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Short Communication

Surveillance and population buildup studies of invasive tomato pinworm, *Tuta absoluta* (Meyrick) in Himachal Pradesh

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Abstract

Survey carried out at two locations under low and mid hills of Himachal Pradesh revealed that *Tuta absoluta* (Meyrick) infestation in tomato was high at Sundernagar under both protected as well as field conditions compared to Palampur region. The per cent leaf infestation and fruit damage varied from 8.73 (open conditions) to 45.70 per cent (protected conditions) and 4.40 (open conditions) to 21.94 per cent (protected conditions), respectively, at the two locations. The leaf infestation (%) and live mines had positive and significant correlation with minimum temperature, relative humidity and rainfall. Fruit infestation had a positive and significant correlation with maximum relative humidity and rainfall. Trap catches under open field conditions showed negative non-significant correlation with minimum, maximum temperature, maximum relative humidity and rainfall. The adult trap catch under protected conditions, however, showed a significant positive correlation with live mines and blotches at Palampur.

Key words: Surveillance, population buildup, tomato pinworm, invasive

Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae), a highly destructive pest of tomato, has invaded India during 2014 and has fast spread to almost all the tomato growing regions of the country including Himachal Pradesh. It is a serious pest on solanaceous vegetables (Sridhar *et al*. 2015), consequently also known as South American tomato moth or tomato pinworm. Although, tomato is the primary host of this pest, it has also been recorded on other Solanaceous (potato and brinjal) and Fabaceous (french bean) hosts in India. In addition, weed plants from Solanaceae and Chenopodiaceae families serve as secondary hosts of *T. absoluta*. In North-Western Himalayan region, the first case of *T. absoluta* infestation on tomato was reported in the mid-hills of Himachal Pradesh, in 2015 (Sharma and Gavkare 2017). Later, in the Mandi district of Himachal Pradesh, the pest was found in epidemic form under protected conditions (Sood and Yadav 2017). In contrast to previous reports of the pest's prevalence in tropical areas, it has been found on tomato at altitudes of up to 1400 metres above mean sea level in sub-temperate cold conditions.

The pest has been rapidly spreading and wreaking havoc on tomato crop in both protected and open fields. Damage occurs when larvae feed on leaf mesophyll expanding mines, reducing the photosynthetic potential of crop and its yield. *T. absoluta* is the most significant threat to tomato production in the world, with the potential to reduce yield and fruit quality by 50 to 100 per cent in greenhouses and fields (EPPO 2005; Shashank *et al*. 2015). Under favourable conditions, the tomato pinworm has a high reproductive capacity (Cuthbertson *et al*. 2013), with 10 to 12 generations per year (IRAC 2011). The pest attacks all parts of the plant including leaf, stem and fruit impairing growth and resulting in 100 per cent crop destruction, if no control measures are implemented (Desneux *et al*. 2010). On leaves the larvae feed on the mesophyll tissues forming irregular leaf mines and later becoming necrotic. Larvae can form extensive

galleries in the stem which affect the development of the plants. The presence of characteristic pin holes can also be used to identify *T. absoluta* infested fruits; such fruits are unfit for marketing. Considering the damage potential and threat of this invasive pest to commercial solanaceous crops in the state, the present studies were undertaken to know the pest status and its population buildup.

Survey and Surveillance

Field surveys were conducted at two locations covering the low and mid hill agro-climatic zones of Himachal Pradesh to record the incidence of the pest on tomato, potato and brinjal. The locations covered were Sundernagar (Zone-I) and Palampur (Zone-II). Observations were recorded at fortnightly interval on leaf and fruit infestation during June to August 2020 under protected and open conditions. For the purpose, data on pinworm infestation on leaves and fruits on ten randomly selected plants were recorded. Leaves having pinworm mines and total leaves were recorded to work out per cent leaf infestation. Also at each harvest, fruits with characteristic pin holes and total fruits were recorded to work out per cent fruit infestation.

Population buildup

Population buildup of tomato pinworm, *T. absoluta* was studied at Sundernagar on tomato by recording leaf infestation, fruit infestation and larval population (live mines per three leaves- one each from upper, middle and lower canopy) on ten randomly selected plants at weekly intervals. While recording data on leaf and fruit infestation, total number of leaves/fruits observed and number of leaves/fruits infested were recorded to work out the per cent leaf/fruit infestation. The population buildup data were correlated with weather parameters to establish relationship with the abiotic factors (maximum & minimum temperature, maximum relative humidity, minimum relative humidity and rainfall) through simple correlation analysis (Chandel 1993). The weather data were collected from the agrometeorological station of Krishi Vigyan Kendra, Sundernagar (Mandi).

$$\text{Per cent fruit infestation} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

$$\text{Per cent leaf infestation} = \frac{\text{Number of infested leaflets}}{\text{Total number of leaflets}} \times 100$$

