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Feeding preference of *Tuta absoluta* on solanaceous host plants under field conditions

Abdul Hayee Gabol[1], Lubna Bashir Rajput[1], Jamal-U-Ddin Hajano[2], Ghulam Hussain Jatoi[2], Arfan Ahmed Gilal[1*], Ghulam Qader Mangrio[1], Muhammad Musavir Koondhar[1], Ghulam Fareed[3]

1. Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University, Tandojam, Pakistan
2. Department of Plant Pathology, Faculty of Crop Protection, Sindh Agriculture University, Tandojam, Pakistan
3. Department of Agriculture, University College of Dera Murad Jamali (LUAWMS) Naseerabad, Balochistan, Pakistan

***Corresponding author e-mail:** aagilal@sau.edu.pk

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SUMMARY

The invasive tomato leaf miner *Tuta absoluta* has recently invaded tomato growing areas of lower Sindh, hence endangered its productivity and quality. Besides tomatoes, *T. absoluta* also damage on other solanaceous crops of the economic importance. Therefore, a study was carried out at a farmer's field in Shaheed Benazir Abad to determine the feeding preference of *T. absoluta* on tomato, potato, brinjal, chilies, and peppers. The experiment was arranged in a randomized complete block design with five replications maintained for each treatment host. The data was collected from ten randomly selected plants per replication of each plant by counting the number of infested fruits and leaves based on *T. absoluta* characteristics mines. Weather data was also obtained to determine its influence on the *T. abslouta* infestation on various hosts evaluated. The study results confirmed that *T. absoluta* infested leaves of all the tested host plants, whereas it only damaged fruits of tomatoes. An increasing trend in *T. absoluta* infestation was recorded in all the host plants with their growth with comparatively rapid infestation recorded in tomato leaves and fruits. Overall results confirmed a highly significant difference in the infestation percentage of *T. absoluta* on different hosts as the highest (22.91±0.67%) and lowest (1.44±0.06%) infestation percentage was recorded on tomato leaves and chilies, respectively, whereas 5.02±0.19, 4.07±0.14, 2.52±0.11, and 7.64±0.34% infestation was observed on brinjal, potatoes, peppers, and tomato fruits, respectively. All the weather parameters i.e., temperature, relative humidity, and wind velocity elicited a weak to moderate, but significant impact on the mean *T. absoluta* infestation percentage in the studied host plants. Thus, study concluded that tomato was found to be preferred host for *T. absoluat* with brinjal and potato being its preferred alternative hosts. Therefore, it is recommended that further studies should be conducted to determine the overall host range of *T. absoluta* in Sindh along with their impacts on its biological parameters to restrict it spread and adopt adequate management.

Keywords: Damage, Infestation, Management, Solanaceae, Tomato, Weather

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INTRODUCTION

Tuta absoluta (Lepidoptera: Gelechiidae) has threaten tomato production outside of its native range of South America into European, African, and Asian countries (Desneux et al., 2010, 2011; Biondi et al., 2018). Its presence has also been reported in Pakistan (Ishtiaq et al., 2020; Sadique et al., 2022), most recently in main tomato growing areas of lower Sindh (Gabol et al., 2023). *Tuta absoluta* is an oligophagous pest of Solanaceae family with tomato being its preferred host (Desneux et al., 2010; Campos et al., 2017; Biondi et al., 2018). Özgökçe et al. (2016) reported that *T. absoluta* can fed on 26 different host plants, however it showed strong preference for tomato, potato and other solanaceous hosts (Desneux et al., 2010; Abbes et al., 2016). Moreover, *T. absoluta* can also deposit its eggs and develop on host plant species belonging to Amaranthaceae, Fabaceae, Malavaceae, and Convolvulaceae families (Biondi et al., 2018). However, due to the rapid expansion of *T. absoluta* in various regions, it is expected that *T. absoluta* may also have expanded its host range (Husariu et al., 2017) in various African countries as it is also recorded on watermelon, alfalfa, spinach, and many weed species (Mohamed et al., 2012; Husariu et al., 2017; Machekano et al., 2018).

