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Population Dynamics of Tomato Leafminer *Tuta absoluta* Meyrick (Lepidoptera: Gelichiidae), On Two Tomato Varieties Tomallow and Cartier in the Kabylia Region (Algeria)

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Abstract:

The tomato leafminer *Tuta absoluta* is a potentially dangerous pest for growing greenhouse tomatoes (*Lycopersicon esculentum* Mill). The objective of this study is to follow the bioecology of the tomato leafminer on two hybrid varieties of tomato Cartier and Tomallow under greenhouse in the region of Azeffoun on the coast of Kabylia. The study showed that the evolution over time of the numbers of adult males of the leafminer is under the control of the climatic conditions, in particular the temperature and the air humidity. The presence of this pest was noted for most of the sampling period. Five generations are registered on both varieties. Observations indicate that there expresses a preference for the Tomallow variety. Otherwise, the infestation is more important on the intermediate and apical leaflets, the females of this pest express a preference for the underside of the leaflets to deposit their eggs and this for both varieties studied.

Keywords: *Tuta absoluta*, populations, tomato, variety, littoral, Kabylia

1. INTRODUCTION

Among the insect pests attacking the tomato (*Lycopersicon esculentum* Mill) *T.absoluta* who is a microlepidopteran belonging to the family Gelechiidae classified in Annex A1 of the EPPO (quarantine organism of the European and Mediterranean organization) (Guedes and Picanço, 2012). Indeed, the tomato miner *T. absoluta* settled in several foci along the Mediterranean coast from 2007 and considered like an invasive species (Desneux and al., 2010). In Algeria its first appearance was in Mostaganem in March 2008, then it spread in the rest of the country to Tunisia during the same year (Guenaoui, 2008, Lebdi-Grissa and *al*., 2011). It causes losses of 80 to 100% in the tomato growing (Alili and *al*., 2014). Blancard and *al.* (2009) recalls that *T. absoluta* is a pest with great potential for spread, mainly related to its biological characteristics, its ability to acclimate and also to trade. The management of this pest is based mainly on prophylactic measures, early detection by sex pheromone traps and the use of insecticides (Collavino and Gimenez, 2008). According to Siquiera and *al.* (2000), the insect is highly resistant to certain insecticides.

In view of the serious damage caused to greenhouse tomato cultivation, we proposed to carry out a study on this pest in a region on the Kabylia's coast (Azeffoun). The purpose of this study is, firstly, to follow the population dynamics of this insect and to determine the number of generations as well as the rate of infestation on the different leaf stages for two tomato's varieties Cartier and Tomallow grown in the same greenhouse, to better guide the fight.

2. MATERIAL AND METHODS

The study is conducted under greenhouse conditions on two hybrid tomato varieties Cartier and Tomallow, in Azeffoun a Kabylia's littoral area. The study area is located in the village of M'letta 4km from the town of Azeffoun at an altitude of 50m 36° 53'46 '' North Latitude and 4° 25 '13'' East Longitude. The observations are focused on the population dynamics of *T.absoluta* to determine the number of generations and to anticipate the most resistant variety to this pest over a period stretching from April to August 2014.

Sampling technique

Capture of adult males of *T. absoluta* pheromone traps are sexual traps, they are used to capture adult males. The traps used during the experiment are water traps, which are circular containers, containing water mixed with a little soap, and a pheromone, which is attached to the top of the container. The male butterflies thus attracted by the synthetic female hormone are drowning. The traps are placed in the middle of the greenhouse at 1.5 m height of the plants, the contents of the trap is renewed each week, and the renewal of pheromones every 5 weeks.

Observation of the different stages of development of *T. absoluta*

Throughout the experimental period, weekly tomato leaf samples are taken for each of the two varieties. The sampling is random. 50 leaves of each variety are taken from each leaf stage (apical, intermediate and basal). Samples are put in labeled plastic bags and possibly put in the cool to avoid drying out. The observation is made in the laboratory under a binocular loupe and the different stages of development of the leafminer (eggs, larvae and pupae) are noted. Also note the installation of a thermohygrometer in the greenhouse to record temperature and humidity.

