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Host Plant Suitability of *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) on Four Different Plant Species

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Abstract: Tomato leaf miner [*Tuta absoluta Meyrick (Lepitoptera: Gelehiidae)]* is a major pest causing significant losses in tomato crops. This study examined the growth and development of *T. absoluta* when fed on four host plant species. The host plant potential of three species from Solanaceae family (*Solanum lycopersicum* L., *Solanum tuberosum* L., *Solanum nigrum* L.) and one species from Chenopodiaceae family (*Chenopodium album* L.) was evaluated. Key development parameters including egg hatching, larval, pupal and total development periods of *T. absoluta* were recorded to assess the completed life cycle of *T. absoluta*, from egg to adult. The results showed that *T. absoluta* fed on solanaceous plants successfully completed its life cycle, but failed to complete life cycle on *C. album*, where larvae died during the egg stage. It was determined that the stage of all periods obtained in *S. nigrum* plants. In S. *lycopersicum* and *S. tuberosum* plants, values close to each other were obtained. The highest survival rate was observed in *S. nigrum* plant. This study concludes that *S. nigrum*, *S. lycopersicum* and *S. tuberosum* plants (Solanaceae family) are suitable hosts for *T. absoluta*, whereas *C. album* (Amaranthaceae family) is non-conducive for its development.

Keywords: Host plant preference, development period, pest management, Solanaceae plants, tomato pests, tomato leaf miner.

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1. Introduction

Tomato [(*Solanum lycopersicum*) (Solanaceae)] is an edible herbaceous plant that originated from South and Central America and is widely cultivated across the world (Fuentes et al., 2021; Kumar et al., 2020). Tomato fruits are a significant source of vitamins including vitamins C and D, and are rich in beneficial phytochemicals including lycopene and glycoalkaloids (Perveen et al., 2015; Wang et al., 2023; Woods, 2010).

Tomato production is susceptible to various diseases and pests, causing significant crop losses (Gatahi, 2020; Kennedy, 2003; Panno et al., 2021). Tomato leaf miner [(*Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae)] is among the most destructive pests, causing substantial damage to tomato crops. The larvae of *T. absoluta* destroy the tomato canopy by burrowing into the leaves, buds and shoots. Moreover, they also damage flowers and fruits (Biondi et al., 2018; Erdogan and Babaroglu, 2014; Pandey et al., 2023; Yadav et al., 2022). Under favorable conditions, this pest can potentially cause complete failure of tomato crops (Chouikhi et al., 2023; Negi et al., 2018).

Though tomato is the most preferred host of *T. absoluta*, it has also been reported to infest potato, brinjal, common bean, tobacco and many other plants of the families Solanaceae, Fabaceae, Cucurbitaceae, Euphorbiaceae, and Amaranthaceae (Bawin et al.,

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2015; Negi et al., 2018). *T. absoluta* is a highly prolific species with wide adaptability and capable of rapid growth under favorable conditions (Guenaoui et al., 2010; Terzidis et al., 2014).

Tomato plant volatiles are more attractive to the female moths, especially leaf miner, Tuta absoluta, than to males (Biondi et al., 2018; Subramani et al., 2021). Olfactometer assay demonstrates a strong preference among female moths for the volatiles emitted by tomato plants. This preference plays a crucial role in their oviposition behavior. Subsequently, female moths tend to lay more eggs on tomato plants than on other Solanaceous host plants like potatoes and eggplant (Chen et al., 2023; Mandour et al., 2020).

T. absoluta is a highly prolific and adaptable species, capable of rapid growth under favorable conditions. As a multivoltine pest with overlapping life cycles, it grows well under suitable environments that support its development (Ongonge et al., 2023; Vivekanandhan et al., 2024). Despite having a strong predisposition preference for tomato, *T. absoluta* is an oligophagous pest that can infest the aerial parts of various other Solanaceous host plants, including weeds, potato, eggplant, pepino, and tobacco (Idriss et al., 2020; Konan et al., 2022; Pandey et al., 2023).