Correlation between trap catch and tomato pinworm infestation in tomato

In another experiment under protected conditions at Palampur, three pheromone baited traps (delta trap, water pan trap and pheroglow trap) were installed during the month of May to June 2021. The lure was replaced after one month. The observations of adult catch, live mines and blotches (3 leaves-one upper, middle and lower canopies of 5 randomly selected plants) were recorded at weekly intervals. The data obtained were analyzed to work out the simple correlation between adult trap catch and leaf infestation (live mines and blotches) of corresponding week and succeeding one and two week leaf infestation to draw inferences. The results obtained are presented and discussed here under:

Survey and Surveillance

Random survey was undertaken during June to August 2020 at two locations comprising low and mid hill agro-climatic zones of Himachal Pradesh under open and protected conditions. The damage to the crop was recorded in terms of per cent leaf infestation and per cent fruit damage. Data presented in Table 1, reveal

Table 1.Survey of *Tuta absoluta* infestation in solanaceous crops

Location	Crop environment	Tomato		Brinjal		Potato	
		Leaf mine (blotch) (%)	Fruit damage (%)	Leaf mine (blotch) (%)	Fruit damage (%)	Leaf mine (blotch) (%)	Fruit damage (%)
Sundernagar	Open	9.97	6.97	2.20	0.91	3.45	-
	Protected	45.70	21.94	22.82	12.20	-	-
Palampur	Open	8.73	4.40	4.41	1.95	3.21	
	Protected	25.07	13.87	-	-	-	-

that maximum infestation was recorded in tomato crop both under protected as well as open conditions at Sundernagar (45.70% blotches, 21.94% fruit damage and 9.97% blotches, 6.97% fruit damage, respectively). At Palampur, the leaf infestation in tomato varied from 8.73 per cent in open conditions to 25.07 per cent in protected conditions while fruit infestation was 4.40 and 13.87 per cent, respectively. In brinjal, the pest incidence was relatively low. Leaf infestation in open fields was 2.20 per cent at Sundernagar and 4.41 per cent at Palampur, whereas in protected conditions it was 22.82 per cent at Sundernagar. The fruit infestation on brinjal was also lower than in tomato and varied from 0.91 per cent (open conditions) to 12.20 per cent (protected conditions) at Sundernagar, while it was 1.95 per cent at Palampur under open conditions. In case of potato, the leaf infestation varied from 3.21 to 3.45 per cent under open conditions at Palampur and Sundernagar, respectively. It was evident from the results that tomato crop was the most susceptible and preferred host of *T. absoluta* followed by brinjal and potato. More damage was recorded at Sundernagar as compared to Palampur in almost all crops. Under polyhouse conditions, the pest was more severe than in open fields, resulting in up to 100 per cent losses in severe infestation. Arturo *et al*. (2012), had also recorded 100 per cent crop damage in tomato in the absence of control measures and under favourable environment. The findings are in agreement to earlier reports of Speranza and Sannino (2012), who have also observed the pest to be more severe in polyhouses than in open fields.

Population buildup of tomato pinworm

The data on population buildup of tomato pinworm, *T. absoluta* recorded on tomato crop during June and July months at Sundernagar (Table 2) revealed that the leaf infestation (%), live mines/three leaves and fruit infestation increased progressively with the crop advancement. However, the trap catch using pheromone traps (average of delta, funnel, water pan and commercial yellow sticky trap) did not follow the same trend corresponding to pest incidence (leaf infestation, live mines and fruit infestation) in that particular week which could be attributed to low populations trapped in water pan traps at Sunderngar. The higher incidence was observed coinciding with fruit bearing and maturity of the crop.The maximum leaf infestation (48.19%), live mines/three leaves (1.40) and fruit infestation (12.43%) was observed during 21st July, 2020 coinciding with the maturity of the crop. The correlation between pest density parameters such as leaf infestation (%), live mines, pheromone trap catch and fruit infestation (%) and weather parameters such as maximum temperature, minimum temperature, relative humidity and rainfall

Table 2. Incidence of *T. absoluta* in relation to abiotic factors at Sundernagar

Date of observation	Incidence of *T. absoluta*				Abiotic factors				
	Leaf infestation (%)	Live mines per 3 leaves	Pheromone trap catches per week per trap	Fruit infestation (%)	Min. Temp. (^{0}C)	Max. Temp. (^{0}C)	Max. RH (%)	Min. RH (%)	Rainfall (mm)
09-06-2020	3.65	0.13	42.50	0.00	17.0	31.1	78	65	1.7
16-06-2020	5.36	0.27	28.75	1.15	19.3	35.5	65	44	0.1
23-06-2020	9.72	0.55	14.25	1.87	20.2	34.8	70	49	6.0
30-06-2020	17.36	0.65	13.00	1.23	20.9	32.6	81	61	8.5
07-07-2020	24.46	0.53	25.25	3.83	21.4	33.9	80	61	13.3
14-07-2020	35.07	0.90	18.25	6.79	21.7	32.4	86	70	6.8
21-07-2020	48.19	1.40	27.00	12.43	22.1	32.5	91	71	12.1
Mean±SE	20.54±6.24	0.63±0.16	24.14±3.86	3.90±1.66					