Statistical analyzes

The linear correlation coefficient is calculated to determine if there is a relationship between the number of male adults and the climate conditions of the greenhouse. Analysis of variance (ANOVA) is calculated for ovi position between the two lower and upper sides of the leaflets, the infestation of the different leaf stages and the choice of the variety when the differences are significant, the calculation is followed by the Newman and Keuls test to determine homogeneous groups with the software Stat Box version 6.4.

3. RESULTS

The number of male adults caught by the trap, the temperature values and the humidity levels recorded in the study greenhouse (Fig. 1)

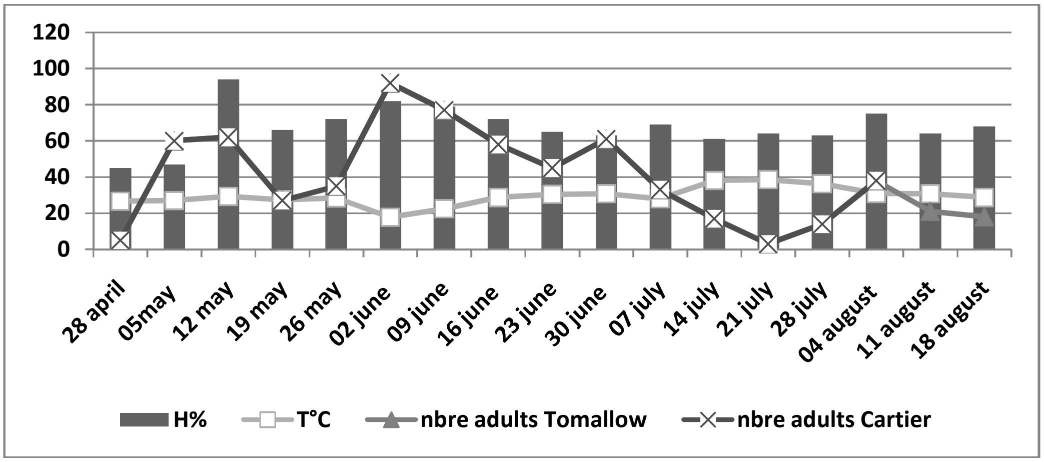


Figure 1: Temporal evolution of the number of male adults caught and temperature variations and moisture levels in both tomato varieties Cartier and Tomallow.

The number of male adults caught in this greenhouse has fluctuated during all months of sampling. After one week of setting up the pheromone traps 5 individuals are caught at a temperature of 26.5°C and a humidity of 45%. A maximum of 92 male butterflies were noted on June 2 at 17.7°C and 82% humidity. The minimum of 03 individuals is observed on July 21 when the temperature reached 38.5°C with 64% of humidity. To check if there is a significant relationship between the temperature and the number of adult males caught from *T. absoluta*, the linear regression test is calculated, with a regression coefficient y = 3.531x + 145.2 with R2 = 0.533 and y = 3.537x + 142.9 with R2 = 0.493, R2 = 0.75.

Temporal evolution of the number of eggs laid on leaflets in both tomato varieties

On the Cartier variety, the density of eggs laid by leaflet has several peaks throughout the study period. An average of 0.02 eggs/leaflet is counted during only the second week of observation. Subsequently 5 peaks are counted and the highest density of 0.04 eggs/leaflet is recorded on 19 May. For the Tomallow during the first two weeks of sampling, the leaflets are totally devoid of eggs. Oviposition did not begin until May 12^{th} (Fig. 2). The number of eggs laid per leaflet rose in the fourth week to reach the peak of 0.086 eggs / leaflet. From this week, a remarkable fall is observed with a succession of three peaks until not having any eggs during the last week of observation. Tomallow's variety is most infested then the Cartier's variety (p=0,00) Tomallow is classed in the group A by the Newman and Keuls test.

