cent during 2023 and 2.51-22.40 and 1.16-10.71 per cent during 2024, respectively. Minimum temperature had a positive and significant correlation with population parameters and infestation level (leaf and fruit damage) of the pest. Relative humidity and rainfall also had positive and significant correlations with leaf and fruit damage during both years of study.**

Keywords: Live Mines, Pinholes, Population Buildup, Tomato Pinworm, *Tuta absoluta* (Meyrick), Seasonal Abundance

Tuta absoluta (Meyrick), an invasive pest of tomato commonly called tomato pinworm, native to South America, belongs to the family Gelechiidae of the Lepidopteran insect order. It has been a great threat to tomato (*Solanum lycopersicum*) worldwide. The main host plants of *T. absoluta* belong to the Solanaceae family, including potato (*Solanum tuberosum*), brinjal (*Solanum melongena*), European black nightshade (*Solanum nigrum*), bell pepper (*Capsicum annuum*), and tomato as suitable hosts. Other alternative hosts of tomato pinworm are plants of the Amaranthaceae and Leguminosae families (Desneux *et al.* 2011). This pest can destroy 80-100 per cent of the tomato crop if no control measures are taken in invaded areas. The pest was first detected outside its native place in Spain in 2006, and it rapidly invaded tomato-producing areas along the Mediterranean coast. Among Asian countries, its first infestation was reported from Israel in 2009, then it rapidly attacked 15 West Asian countries between 2010 and 2015 (Han *et al.* 2018). *T. absoluta* was first noticed on tomato in India during the *Rabi* season of 2014 at the Indian Institute of Horticultural Research (IIHR), Hessaraghatta, Bengaluru, Karnataka. Consequently, the pest was recorded from Pune and then in Malnad and in the Hyderabad-Karnataka region (Nayana *et al.* 2018). Sharma and Gavkare (2017) reported *T. absoluta* for the first time on tomato from the mid-hills of Himachal Pradesh during 2015. The pest was later found in epidemic form under protected conditions by Sood and Yadav (2017) in the Mandi district of Himachal Pradesh.

All aerial parts of tomato are attacked by *T. absoluta* larvae as it damages stems, flowers, leaves and fruits of tomato plants. Due to a high larval population, excessive mines formed on leaves, indicating larval feeding activities, which leads to a reduction in yield.

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Larvae tunnel into the mesophyll cells of leaves, which further disrupts the photosynthetic process of the host plants (Desneux *et al.* 2010). Pest is holometabolous, having four larval stages. An adult female moth can lay about 260 eggs during its life cycle. Larvae formed pin-sized holes on tomato fruits, hence known as tomato pinworm (Simala *et al.* 2011). The "thermal window" for *T. absoluta* varies between 14-35°C, as it is both cold and heat-tolerant (Aigbedion-Atalor *et al.* 2019). Pest has the potential to pass through 12 generations annually under favourable environmental conditions; therefore, known as a homodynamic species (Desneux *et al.* 2010). Weather parameters like temperature and precipitation play a significant role in the development, reproduction, and invasion success of *T. absoluta* (Early *et al.* 2022). Keeping in view its damaging potential and invasion success, the present investigation was carried out to study infestation and population buildup under the low-hill region (Sundernagar) of Himachal Pradesh.