(Table 3) showed that minimum temperature was positively & significantly correlated with per cent leaf infestation (r=0.83*) and live mines (r=0.83*). However, it had a non-significant positive correlation with per cent fruit infestation (r=0.72) and negative non-significant correlation with pheromone trap catches/trap/week (r=-0.67). Maximum temperature showed negative non-significant correlation (r≤0.36) with per cent leaf infestation, live mines, pheromone trap catch and per cent fruit infestation, respectively. Maximum relative humidity showed positive significant correlation with per cent leaf infestation (r=0.86*), live mines (r=0.77*) and per cent fruit infestation (r=0.76*), whereas it had negative non-significant correlation with trap catches (r=0.04). Minimum relative humidity had positive non-significant correlation with per cent leaf infestation (r=0.72), live mines (r=0.59), pheromone trap catch (r=0.14) and per cent fruit infestation (r=0.62). Rainfall depicted a positive significant correlation with leaf infestation (r=0.91*), live mines (r=0.89*) and fruit infestation (r=0.79*), but it had negative non-significant correlation with pheromone trap catches/trap/week (r=0.40). Earlier, Goftishu *et al*. (2014) had also observed that the number of collected moths under greenhouse and open field tomato crops, the number of moths captured in pheromone traps increased linearly. Venkataramanaiah *et al*. (2021) reported that maximum temperature, minimum temperature and morning relative humidity had a non-significant positive relationships with *T. absoluta* moth captures, however evening relative humidity (r = -0.618) and rainfall (r=-0.467) had a significant negative relationship. Temperatures at the maximum (r=0.840) and minimum (r=0.750) had a significant positive relationship with fruit infestation, whereas night time relative humidity (r=-0.537) had a significant negative relationship.

Correlation between trap catch and tomato pinworm infestation in tomato

To further validate the correlation between adult trap catch and live mines & blotches, studies conducted under protected conditions revealed that adult trap catches showed a positive significant correlation with both, live mines (r=0.88*) and number of blotches (r=0.84*). The adult trap catches after one and two weeks also showed positive significant correlations with live mines (r=0.97* and 0.91*) and number of blotches (r=0.98* and 0.95*), respectively (Table 4). The findings under protected

Table 3. Correlation coefficients between incidence of *T. absoluta* on tomato with abiotic factors at Sundernagar

Parameters	Correlation coefficient (r value)			
	Leaf Infestation (%)	Live mines per 3 leaves	Pheromone trap catches per trap per week	Fruit Infestation (%)
Min. T (^{0}C)	0.83*	0.83*	-0.67	0.72
Max. T (^{0}C)	-0.28	-0.19	-0.36	-0.20
Max. RH (%)	0.86*	0.77*	-0.04	0.76*
Min. RH (%)	0.72	0.59	0.14	0.62
Rainfall (mm)	0.91**	0.89*	-0.40	0.79*

*Correlation is significant at α = 0.05 (df = 5, r statistic = 0.755)
**Correlation is significant at α = 0.01

Table 4. Correlation coefficients between adult catch and infestation of *T. absoluta*

Date of observation	Weekly adult catch			Adult trap catch (N)	Live mines (3 leaves)	Blotches (3 leaves)
	Delta trap	Water pan trap	Pheroglow Trap			
12-05-2021	14	22	26	62	0.47	3.80
19-05-2021	24	37	42	103	0.20	2.83
26-05-2021	19	45	48	112	0.43	3.03
02-06-2021	22	78	82	182	0.30	2.90
09-06-2021	10	120	132	262	0.77	4.00
16-06-2021	52	124	210	386	0.77	4.30
23-06-2021	59	168	246	473	1.47	6.47
30-06-2021	63	182	293	538	-	-
				N	0.88*	0.84*
	Correlation			N+1	0.97*	0.98*
				N+2	0.91*	0.95*

*Correlation is significant at α = 0.05 (df = 6, r statistic = 0.707)

conditions are therefore, more appropriately interpreting the correlation between adult trap catch and plant infestation by *T. absoluta* as the trap catch under protected conditions being more accurate compared to open conditions. The studies of Venkataramanaiah *et al*. (2021) are in line with present findings where they had also observed that pheromone trap captures were having a strong positive correlation with *T. absoluta* leaf infestation in tomato.

From the studies, it can be concluded that the incidence of tomato pinworm was found severe in tomato crop especially under protected conditions in the state and tomato was observed to be the most susceptible host. The incidence of damage and number of trap catches increased with the phenological development of the tomato crop causing considerable damage to the crop.

Conflict of interest: There is no conflict of interest among the authors of the present study.

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