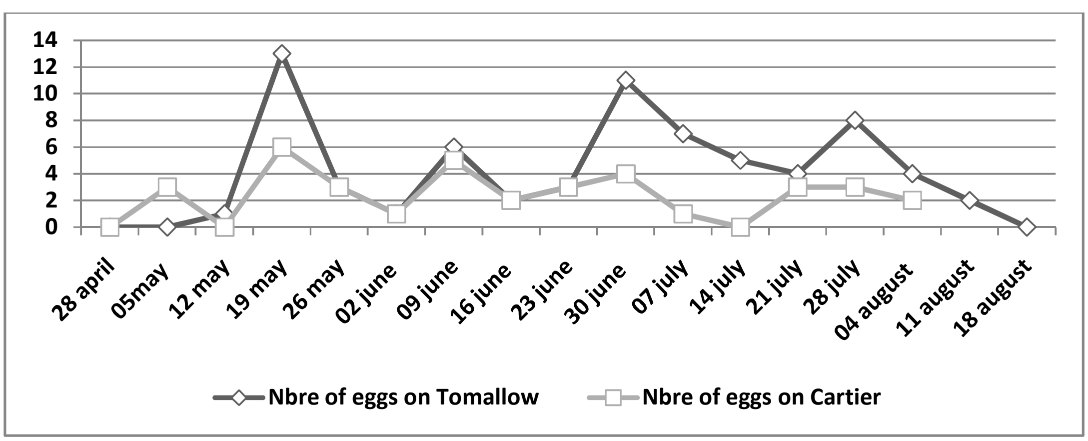


Figure 2: Temporal evolution of the number of eggs laid on the leaflets in the two tomato varieties Cartier and Tomallow.

Temporal evolution of the number of eggs laid on the lower and upper sides of the leaflets in both tomato varieties

Subsequently, 04 peaks are visible on the graph representing the upper face, the first of which is spread over two consecutive weeks on the dates of 19 and 26 May. The second peak is observed on June 09, the two peaks have a maximum value of 0.013 eggs / leaflets. A density of smaller eggs laid with a value of 0.006 eggs/leaflets representing the third peak noted for June 30 and for the fourth peak that spans three consecutive weeks at the dates of 21, 28 July and 04 August. Regarding the underside of leaflets 05 peaks are recorded. A value of 0.02 eggs/leaflet is marked for three peaks recorded on May 05, June 09 and during the two consecutive weeks on June 23 and 30. A maximum value of 0.026 eggs/leaflet is noted on May 19^{th}. The fifth peak is an estimated density of 0.013 eggs/leaflet that spans two successive weeks on the dates of July 21^{st} and 28^{th}.

On the variety Tomallow infestation is observed on the faces of the leaflets only from the third week of observation for the lower faces and the fourth week for the upper faces. Four peaks are observed on the representative graph of the upper face, the first peak with 0.013 eggs/leaflet noted on 19 May. The second peak is recorded on June 09 with an average density of 0.02 eggs/leaflets while the third and fourth peaks have the same value of 0.026 eggs/leaflets recorded respectively on July 07^{th} and 28^{th}.

For the underside of leaflets, 04 peaks are also observed with the first recorded on May 19 with an average of 0.073 eggs/leaflets. An average of 0.02 eggs/leaflets and 0.066 eggs/leaflets noted respectively on 09th June 30th. The last peak with 0.026 eggs/leaflet is recorded on July 28^{th} (Fig. 3)The lower face is more infested than the upper face significant difference P = 0.0 lower face classified in group A by Newmann and Keuls test.