The successful invasion of *T. absoluta* can be attributed to its primary biological traits, including high reproductive capacity, the ability to produce multiple generations each year, and a short generation time (de Campos et al., 2021; Mansour et al., 2019). Adults, eggs, larvae, and pupae are the four life cycle stages of *T. absoluta*. The optimum temperature range for development throughout these stages is between 19°C and 25°C. This temperature range is aligned with the average daily temperatures generally observed during the tomato growing season. Under these thermal conditions *T. absoluta* can potentially produce nine to twelve generations throughout the year, depending on diverse factors including agroclimatic conditions, crop management and host plant characteristics (Desneux et al., 2022; Mohamed et al., 2022; Silva et al., 2021; Tabikha et al., 2015).

T. absoluta affects all parts of the host plant, leaves, blossoms, stems, and fruits, from seedlings to fully grown plants. Larvae feed on mesophyll tissues, creating distinct galleries filled with larval excrement leading to browning, necrosis, reduced functional leaf area, structural damage and impaired photosynthesis (Pandey et al., 2023; Uygun and Ozguven, 2024). This can result in severe yield losses, including complete fruit damage, if not properly managed (Aynalem, 2022; Loyani et al., 2021).

The emergence and success of invasive phytophagous insects in specific agroclimatic conditions depend on their ability to locate and adapt to new host plants, influencing their development, reproduction, and interactions with host plants (de la Masselière et al., 2017; Skendžić et al., 2021). However, physiological and behavioral of insects limit the host range (Bodlah et al., 2023; Idriss et al., 2020; Suckling et al., 2014).

In addition to the current impediment to global tomato production, *T. absoluta* is also a threat to other cultivated species of Solanaceae, including black nightshade (*Solanum nigrum* L.), potatoes (*Solanum tuberosum* L.), and tobacco (*Nicotiana tabacum* L.) (Desneux et al., 2022; Subramani et al., 2021; Mohamed et al., 2015).

T. absoluta was also reported to infest non-solanaceous host plants, such as *Malva* spp. (*M. cathayensis*, *M. pusilla*, *M. verticillate* (Caponero 2009), *Vicia faba* L. (Abdul-Ridha et al.,2012), *Chenopodium album* L. (Portakaldali et al., 2013), and *Volvulus arvensis* L. (Portakaldali et al., 2013). Moreover, numerous wild plant species, often found in urban areas, logged regions, croplands, and wastelands (Bawin et al., 2015), may serve as alternate host plants for *T. absoluta*, supporting pest survival and spread.

The potential to exploit these diverse conditions and host plants describes the adaptability and resilience of *T. absoluta* as an invasive pest (Desneux et al., 2022; Pandey et al., 2023). This broad host range complicates management efforts and poses significant challenges to crop productivity. This emphasizes the significance of its efficient monitoring and management (Colmenárez et al., 2022; Vivekanandhan et al., 2024).

This study was designed to evaluate the development and life span of *T. absoluta* from egg to adult on both cultivated and wild plants, including potential hosts from the Solanaceae and Amaranthaceae.

2. Materials and Methods

2.1. Host Plants

The tomato (cv Daffodil) and potato (cv Agria) plants used in the experiment were grown in pots in the greenhouse. *Chenopodium album* and *Solanum nigrum* plants were freshly collected from unsprayed fields when necessary.

2.2. *Tuta absoluta* culture

Larvae of *T. absoluta* were collected from tomato greenhouses in Adana, Turkey. The tomato plant and *T. absoluta* larvae were maintained in a 50 × 50 × 30 cm cage. Newly emerged adults were transferred to separate cages containing tomato plants (cv Daffodil) grown in greenhouses. *T. absoluta* cultures were maintained in a climate-controlled room (25±1ºC, 65±5% R.H., with a photoperiod of 16 h light: 8 h dark).

Fig. 1. The experiment *T. absoluta* no-choice test.