Thus, the availability of such huge number of alternate hosts increases colonization and multiplication of *T. absoluta* in the invaded areas, even in absence of its prime host tomato (Machekano et al., 2018; Younes et al., 2018). However, it also showed variable level of preference for various biological parameters i.e., feeding, oviposition, hatching, larval developmental, and adult longevity on other host plants, especially from the Solanaceae family such as potato, brinjal, pepper, tobacco, litchi tomato, Mapacho tobacco, apple of Peru, bittersweet, sugar beet, and others (Desneux et al., 2010; Ouardi et al., 2012; Urbaneja et al., 2013). It has been mentioned that evolution of host range holds a key importance in the management of any pest, particularly the alien invasive species of the particular agro-ecosystems (Sylla et al., 2019).

Tuta absoluta has recently been reported from Pakistan and Sindh, no systematic studies have been conducted on its damage potential on different host plants, especially from the Solanaceae family. Therefore, this study was undertaken to determine the feeding potential of *T. absoluta* on important solanaceous plants i.e., potato, brinjal, chilies, peppers, along with its main host tomato under field conditions. The outcome of study will provide a base for the host expansion of *T. absoluta* in Sindh, Pakistan to devise an appropriate management against it.

MATERIALS AND METHODS

Experimental area

The study was carried out at a farmer's field located in the district of Shaheed Benzair Abad. The host plants evaluated against *T. absoluta* in the study were:

1. Tomato, *Solanum lycopersicon* L.
2. Potato, *Solanum tuberosum* L.
3. Brinjal, *Solanum melongena* L.
4. Chilies, *Capsicum frutescens* L.
5. Peppers, *Capsicum annuum* L.

Experimental setup, data collection and analysis

Each host plant species was initially grown using its recommended sowing rate. After emergence of the nursery, each host plant was then planted in a 10x10 square feet replicated plot. A total of five replications were maintained for each host plant species as the entire experiment was arranged in a Randomized Complete Block Design. All agronomic practices were used as per standard recommendation for the individual host with no synthetic spray done during the entire study.

Collection of data on *T. absoluta* infestation based on its characteristic mining symptoms on leaves and fruits of the evaluated host plants was started since the growth of each host plant and then continued weekly till their final harvesting. The data on *T. absoluta* infestation was carried out from all the plant parts of host plants except roots. Ten randomly selected plants per replication of each host was observed to collect the data on *T. absoluta* infestation, whereas following formula was used to calculate its percentage infestation:

Percentage infestation = (Number of infested part / total number of the part) * 100

The data for various weather parameters such as temperature, relative humidity, and wind velocity was acquired from the local meteorological station, Shaheed Benazir Abad to determine their effect on the population of *T. absoluta*, that also corresponds to their infestation on all the evaluated host plant species.

Analysis of Variance was used to analyze the collected data, whereas the LSD was used to separate means with significant differences at 5% probability. Moreover, the association of the mean infestation of *T. absoluta* on different host plants with weather factors was calculated using Pearson's correlation. The computer software STATISTIX 8.1 was used for the analysis of the data.

RESULTS

Results for the mean infestation of *T. absoluta* on different host plants is given in Figure 1 which confirmed that besides its main host (tomatoes), the pest has also showed potential to infest all the studied hosts i.e., brinjal, potatoes, chilies, and peppers. However, there was a significant variation in its level of infestation on various host plants. Except tomatoes where *T. absoluta* causes damage to both leaves and fruits, its infestation was recorded on the leaves of other host plants. The infestation of *T. absoluta* was observed on tomato leaves, brinjal and potatoes, within the second week of their growth, however, it took three or four weeks to record its first infestation on peppers and chilies, respectively. It started infesting tomato fruits since their appearance during the fifth week after the transplantation. The initial mean infestation percentage recorded on different host plants i.e., brinjal, potatoes, chilies, peppers, tomato leaves, and fruits was 0.44±0.12, 0.36±0.10, 0.20±0.10, 0.24±0.10, 2.96±0.48, and 0.24±0.10%, respectively. Afterwards, a rapid increase in the mean infestation percentage of *T. absoluta* was recorded in tomatoes, followed by brinjal and potatoes, whereas its infestation was generally low in chilies and peppers. Accordingly, the maximum per week mean infestation percentage of *T. absoluta* (39.56±3.38%) was recorded in tomato leaves during the week twenty after the transplantation, followed by 18.00±1.68 and 10.08±1.26% infestation observed in tomato fruits and brinjal during the week twenty-one and sixteen, respectively. The

maximum mean infestation percentage recorded in potatoes, chilies, and peppers was 7.08±0.72, 3.04±0.34, and 5.12±0.66% that were recorded during seventeen, fifteen, sixteen, respectively of their transplantation. After the peak *T. absoluta* infestation observed in various host plants, its infestation showed a declining trend in all the host plants towards their final harvesting. Accordingly, statistically, a highly significant ($F = 15.83$, $P < 0.001$) difference in the weekly mean infestation percentage of *T. absoluta* was observed on different host plants including tomato leaves and fruits.