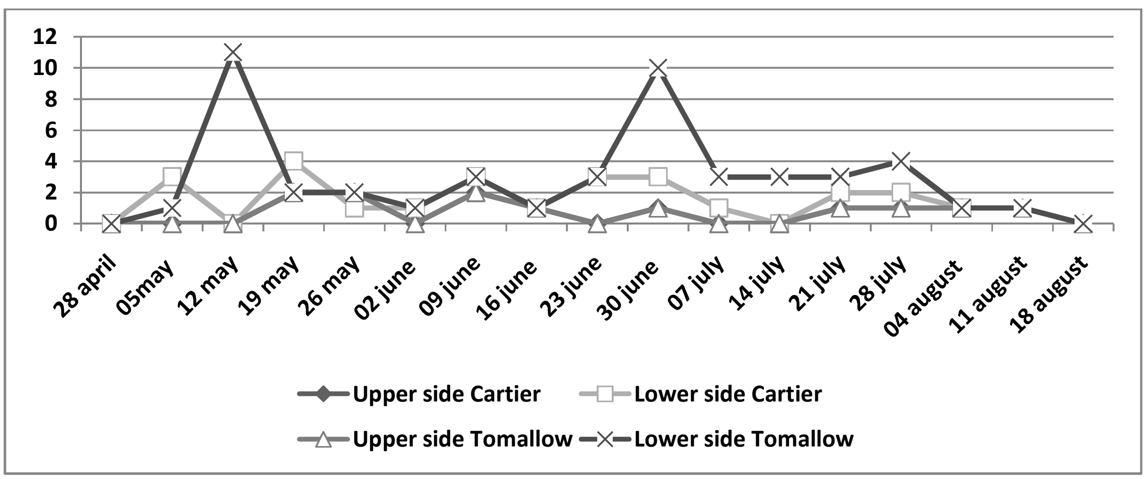


Figure 3: Temporal evolution of the number of eggs laid on the upper and lower sides of the leaflets of the two tomato varieties Cartier and Tomallow.

Temporal evolution of the number of 4 larval and pupae stages on both tomato varieties

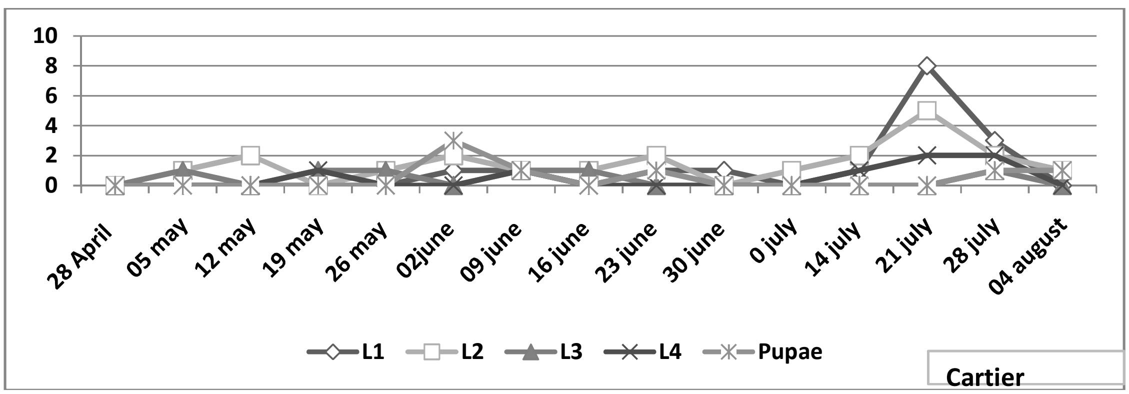
The first L_1 larvae is observed on May 26^{th} and three peaks are noted from this date. A single larva is observed over three consecutive weeks at the dates of 26 May, 02 and 09 June for the first peak and at the dates of 23 and 30 June for the second peak. The third peak with a maximum of 8 larvae L_1 is recorded on July 21^{st}, and from this date a gradual decline in L_1 is noted to cancel at the end of the study on the Cartier's variety. Second instars' larvae are observed for the first time on 05 May. 04 peaks are noted of which the first three corresponding to the dates of May 12, 02 and June 23 marked by 2 L_2 larvae and the fourth largest peak with 05 larvae. A gradual decline to a single larva is noticed at the last sampling week. The presence of 3rd instars' larvae is noted during the second week with a 3 invidious, 3 other peaks succeed one of which is noted a single larva L_3 recorded on May 19 for the first, 09 and 16 June for the second and July 28 for the third. No L_3 larva was observed during the last week of observation. It's only from the fourth week that the fourth instars' larvae is noted. 3 peaks are with 2 L_4 larvae for the last peak which spans two consecutive weeks on the dates of 21st and 28th July. No L_4 larvae were seen during the last week of observation.

In the first five weeks of the study no pupa is observed. The first 03 pupae are observed on June 2nd and only 2 pupae are counted during the last two weeks of observation (Fig. 4).