2.3. Experiment procedure

Female and male pupae (10 each) were collected from larvae reared on the tomato plant. When adults emerged, moths were provided a sucrose solution (10 % sucrose) and allowed to mate for one day in a cage. Subsequently, one-day-old eggs were placed in Petri dishes (3.5 cm diameter) containing moistened disc cotton and a 3 cm leaf disc from the experimental plants (*Solanum lycopersicum*, *Solanum tuberosum*, *Solanum nigrum*, and *Chenopodium album*). A total of 60 eggs per plant species were used, with each egg placed in a separate petri dish (Fig.1). Observations included the duration of egg hatching, larva instar, pupa instar and the total development period from egg to adult.

2.4. Choice and No-Choice Tests

To evaluate the feeding behavior of third-instar larvae on *C. album*, both choice and no-choice tests were conducted. In the choice test, one leaf of *C. album* and one leaf of *S. lycopersicum* were placed in a Petri dish (9 cm diameter) lined with moistened cotton wool. However, in the no-choice test, only *C. album* leaves were provided. Five larvae were introduced into each Petri dish, with four replicates for each test condition. Daily observations were conducted to monitor larval feeding behavior. All experiments were conducted in a climate-controlled room under standardized conditions (25±1ºC, 65±5% relative humidity (R.H.), and a 16:8 h light: dark photoperiod).

2.5. Statistical Analysis

The obtained results were analyzed using analysis of variance, and means were compared with Duncan's test (P = 0.05) using SPSS version 20.6.

3. Results and Discussion

3.1. Choice and No-Choice Tests

T. absoluta eggs deposited on four different plant species successfully completed their development only on *S. lycopersicum*, *S. tuberosum* and *S. nigrum* plants. A very low emergence rate (8.33%) was observed for larvae from eggs laid on *C. album* plants, but none of these larvae died before completing their development (Fig. 2a, b).

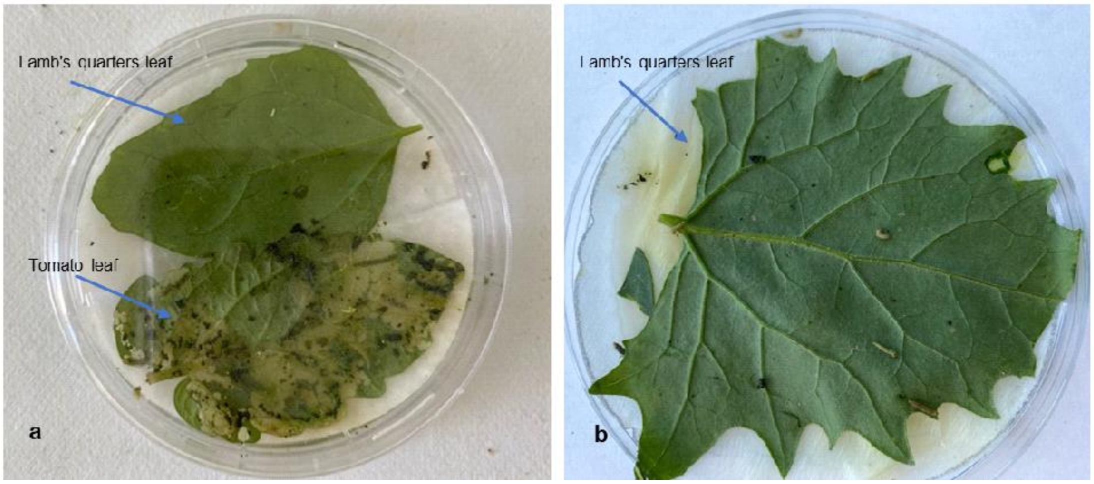

Fig. 2. a) Choice test **b) No-choice test**

Table 1. Preadult development period (days) of *Tuta absoluta* on different host plant species

Stage	*Solanum nigrum*	*Solanum lycopersicum*	*Solanum tuberosum*	*Chenopodium_album***
Egg	3.87±0,66 a*	4,54±0,73 a	5,10±0,80 b	5.30
Larva span	9.53±1,33a	12,83±1,45b	13.06±0,66 c	0.00
Pupae span	8.01±0,83a	8.54±1,03a	9.03±1,04 b	0.00
Total life span	23.24±0,13a	28.00±1.03b	27.80±1.69 b	0.00
% Survival (egg to adult)	38.34	36.67	33.34	0.00

*****Within columns, means ± SE followed by the same letter are not significantly different (DUNCAN's multiple F-test P < 0.05). ****** the larvae were not fed.