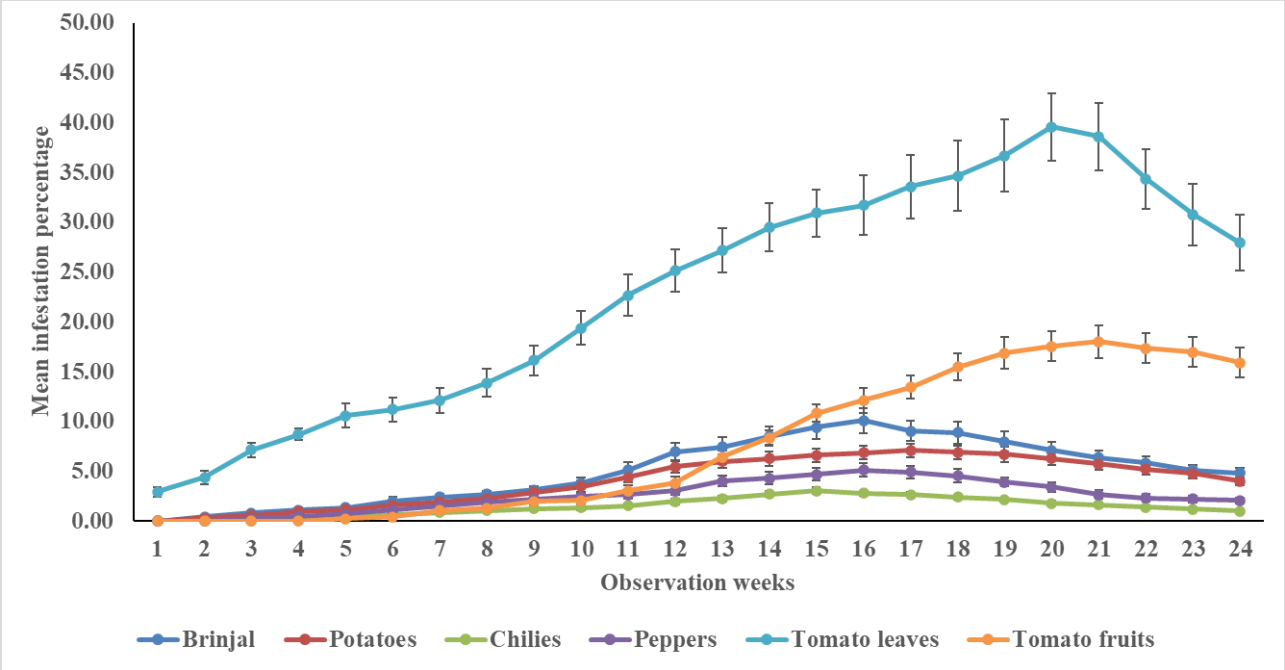

Figure 1: Mean infestation percentage of *Tuta absoluta* on various host plants.

Results for the overall mean *T. absoluta* infestation percentage on various host plants evaluated is given in Figure 2; that confirmed a highly substantial variation among the treatment host plants. Significantly, the highest *T. absoluta* infestation percentage (22.91±0.67%) was recorded on tomato leaves, whereas the lowest infestation (1.44±0.06%) was observed on chilies, respectively. Moreover, the overall mean infestation percentage recorded in brinjal, potatoes, peppers, and tomato fruits were 5.02±0.19, 4.07±0.14, 2.52±0.11, and 7.64±0.34%, respectively.

Table 1 illustrates the results regarding the impact of various abiotic factors on the infestation percentage of *T. absoluta* on different host plants using correlation coefficients. It was observed that all the weather parameters elicited a weak to moderate, but significant impact on the mean *T. absoluta* infestation percentage in solanaceous host plants. In chilies, *T. absoluta* infestation exhibited a positive and weak but negative relationship with minimum temperature ($r = -0.1896$, $P < 0.001$), maximum temperature ($r = -0.1800$, $P < 0.001$), and wind velocity ($r = -0.1274$, $P = 0.0018$). The similar trend of results was also recorded in potatoes, chilies, and peppers where minimum temperature ($r = -0.1665$, -0.3122, and -0.2685, respectively; $P < 0.001$), maximum temperature ($r = -0.1519$, -0.2911, and -0.2423, respectively; $P < 0.001$), and wind velocity ($r = -0.1213$, -0.1481, and -0.1328, respectively; $P <$

0.01) exhibited a weak to moderate but significant and negative relationship with *T. absoluta* infestation, whereas relative humidity (r = 0.2242, 0.2263, and -0.1802, respectively; P < 0.001) exhibited a positive, weak, and significant relationship.