On the Tomallow variety, the 1st larvae of the 1st L_1 stage are observed on May 19th, then no larvae are observed during the following three weeks. From June 30, an increase in the number of L_1 is noticed to reach 10 larvae noted on July 21st. No L_1 is observed in the last week of the study.

The first larva of the 2nd stage L_2 is observed on May 26th and their absence is noticed during the first two weeks that follow. Two peaks are recorded on June 30 with 15 larvae and the other on July 21 with 16 larvae. A total absence of L_2 is noted during the last three weeks of observation. The third stage larvae L_3 are totally absent for the first 6 weeks of sampling. L_3 are noted between 09 June and 28 July to reach a peak of 11 larvae registered on 14 July. A total absence of L_3 is noted during the last three weeks of the study (Fig. 4).During the first five weeks of observation no fourth instars larva L_4 is noted. The first L_4 was recorded during the two consecutive weeks on June 2nd and July 9th and no larvae were noted within the next three weeks. The presence of L_4 larvae is noted in the July samples, with a maximum of 5 hoppers recorded on July 14th. L_4 are absent in the last three weeks.

The first pupa is noted on May 19th. During the period between May 26 and July 07, the presence of single pupae on June 23 is marked. One of 5 pupae is observed on July 14th. The absence of pupae during the last two weeks of observation is noted.



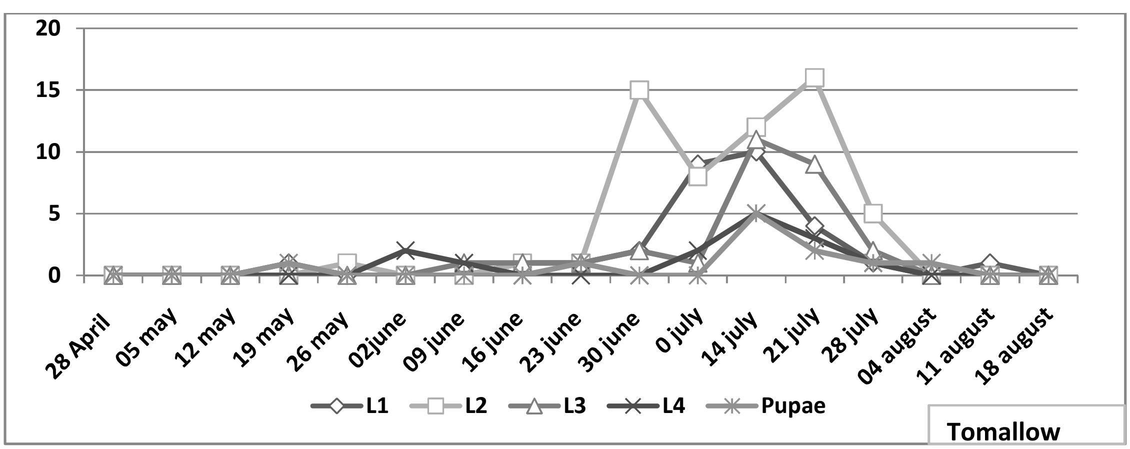
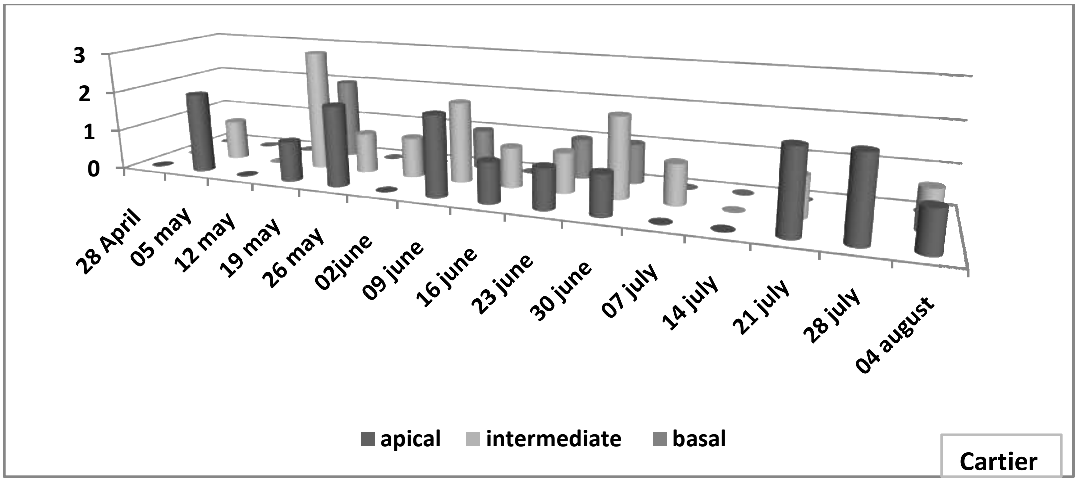