MATERIALS AND METHODS

Seasonal abundance of *T. absoluta* was studied at Dadour, Sundernagar (Sub Mountain and low-hills tropical zone) on tomato crop growing in open field conditions during 2023 and 2024 for the whole growing season. Tomato seedlings were transplanted in the field on 18th March 2023 and on 25th March 2024. Pest attack was noticed during the 17th and 19th SMW during 2023 and 2024, respectively. Observations on infestation and population buildup were recorded. The observations were taken by recording the number of eggs, number of larvae (live mines) and number of mine blotches per 3 leaves (upper, middle, and lower strata) on ten randomly selected plants at weekly intervals. The number of infested leaflets and the total number of leaflets were recorded in selected tomato plants. For each plant, the total no. of fruits and infested fruits having pin holes formed by larvae were also counted. Average data was worked out for each observation to draw the inferences. Leaf and fruit damage (%) was calculated using the given formulae. Pheromone-baited delta traps were installed in the tomato field. Two pheromone-baited delta traps were installed in the tomato field and adjusted 30 cm above the crop canopy. Moth population was monitored weekly, starting from transplanting until final harvest by using pheromone-baited delta traps during 2023 and 2024. The lures were replaced after one month to obtain accurate results of adult catch. The population buildup data were correlated with weather parameters (maximum temperature, minimum temperature, relative humidity, and rainfall) to establish a relationship with the abiotic factors. Weather data was obtained from KVK, Sundernagar, for the years 2023 and 2024.

$$\text{Leaf damage } (\%) = \frac{\text{Number of infested leaflets}}{\text{Total number of leaflets in a leaf}} \times 100$$

$$\text{Fruit damage } (\%) = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

RESULTS AND DISCUSSION

Seasonal Abundance and Infestation of *Tuta absoluta* during 2023

Based on data presented in Table 1, it was revealed that *T. absoluta* infestation started during the 17th SMW (last week of April), which gradually increased and continued throughout the whole growing season. The number of eggs/3 leaves varied from 0.36 to 10.04, with the maximum number of eggs (10.04) being recorded during the 27th SMW. *T. absoluta* live mines were also noticed during the 17th SMW, which varied from 0.23 to 8.03 live mines/3 leaves, and the number of mines/3 leaves ranged between 1.02 to 11.24 mines. Maximum larval count (live mines) and mines were recorded during the 28th SMW. As maximum eggs on leaves were recorded prior to peak larval activity, coinciding with the maximum number of adults trapped (258 adults) in that week, *i.e.*, 27th SMW (Table 2). Leaf damage varied from 3.05 to 22.41 per cent, which started increasing from the 17th SMW up to the harvesting of the fruits towards the end of the cropping season. Larvae started infecting the fruits from 24th SMW up to 33rd SMW, with maximum damage of 10.25 per cent recorded during 29th SMW (2nd fortnight of July) (Table 2). The number of adults trapped through pheromone-baited delta traps was recorded minimum (5 adult moths) at the appearance of the pest in the field and a maximum (258 adult moths) during the 27th SMW, which further started declining and reduced to 43 adult moths toward the end of the cropping season (Table 2).



a) Mines b) Live mine (leaf having larva) c) Pin holes

Figure 1. Damaging symptoms of tomato pinworm, *Tuta absoluta*.

Table 1. Seasonal abundance of *Tuta absoluta* under open field conditions at Sundernagar during 2023

S. No.	Date of observation	SMW	Eggs/3 leaves (No.)	Live mines (larvae)/3 leaves (No.)	Mines/3 leaves (No.)
1	April-23	17	0.36±0.10*	0.23±0.09	1.02±0.45
2	April-30	18	0.75±0.07	0.64±0.17	1.50±0.17
3	May-7	19	1.12±0.45	0.98±0.03	2.16±0.08
4	May-14	20	1.86±0.25	1.25±0.76	2.96±0.19
5	May-21	21	2.14±0.56	1.85±0.43	3.05±0.46
6	May-28	22	2.47±0.09	1.47±0.06	3.37±0.07
7	June-4	23	2.95±0.16	2.51±0.27	4.50±1.10
8	June-11	24	4.31±0.21	3.90±0.27	5.28±0.07
9	June-18	25	5.49±0.08	2.68±1.16	6.85±0.19
10	June-25	26	8.95±0.22	4.77±0.35	7.56±0.08
11	July-2	27	**10.04±1.12**	7.91±0.07	9.35±0.41
12	July-9	28	7.35±0.25	**8.03±0.21**	**11.24±0.21**
13	July-16	29	5.78±1.16	4.18±0.11	5.10±0.72
14	July-23	30	4.54±0.06	2.85±0.07	3.31±0.83
15	July-30	31	2.01±0.05	1.12±0.56	1.82±0.61
16	August-6	32	1.25±0.32	0.94±0.06	1.00±0.07
17	August-13	33	0.85±0.03	0.75±0.15	1.08±0.74