The remaining eggs desiccated before hatching. *T. absoluta* eggs laid on the leaves of four different plants completed development only on *S. lycopersicum*, *S. tuberosum* and *S. nigrum* plants. The mean egg hatching periods were 3.87, 4.54, and 5.10 days for *S. nigrum*, *S. lycopersicum* and *S. tuberosum*. On all three host plants, the newly hatched larvae successfully formed galleries or leaf mines and developed normally. Statistical analyses revealed significant differences in egg hatching periods among the host plants (F= 87.44; p<0,05). Based on egg hatching period, *S. nigrum and S. lycopersicum* were grouped together, while *S. tuberosum* formed a separate group (Table 1).

The period of larva instar was assessed on *S. nigrum*, *S. lycopersicum* and *S. tuberosum* as host plants. The average larval period was shortest when fed on S. nigrum (9.53 days), followed by S. lycopersicum (12.83 days) and S. tuberosum (13.06 days) (Table 1). Statistical analyses revealed significant differences among host plants (F = 50.96; *p* < 0.05). The data obtained from *S. nigrum* and *S. lycopersicum* plants were in the same group, while *S. tuberosum* plants were in different groups (F=50.96; p<0.05).

The period of pupa instar was determined as 8.01 days in *S. nigrum*, 8.54 days in *L. lycopersicum* and 9.03 days in *S. tuberosum*. In statistical analyses in terms of the period of pupa instar, *S. tuberosum* plants were in different groups and *L. lycopersicum* and *S. nigrum* plants were in the same group. (Table 1) (F=11.16; p<0.05).

The total development time from egg to adult was 23.24, 28.0 and 27.80 days in *S. nigrum*, *L. lycopersicum* and *S. tuberosum* plants, respectively (Table 1). The development stage indicated that the survival rates of *S. nigrum*, *S. lycopersicum*, and *S. tuberosum* plants from egg to adult were 38.34, 36.67, 33.34 and 0.00 days, respectively (Table 1).

In addition, in the no-choice and choice tests using third-instar larvae, it was determined that all larvae fed on *C. album* plants died. In the choice test, the larvae consumed *L. lycopersicum* leaves and avoided *C. album* leaves. Since no larvae fed on *C. album* leaves (Fig. 2a, b), therefore, no statistical analysis was performed in this experiment.

In previous studies, *T. absoluta* prefers tomato as its host it also attacks several other of solanaceous crops including *Solanum melongena* L., *Solanum tuberosum* L., *Nicotiana tabacum* L., *Solanum aethiopicum* L. (Cherif and Verheggen, 2019; EPPO, 2005; Pereyra and Sánchez, 2006; Megido et al., 2013; Negi et al., 2018).

It was recorded that the hatching time of *T. absoluta* eggs in tomato plants was around 4-5 days (EPPO, 2005; Torrest et al., 2001). Erdogan and Babaroglu (2014), reported that the average egg hatching time in tomato plants of 4.10 days. Idriss et al., (2020) revealed that the egg hatching period on *S. lycopersicum* plants was 6.8 days. In the same study, it was recorded that the egg hatching period was 6.6 days in *S. nigrum* plants. According to the results of the study conducted by Bawin et al. (2015), it was reported that *T. absoluta* eggs hatch in 4.3 days in *S. tuberosum* plant. In the same study, it was determined as 3.8 days in *Solanum dulcamara*, which is in the same family with *S. nigrum*.