Figure 4: Temporal evolution of the number of the 4 larval and pupae stages of the two varieties Cartier and Tomallow.

Temporal evolution of egg distribution by height of plants in both tomato varieties

On the Cartier variety, the histogram clearly shows that the *T.absoluta* females prefer to lay on the intermediate leaves with respect to the other apical and basal leaves. On the Tomallow variety the histogram clearly shows that *T.absoluta* females prefer to lay on basal leaves compared to the other two leaf stages (middle leaf and base leaves) (Fig. 5).The upper and middle floors are the most infested by this pest, compared to the basal stage P=0,00425, these two stages are classified in the homogeneous group A by Newman and Keuls test



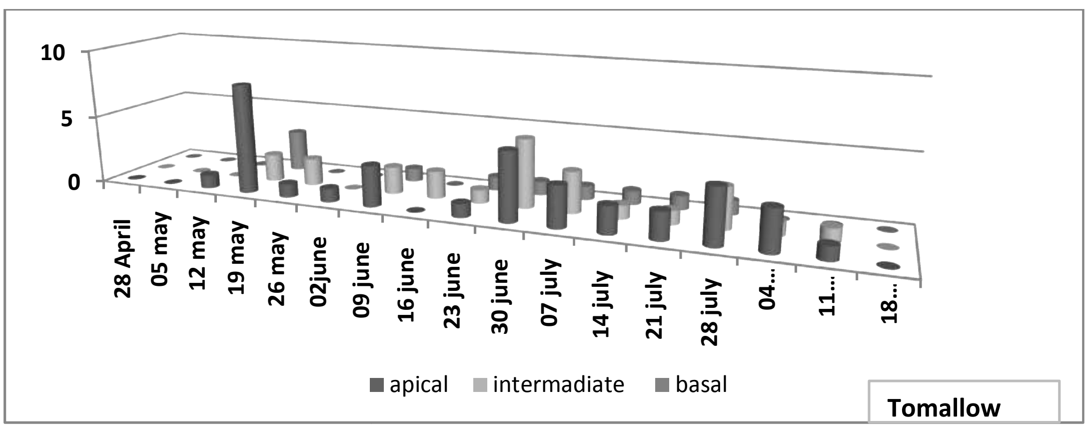


Figure 5: Temporal evolution of the distribution of eggs according to the height of the plants in the two tomato varieties Cartier and Tomallow.

4. DISCUSSION

Monitoring the population dynamics of the tomato leafmineris carried out on two tomato varieties under greenhouse Cartier and Tomallow. The sexual pheromone trap allowed the capture of 627 males on the Cartier and 666 males on the Tomallow variety respectively. The results obtained by the linear regression line show that temperature and humidity influence the number of adults caught in the greenhouse. Our results corroborate those of Estay (2009) who indicate that *T. absoluta* populations are not very active, do not mate and do not lay enough eggs at low temperatures.

Guenaoui (2008) shows that tomato leafminer populations are regulated by climatic factors, in particular temperature and humidity. Jacobson (2012) states however that 10°C is the lower end of the favorable temperature range for the development of this insect. Our results are comparable with the reports of producers in southern Italy who observed that the population of *T. absoluta* is large in the early summer and at its end with respite to summer, which also joins the results of Silva (2008). Reminding that the life span is 10 to 15 days for females and 6 to 7 days for males (Estay 2000).