*Mean±SE (Mean of 10 observations)

Seasonal abundance and infestation under field conditions during 2024

Data presented in Table 3 showed that during 2024, the pest appeared in the open tomato fields during the 19th SMW (1st week of May) and continued to attack the tomato crop up to the harvesting. Initially, at the onset of infestation, 0.95 eggs/3 leaves and 0.50 live mines and 1.87 mines/3 leaves were recorded, which gradually kept on increasing as the crop ripened phenologically, reached a maximum and then started declining. The highest numbers of eggs and live mines/3 leaves were recorded during the 29th SMW, which counted as 12.53 eggs and 9.48 live mines/3 leaves. Although, maximum number of mines/3 leaves was 12.75 mines recorded during the 30th SMW. As mentioned in Table 4, adult moth activity reached its peak (270 adults moth) during the 29th SMW, leading to increased egg and larval live mines density. Leaf damage ranged from 2.51 to 22.40 per cent with a maximum (22.40%) recorded during the 34th SMW (Table 4). Fruits started to be infested with pinholes during 24th SMW (2nd week of June), which varied from 1.16 to 10.17 per cent, being highest during 32nd SMW. At the onset of pest infestation, a

Table 2. Incidence of *Tuta absoluta* under open field conditions at Sundernagar during 2023

S. No.	Date of observation	SMW	Leaf damage (%)	Fruit damage (%)	Adults trapped/week (No.)
1	April-23	17	3.05	0.00	5
2	April-30	18	3.65	0.00	11
3	May-7	19	4.73	0.00	52
4	May-14	20	4.94	0.00	48
5	May-21	21	4.89	0.00	62
6	May-28	22	5.06	0.00	74
7	June-4	23	5.45	0.00	105
8	June-11	24	6.79	2.70	142
9	June-18	25	7.52	0.00	186
10	June-25	26	10.24	1.95	203
11	July-2	27	11.63	5.24	**258**
12	July-9	28	12.87	7.95	147
13	July-16	29	18.59	**10.25**	110
14	July-23	30	20.35	4.67	85
15	July-30	31	20.84	7.21	97
16	August-6	32	21.56	3.47	64
17	August-13	33	22.41	4.62	43

Table 3. Seasonal abundance of *Tuta absoluta* under open field conditions at Sundernagar during 2024

S. No.	Date of observation	SMW	Eggs/3 leaves (No.)	Live mines (larvae)/3 leaves (No.)	Mines/3 leaves (No.)
1	May-5	19	0.95±0.18*	0.50±0.31	1.87±0.10
2	May-12	20	1.26±0.56	0.98±0.27	2.50±0.07
3	May-19	21	2.67±0.54	0.83±0.41	1.95±0.31
4	May-26	22	2.90±0.28	2.25±0.17	3.56±0.45
5	June-2	23	2.87±0.65	3.50±0.08	4.46±0.22
6	June-9	24	3.74±0.19	2.73±0.24	4.57±0.09
7	June-16	25	3.95±0.63	3.27±0.07	5.10±0.45
8	June-23	26	5.31±0.52	4.10±0.12	6.88±0.11
9	June-30	27	7.20±0.07	3.40±1.04	7.95±0.09
10	July-7	28	10.46±0.64	5.77±0.05	8.21±0.16
11	July-14	29	**12.53±0.96**	**9.48±0.29**	10.29±0.22
12	July-21	30	7.88±0.71	6.54±0.34	**12.75±0.17**
13	July-28	31	4.78±1.20	3.46±1.14	7.32±0.78
14	August-4	32	3.50±0.74	2.30±0.42	5.19±0.21
15	August-11	33	2.56±0.15	0.85±0.07	2.82±0.09
16	August-18	34	1.50±0.17	0.56±0.19	1.55±0.15
17	August-25	35	1.15±0.13	0.70±0.27	1.01±0.07