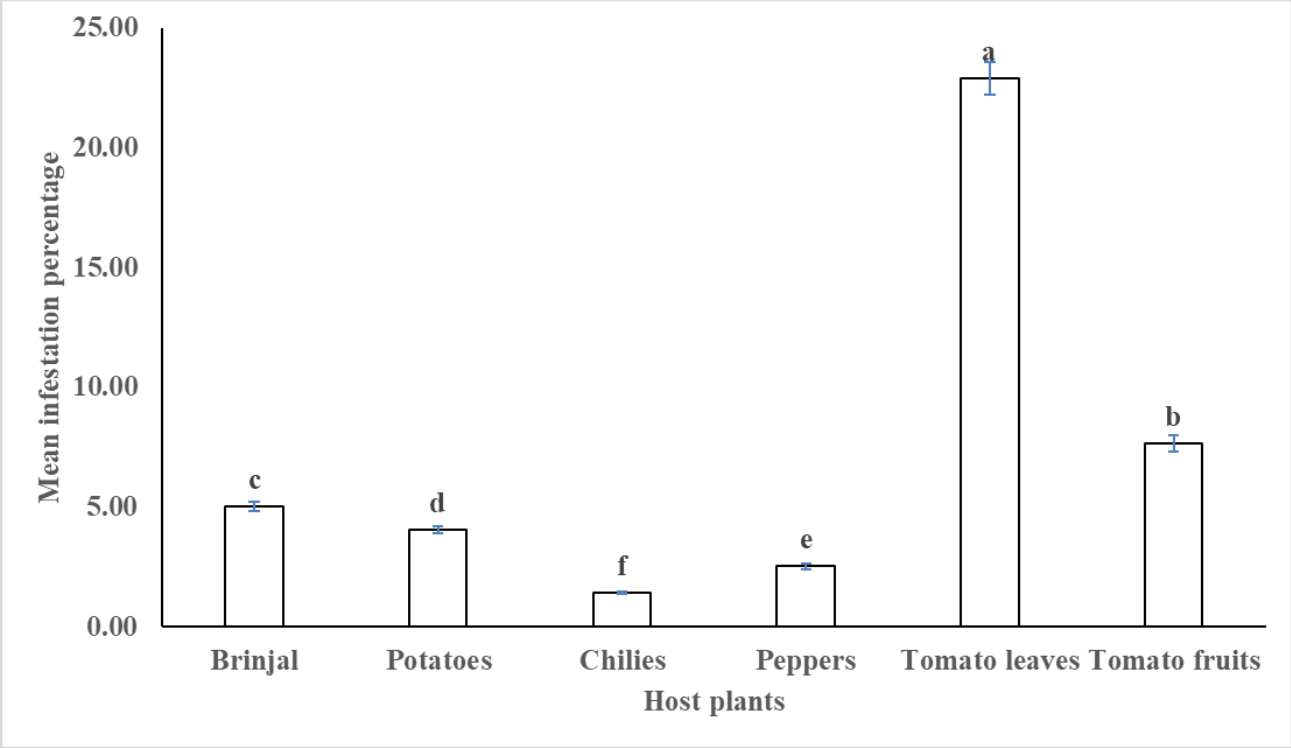

Figure 2: Overall mean infestation *Tuta absoluta* on various host plants *Means with different letters differ significantly from each other (LSD = 0.6267, P < 0.05).

Table 1: Correlation co-efficient of various weather parameters on the mean infestation of *T. absoluta* on different host plants.