According to Mahdi and al. (2011), *T. absoluta* is a polyvoltine species that can have 10 to 12 generations per year. The duration of the development cycle greatly depends on environmental conditions, with an average development time of 76.3 days at 14°C, 39.8 days at 19.7°C and 23.8 days at 27.1°C (Barrientos and al., 1998) Life span ranges from 10 to 15 days for females and 6 to 7 days for males. During the months of study, we found an overlap of generations on both varieties.

Viaene (1992) recalls that the duration of a generation depends on climatic factors and the host plant. Our results show the existence of 5 generations for the two varieties. Three generations have been highlighted on tomato under glass in Biskra (Algeria) (Allache and al., 2012). The overall analysis of the results obtained on the different larval stages on the two varieties reveals that the number of larvae of *T. absoluta* becomes more and more important, going from the beginning to the end of the culture. During our experiment, the larvae of the L_2 stage are the most frequent compared to the larvae of the 3 other stages L_1, L_2 and L_3. Larvae of the L_4 stage are less frequent, we counted an average number of 07 larvae for the variety Cartier and 13 larvae for the variety Tomallow, which is explained by the studies undertaken by Price (1984) which shows that during From the fourth stage, there is more competition for food so the larvae need to spread on the tomato plant and evolve. However, during our study the time between 02 successive samplings is one week, a sufficient time to allow the larva L_4 to turn into a chrysalis, this is confirmed by Trottin Caudal and al. (2010) who reports that at a temperature between 27°C and 30°C, the development time of larval stages is between 9.5 and 11 days. Indeed, throughout our sampling the average temperature in the greenhouse was 28.1°C.

Meriguet and Zagatti (2001) reported that pupation can occur on the ground, on the leaves or inside mines. For this reason, during our study, we noted a low presence of pupae on the leaves. As for the varietal preference, our results show the two varieties studied are attacked by *T. absoluta* with a preference for Tomallow variety on which the sampling time is longer, it is 17 weeks compared to the Cartier variety of 15 weeks before the total destruction of the crop by the damage caused by the leafminer which are observed on the foliage forming galleries and on the ripe and immature fruits by forming exit holes of the larvae of the last stadium. Shultz (1983) explains that the heterogeneity of foliage quality between leaf stages is binding for insects, making high quality foliage difficult to find. Larvae are forced to move frequently for quality foraging, this may explain the difference in spatio-temporal distribution of populations on both varieties and the three leaves. The reduced egg-laying on the apical leaves may be due to their exposure while the females are often looking for shelter to protect their eggs from various climatic contingencies. While Lacordaire and Feuvier (2010) found that the *T.absoluta* damage on the lower floors is significantly higher than the attacks of the middle and upper stages of the plant. On the other hand for Hunter and al. (1991) a higher infestation is observed more on the apical leaves than on the basal and intermediate leaves. The very high infestation rate could also be explained by migrations of the larvae to flee the aggressions either by stripping on basal leaves, heat or pesticides.

With regard to the lay rates on both upper and lower faces, the Newman and Keuls test allowed us to conclude that the females have a preference for laying on the lower faces for the two varieties Cartier and Tomallow, which is explained by the shelter that females provide to their eggs by fleeing the upper faces most exposed to the various external threats. According to Bodendörfer and al. (2011), which certify that it is often the underside that is most infested with respect to the upper surface of the leaves. In addition, Andrew and al. (2013) demonstrate that eggs are robust but are located in exposed positions on the leaf surface, where they are vulnerable to parasitoid attacks and moreover Torres and al. (2001). Indeed, at the time of egg laying, the female always selects the most favorable sites for the development of her offspring and for the protection of eggs from bad weather and predators.

Prophylactic measures and biotech control would be needed to assess the risks of *T. absoluta*. The results of the life cycle examination of this pest performed by Biondiand al. (2012) indicate that control measures should target larvae without touching the tomato. Urbaneja and al. (2012) propose several biological control agents that can attack larvae of *T.absoluta* in leaves including predatory bugs, *N.coristenuis* and *M.pygmaeus*. This non-polluting control method would regulate the attacks of this pest on the tomato crop, effectively without causing adverse effects on human health and the environment.

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