*Mean±SE (Mean of 10 observations)

Table 4. Incidence of *Tuta absoluta* under open field conditions at Sundernagar during 2024

S. No.	Date of observation	SMW	Leaf damage (%)	Fruit damage (%)	Adults trapped/week (No.)
1	May-5	19	2.51	0.00	45
2	May-12	20	2.95	0.00	36
3	May-19	21	3.56	0.00	72
4	May-26	22	4.00	0.00	80
5	June-2	23	5.45	0.00	109
6	June-9	24	6.12	1.16	124
7	June-16	25	8.71	1.95	165
8	June-23	26	7.45	1.80	204
9	June-30	27	9.50	2.65	140
10	July-7	28	11.25	2.40	221
11	July-14	29	13.71	4.55	**270**
12	July-21	30	14.21	6.85	129
13	July-28	31	16.23	9.52	110
14	August-4	32	19.54	**10.17**	116
15	August-11	33	21.72	4.28	87
16	August-18	34	22.40	2.95	74
17	August-25	35	20.27	1.70	51

total of 45 adult moths were trapped during the 19th SMW, which reached its maximum number (270 adult moths) during the 29th SMW and thereafter started decreasing towards the end of the cropping season.

According to Ibrahim *et al.* (2011) adult moths monitoring carried out at four locations in the Homos region, Syria with peak pest activity during July month at 2 locations (1st peak in the 1st week: trap catch of 750 and 764 male moths/trap/week and a 2nd peak at in the 4th week: 620 and 490 male moths/trap/week), which further corroborated with timings of highest adult catches in present results instead of number of moths. Our results were supported by Sood and Yadav's (2017) work, authors reported the pest in Mandi district of Himachal Pradesh, where per cent of leaf infestation and fruit damage varied from 1.7 to 18.0 per cent and 0.5-9.8 per cent under open conditions, respectively, in different tomato growing areas of the district. According to Nayana *et al.* (2018), infestation was low during the early crop phenological cycle. With the advancement of crop growth stages, pest density started increasing, which supports the present findings. Similar observations were recorded by Shiberu and Getu (2018) that pest population increases during advancement in the tomato phenological cycle. Seasonal activity and population fluctuation studies conducted by Asgari and Fathipour (2019) during 2015-16 in Tehran revealed that moths started appearing in pheromone traps in mid-April of 2015 and in mid-May in spring of 2016, showing similar timings of adult activity as recorded in the present study. Kachave *et al.* (2020) investigated that fruit infestation due to TLM varied from 7.08 to 10.58 per cent, which supported the maximum fruit infestation level in the current study. Chaudhary *et al.* (2022) reported higher infestation on tomato crop from Sundernagar in open fields as compared to the Palampur region with leaf mine (blotch) and fruit damage up to 9.97 and 6.97 per cent, respectively, which matched the damage level recorded in the present findings. Our results were supported by outcomes of Sultan *et al.* (2022), who analysed two cropping seasons of tomato (2014-15 & 2015-16) and reported that pest started appearing after one month from the plantation. Sharma and Kumar (2024) recorded per cent leaf and fruit infestation up to 32.68, 12.33 per cent during 2022 and 29.71, 9.09 per cent during 2023, respectively, which were in accordance with our results except higher level of leaf infestation in this study.