Variables	Brinjal	Potatoes	Chilies	Peppers	Tomato leaves	Tomato fruits
Temperature (Minimum)	r = -0.1896**	r = -0.1665**	r = -0.3122**	r = -0.2685**	r = -0.0144^{ns}	r = 0.3136**
Temperature (Maximum)	r = -0.1800**	r = -0.1519**	r = -0.2911**	r = -0.2423**	r = 0.0064 ^{ns}	r = 0.2634**
Wind velocity	r = -0.1274*	r = -0.1213*	r = -0.1481*	r = -0.1328*	r = -0.0910*	r = -0.0448 ^{ns}
Relative humidity	r = 0.2177**	r = 0.2242**	r = 0.2263**	r = 0.1802**	r = 0.1590**	r = -0.001^{ns}

*Significant at P < 0.05 **Highly significant at P < 0.001 ns= non-significant

Moreover, on tomato leaves, both minimum and maximum temperature did not exhibit any influence on the *T. absoluta* infestation, whereas relationship of its infestation with relative humidity (r = 0.1590, P < 0.001) was weak, positive, and highly significant, whereas a negative, very weak, and significant relationship with wind velocity (r = -0.0910, P = 0.0258) was observed. Moreover, both minimum (r = 0.3136, P < 0.001) and maximum (r = 0.2634, P < 0.001) temperature elicited as

highly significant, moderate, and positive impact on the mean *T. absoluta* infestation tomato fruits.

DISCUSSION

Tuta absoluta exhibited a great variation in its level of infestation towards the tested solanaceous host plants where tomato was found to be its most preferred host. It was also observed that *T. absoluta* showed its characteristics mining symptoms on both leaves and fruits of tomatoes, whereas it only causes infestation on leaves of brinjal, potatoes, chilies, and peppers. It has been reported that even in its native range, *T. absoluta* is primarily considered as an oligophagous pest of Solanaceae family with tomato being its most preferred host that supports its variable biological parameters such as feeding, oviposition, development, and survival (Kharroubi, 2008; Desneux et al., 2010; Urbaneja et al., 2013). However, it also showed its potential to survive and reproduce on other plants of Solanaceae family especially potato, brinjal, pepper, tobacco, litchi and potato (Desneux et al., 2010), Amaranthaceae i.e., Lambs' quarters, sugar beet (Portakaldali et al., 2013), Fabaceae i.e., common bean (Wyckhuys et al., 2013), and Convolvulaceae i.e., Field and Bindweed (Portakaldali et al., 2013). Besides above-mentioned host plants from the main cultivated families, it also showed its survival on other wild host plants such as alfalfa, prickly amaranth, fierce thornapple, hairy potato, cut-leaf groundcherry and others (Campos et al., 2017; Sankarganesh et al., 2017; Guimapi et al., 2020; Mansour et al., 2018; Bastola et al., 2020).

A recent study of Sylla et al. (2019) performed experiment to determine the oviposition acceptance, oviposition preference, and development of immature stages of two populations i.e., France (FRA) and Senegal (SEN) of *T. absoluta* on six Solanaceous host plants (tomato, potato, brinjal, Ethiopian eggplant, pepper, and sweet pepper). A highly significant difference in the oviposition acceptance and preference between the two *T. absoluta* populations was observed with SEN *T. absoluta* population showed higher preference for Ethiopian eggplant and sweet pepper along with potato, whereas FRA population showed strong preference for tomato and brinjal. However, overall, both the population performed best on their preferred host tomato, whereas their performance decreased on the alternate solanaceous host plant studied. Another two-year study confirmed that among six above mentioned and widely cultivated solanaceous plants in Senegal, *T. absoluta* showed the highest performance on tomato with severe damage (Brévault et al., 2014), however, it was also frequently observed on brinjal and potatoes, whereas occasionally occurring on the Ethiopian eggplant and a less than 10% infestation recorded on sweet pepper and pepper field (Diatte et al., 2018). Thus, all these studies support findings observed in our study as *T. absoluta* not only showed strong preference on tomatoes by damaging its leaves and fruits, but also showed relatively higher preference for brinjal and potatoes, and less frequently on peppers and chilies. The persistent infestation of *T. absoluta* on sweet pepper has also been reported by Guenaoui et al., (2010), but they also failed to record the completion of life cycle on it. Similar type of results was also reported by Biondi et al. (2018) who also confirmed that *T. absoluta* was poorly adapted to sweet pepper or pepper.

In a comparative field and controlled greenhouse experiments, Cocco et al. (2015a) found that *T. absoluta* showed maximum preference for tomato in both the experimental layouts with highest infestation percentage, whereas its infestation was lowest on potato (< 0.3 mines per leaf), followed by *S. nigrum* (0.16 mines per leaf). The developmental (larval survival, pupal weight, and mean fecundity) and population parameters (net reproductive rate, mean generation time, and intrinsic rate of increase) of *T. absoluta* studied on tomato and potatoes showed that it significantly performed better on tomatoes than potatoes, however its potential development on potato need special attention (Pereyra and Sánchez, 2006). Zhang et al. (2021) while evaluating the geographic and potential host range of *T. absoluta* in China reported that the pest has already well established in tomato growing provinces of the country as its infestation has also been found on four cultivated i.e., tomato, brinjal, potato, and Chinese Lantern and two wild plant species black nightshade and Dutch eggplant.