According to the results obtained from our study, the period of larva instar was 9.53, 12.83 and 13.06 days in *S. nigrum*, *S. lycopersicum* and *S. tuberosum* plants, respectively. Our study results were similar to those reported for *T. absoluta*. Torres et al. (2001) who stated the period of larvae instar of *T. absoluta* was 12 and 16 days at 27 ºC. Pereyra and Sanches (2006) reported that the period of larvae instar of *T. absoluta* was 12.14 days at 25±1ºC *S. lycopersicum*. It was found that the period of larvae instar was 13-15 days *S. lycopersicum* (EPPO, 2005). Similarly, in the study conducted by Erdogan and Babaroglu (2014), the period of larva instar in *S. lycopersicum* plants was determined as 10.97 days. In another study, the period of larva instar in *S. tuberosum* and *S. dulcamara* was 8.5 and 11.8, respectively (Bawin et al., 2015). Also, according to İdriss et al. (2020), the period of larva instar was 10.9 days in *S. lycopersicum* and 12.3 days in *S. nigrum.*

In the present study, the pupal instar duration of *T. absoluta* varied significantly among host plants, lasting 8.01 days on *S. nigrum*, 8.54 days on *S. lycopersicum*, and 9.03 days on *S. tuberosum*. These findings are supported by earlier reports, though with slight variations. These variations can be attributed to differences in experimental conditions (Erdogan and Babaroglu, 2014; Idriss et al., 2020; Torres et al., 2001). Pupal duration of 9.53 days on tomato plants (Erdogan and Babaroglu, 2014), while Torres et al., (2001) observed a range of 7-9 days. Similarly, Idriss et al. (2020) recorded longer pupal durations of 10.8 and 10.7 days on *S. lycopersicum* and *S. nigrum*, respectively. Additionally, Bawin et al. (2015) noted durations of 7.6 and 9.2 days on *S. tuberosum* and *S. dulcamara*, further supporting the influence of host plants on pupal development.

At 25ºC, the average development time of *T. absoluta* from egg to adult varied significantly among host plants, on *S. lycopersicum*, (28.0 days), *S. tuberosum* (27.80 days) and *S. nigrum* (23.24 days). These findings are consistent with the results of Bawin et al. (2015) reported a development period of 24.8 days on *S. dulcamara* (a close relative of *S. nigrum*) and 20.04 days on *S. tuberosum*. Erdoğan and Babaroğlu (2014) observed a longer development period of 30.18 days on *S. lycopersicum*, which aligns with EPPO (2005), reporting 30 days for the complete life cycle.

However, Cuthbertson et al. (2013) noted contrasting results: while development took 23.8 days at 27.1°C, it extended to 35 days at 25°C. Similarly, Idriss et al. (2020) recorded the total development time of *T. absoluta* 29.0 days on S. nigrum and 27.9 days on S. lycopersicum, which are slightly longer than our findings (28.0 days on *S. lycopersicum* and 23.24 days on *S. nigrum*). These variations can be result of differences in environmental conditions, genotypic variations of host plant cultivars, or experimental conditions.

Significant differences observed in the life stages and development periods of *T. absoluta* across different host plants, with eggs failing to hatch of deed on *C. album*. This disparity in survival could be caused by defense mechanism triggered by oviposition or by the morphological traits of host plants, which could disrupt embryonic development. For example, leaf desiccation potentially caused by stomatal closure regulated by anomalies in the humidity or hypersensitive responses, could impair egg viability (Bawin et al., 2015; Hilker and Meiners, 2011; Woods, 2010). Similar defensive strategies have been documented in *Brassica nigra* (Brassicaceae), where necrotic leaf tissue formation beneath eggs of *Pieris rapae* and *P. napi* (Lepidoptera: Pieridae) led to egg desiccation (Griese et al., 2017; Peters et al., 2024; Shapiro & DeVay, 1987). Moreover, plant tissues may contain volatile or contact compounds that interfere with embryonic growth and development (Hilker and Meiners 2011).