Effect of Weather Factors on the Incidence of *Tuta absoluta* on Tomato

Weather factors play a significant role in pest appearance, their abundance, growth, and development of different stages. Correlation coefficients were worked out to understand the influence of weather factors on the population buildup of *T. absoluta*. Meteorological data on weather parameters were obtained from Krishi Vigyan Kendra, Sundernagar. Maximum temperature showed a positive, non-significant correlation with *T. absoluta* population density, damage, and moth activity during 2023 and a negative, non-significant correlation with population density and moth activity during 2024. On the other hand, maximum temperature had a significant negative correlation with leaf (r = -0.72*) and fruit damage (r = -0.63*), which reflected that with an increase in maximum temperature, pest infestation level reduced during that period. Minimum temperature showed positive and significant correlation with number of eggs/3 leaves (r=0.53*), leaf damage (r = 0.82*), fruit damage (r = 0.72*) and number of adults trapped (r = 0.57*) during 2023. Also, during 2024, the number of eggs (r=0.55*), number of live mines (r = 0.55*), number of mines/3 leaves (r = 0.59*), leaf (r = 0.73*) and fruit damage (r = 0.72*) reflected positive and significant correlation which means that with increase in minimum temperature *T. absoluta* infestation increased. During both 2023 and 2024, relative humidity had a positive and significant correlation with leaf (r = 0.77*; 0.78*) and fruit damage (r = 0.72*; 0.64*), respectively. Rainfall also showed positive and significant correlation with leaf (r = 0.59*) and fruit damage (r = 0.49*) during 2023. Although rainfall showed positive and non-significant correlation with population density, damage, and moth activity during 2024.

Our results were supported by the work of several authors, which we discussed here. Tarusikirwa *et al.* (2020) highlighted the importance of temperature, rainfall, and relative humidity in deciding *T. absoluta* seasonality and abundance. Hassan *et al.* (2021) suggested that the impact of temperature and RH on pest population dynamics depends on plant stage and cropping season. Our findings were corroborated by the results of Venkataramanaiah *et al.* (2021), which revealed that maximum temperature, minimum temperature, and relative humidity showed a non-significant positive relationship with moth trap catches.

Table 5. Correlation coefficients between the incidence of *Tuta absoluta* on tomato with abiotic factors at Sundernagar

Parameters	Correlation coefficient (r value)					
	Eggs/3 leaves (No.)	Live mines (larvae)/3 leaves (No.)	Mines/3 leaves (No.)	Leaf damage (%)	Fruit damage (%)	Adults trapped/ week (No.)
2023						
Maximum temperature (°C)	0.17	0.09	0.11	0.17	0.07	0.34
Minimum temperature (°C)	0.53*	0.45	0.38	0.82*	0.72*	0.57*
Relative humidity (%)	0.40	0.37	0.27	0.77*	0.72*	0.30
Rainfall (mm)	0.10	0.17	0.14	0.59*	0.49*	0.03
2024						
Maximum temperature (°C)	-0.20	-0.05	-0.20	-0.72*	-0.63*	-0.11
Minimum temperature (°C)	0.55*	0.55*	0.59*	0.73*	0.72*	0.48
Relative humidity (%)	0.25	0.12	0.26	0.78*	0.64*	0.18
Rainfall (mm)	0.26	0.14	0.33	0.47	0.27	0.07

*Correlation is significant at α=0.05 (df =15 and r statistic =0.482)

Chaudhary *et al.* (2022) studied that the leaf infestation and live mines had a positive and significant correlation with minimum temperature and relative humidity had positive and significant correlation with leaf infestation, which supports the present findings. Mangrio *et al.* (2023) also revealed that temperature showed a significant but very weak impact on trap catches among weather parameters. Sharma and Kumar (2024) showed that the number of mines, leaf infestation and fruit infestation had a significant positive correlation with minimum temperature and relative humidity, thus aligning with the present results. These results were contradicted by Nayana *et al.* (2018), who intimated a positive correlation of maximum and temperature with pest incidence and adult trap catch (moths/trap/week) during both seasons of their investigation.

CONCLUSION

The incidence of damage, population density and number of adults trapped increased with the advancement of the crop phenological cycle. Therefore, timely monitoring and management practices should be taken into consideration by tomato growers. Among weather parameters, minimum temperature showed a positive and significant correlation with pest population and infestation level, indicating a key factor in the seasonal abundance of *T. absoluta*.

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