The developmental pattern of *T. absoluta* was studied by Bawin et al. (2016) on twelve plant species from Solanaceae, Amaranthaceae, Convolvulaceae, Fabaceae, and Malvaceae families under laboratory conditions. The results regarding the recorded parameters of survival, developmental period of immature stages, sex ration, and fecundity was recorded better on all the solanaceous plant species, whereas all other plant species i.e., *Chenopodium* Linnaeus (Amaranthaceae), *Convolvulus* Linnaeus (Convolvulaceae), and *Malva* Linnaeus (Malvaceae) did not support the studied parameters of *T. absoluta*. However, it was observed that the plant species from non-solanaceous families could be opportunistic alternatives for *T. absoluta* to continue its survival in case of absence of its main host i.e., tomato.

Mohamed et al. (2015) studies from 2011 to 2015 in Sudan confirmed that besides tomato, *T. absoluta* also caused significant losses to brinjal and Jimson weed, thus proved to be its preferred host plants in the study area. Moreover, infestation of *T. absoluta* was also recorded from potato, broad bean, alfalfa, watermelon, Physic nut, spiny amaranth, and Ramtouk from families of Fabaceae, Cucurbitaceae, Euphorbiaceae, Amaranthaceae, and Asteraceae, respectively.

Among environmental factors, both minimum and maximum temperature of the day and wind velocity elicited a negative but substantial influence on the population development, thus on infestation of *T. absoluta* on various host plants i.e., tomato, brinjal, potato, peppers, and chilies evaluated. However, relative humidity elicited a positive and significant impact on its infestation on different host plants, whereas overall environmental factor's impact was weak to moderate. Previous studies of Bayram et al. (2017) demonstrated that temperature has shown a positive and significant influence on the population development of *T. absoluta* in the fields of tomato, hence the same contributed to its higher catches in various installed traps i.e., light and pheromone used in the study and infestation on tomatoes. Similarly, a positive correlation in the average catches of *T. absoluta* moths in the traps evaluated was recorded with the increasing temperature as comparatively higher moths were captured in hot summer days than cool winters (Cocco et al., 2015b). A recent study also reported a substantial but weak impact of temperature on the mean catches of adult males and females *T. absoluta* in pheromone and light traps evaluated, whereas no significant role of rainfall and relative humidity was observed on the population and infestation of *T. absoluta*, thus on their mean capture in the traps (Mangrio et al.,

2023). It has also been observed except tomato fruits, a negative relationship of minimum temperature was recorded on the mean *T. absoluta* infestation on other hosts, whereas a different relationship of relative humidity i.e., negative was also recorded with its infestation on tomato fruits. Previously not many studies have studied relationship of *T. absoluta* infestation with weather parameters, hence no particular reason for such deviation of weather parameters among different host species can be established. However, such variation observed in this study regarding relationship of temperature (minimum and maximum) on the mean *T. absoluta* infestation on tomato fruits in comparison to remaining hosts may be attributed to relatively higher infestation on huge quantity of fruits available during the months of December-January (when temperature is very low) and February-April (when temperature is becoming higher).

Therefore, it is evident from the results obtained in our study regarding the highest preference of *T. absoluta* towards tomatoes, but potential to infest other solanaceous hosts (brinjal, potato, pepper, and chilies) was supported by the almost all above-mentioned studies. It has also been suggested that the invasive species like *T. absoluta* generally use secondary host plant species to persist in the habitats where their preferred host plants become scarce (Tonnang et al., 2015).

CONCLUSION

Tuta absoluta showed strong preference for tomatoes with the highest infestation percentage on both its leaves and fruits. However, it also showed its infestation on leaves of brinjal, potatoes, and peppers, whereas chilies suffered the lowest level of infestation. Thus, the potential of *T. absoluta* to damage and survive on alternate host shows its invasive characteristics to continue its survival and spread even in case of the absence of its preferred host tomato. Therefore, it necessitates to carried out further studies to explore all its potential hosts in the invaded areas of Sindh that could suffer its losses and support its various biological parameters.

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