An alternate hypothesis suggests that females responded to a low-quality host plant by devoting fewer resources in embryos, which may compromise offspring fitness (Boggs, 1992). This aligns with the studies suggesting that high-quality diet is associated with the improved survival and faster development in herbivorous insects (Awmack and Leather 2002; Pereyra and Sánchez 2006).

Our findings demonstrate that non-solanaceous plant species are unlikely to be *T. absoluta* hosts because of none supported larval development. According to Proffit et al. (2011), *T. absoluta* females assess host plant quality by using volatile organic compounds (VOCs), which may have led them astray during host selection. Furthermore, the larval development significantly varied among the host plants. *T. absoluta* raised on *S. nigrum* showed faster growth to adulthood than the other host species. The larval instars, or feeding stage, are the primary determinant of development rate under optimum and stress-free conditions. These differences likely reflect variations in the quality of nutrients and/or the production of plant secondary metabolites (Bawin et al., 2015).

Our results demonstrate that *T. absoluta* recorded no feeding activity on *C. album*, consistent with previous studies reporting non-host status of *T. absoluta*. This observation aligns with the work of Bawin et al. (2016), who identified several non-host species (*Calystegia sepium, Convolvulus arvensis*, *Beta vulgaris vulgaris, Vicia paba*), including *C. album*. These plant species neither supported development nor egg deposition of *T. absoluta*. Notably, when eggs were occasionally laid on these unsuitable plants, larvae failed to establish feeding.

The host range of *T. absoluta* appears restricted primarily to species of Solanaceae family, though with varying suitability. While limited development has been reported on certain wild solanaceous plants (*Datura ferox*, and *D. stramonium*, *Lycopersicon puberulum*, *Nicotiana glauca*, *Solanum elaeagnifolium* and *Solanum nigrum*).

Our results confirm that several other Solanaceae species (*D. ferox*, *Physalis viscosa*, *Salpichroa origanifolia*) remain completely non-preferred for oviposition. Particularly *Datura stramonium*, which actively prevents *T. absoluta* from completing its life cycle (Abbes et al., 2016; Bawin et al., 2015; Cherif and Verheggen, 2019). This inhibitory effect suggests the presence of potential resistance mechanisms that warrant further investigation.

It was reported that the eggs laid on these plants could not feed on the plant. *T. absoluta* can show restricted development on a few wild Solanaceae species, such as did not lay eggs on any of the Solanaceous species, including *D. ferox*, *Physalis viscosa*, and *Salpichroa origanifolia*. *T. absoluta* was prevented from completing its life cycle by *Datura stramonium* (Abbes et al., 2016; Bawin et al., 2015; Cherif and Verheggen, 2019). In addition, plants such as *Geranium robertianum* and *C. pepo* did not show any development (Ingegno et al., 2017).

There are studies with different results from our findings. Portakaldali et al. (2013) reported that vinegar grass was also found among the hosts of *T. absoluta*, and this finding was the first record. Similarly, in the study conducted by Ögür et al. (2014), it was reported that *C. album* is the host of *T. absoluta*. There is no literature on the feeding of *T. absoluta* with *C. album*. Thus, it was determined that *T. absoluta* was hosted by *S. nigrum*, *S. lycopersicum*, and *S. tuberosum* plants of the Solanaceae family and that the C. *album* plant of the Amaranthaceae family could not be the host.

4. Conclusion

This study identified *Solanum nigrum* and tomato (*Solanum lycopersicum*) as the most suitable host plants for *Tuta absoluta* development, though the pest also demonstrated successful establishment on potato (*Solanum tuberosum*). These results highlight the importance and need of continuous monitoring of host plant species, as they support critical developmental stages like larval development and life cycle processes, including population expansion and overwintering success. Contrarily, *Chenopodium album*, found to be unsuitable for the survival and development of *T. absoluta*. Results presented demonstrate a strict host specificity of *T. absoluta* on *S. nigrum*, tomato, and potato plants, while being unable to utilize *C. album* as a viable host. These findings have significant implications for integrated pest management programs, particularly in guiding host plant resistance strategies and informing crop rotation decisions in agricultural systems affected by *T. absoluta*.

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