

Tuta Absoluta, The South American Tomato Leafminer

The South American tomato leafminer, *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae), is a serious and devastating pest of fresh market and processing tomatoes (fig. 1). *Tuta absoluta*, or *Tuta*, as it is also known, is thought to be native to South America. Currently, *Tuta* can be found in South America, southern Central America, southern Europe, northern Africa, the Middle East, and in localized parts of India (CABI 2016). *Tuta* is continuing to spread throughout the tomato-growing areas of the world (Desneux et al. 2010). Although it has not been reported in California or elsewhere in the United States, computer models that are used to match the life history of an invasive pest with climate and availability of host plants have predicted that *Tuta* has a moderate likelihood of establishing in the commercial tomato-growing regions of California, Arizona, and the southern United States (USDA 2011).

Tuta absoluta bores into tomato leaves, stems, flowers, apical buds, and fruit, resulting in less fruit set, poor plant structure, and unmarketable fruit. Crop losses can be as high as 80 to 100 percent, and insecticide costs may dramatically increase due to the need for additional insecticide applications (Lopez 1991; Estay 2000; Torres et al.



Figure 1. *Tuta* damage. Photo: J. Arno.

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2001; Desneux et al. 2011). Simply detecting the presence of *Tuta* in an area could lead to imposition of government regulations and quarantines that may restrict the movement of tomatoes. Both domestic and export markets may be closed to trade from those regions.

Adding to the threat posed by *T. absoluta* is the fact that this insect looks very similar to the tomato pinworm, *Keiferia lycopersicella* (Walshingham), another pest of tomato in the moth family Gelechiidae that is already found in California (fig. 2). Distinguishing *T. absoluta* adults from tomato pinworm adults requires dissection of the moth and careful observation of specific morphological structures. *Tuta*

larvae and tomato pinworm larvae are morphologically very similar, and the damage caused by the larvae of both *Tuta* and the tomato pinworm are also very similar (fig. 3). A molecular diagnostic tool has been developed that will assist in identification of all life stages of *Tuta* without having to rely solely on morphological characters. *Tuta* could be easily confused with tomato pinworm, once introduced into California. Because of this, growers with a leafminer problem in a tomato field should not assume that the problem is caused by tomato pinworm. Rather, they should submit a sample to their local county agricultural commissioner for expert identification. Detection of *Tuta* soon after its arrival in California will help to minimize its impact on tomato production and possibly slow its spread throughout the state.

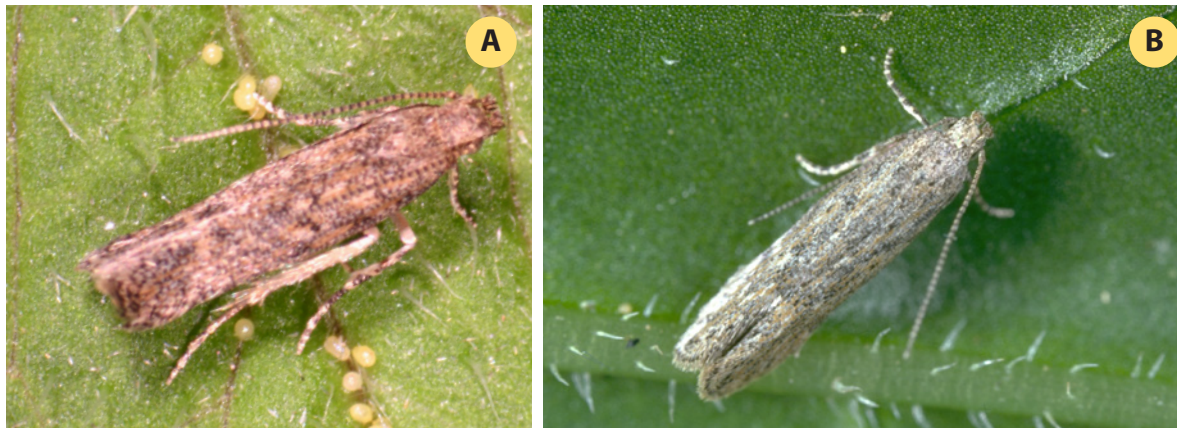


Figure 2. A. *Tuta* adult with eggs. Photo: J. Arno and R. Gabarra. B. Tomato pinworm. Photo: Jack Kelly Clark.

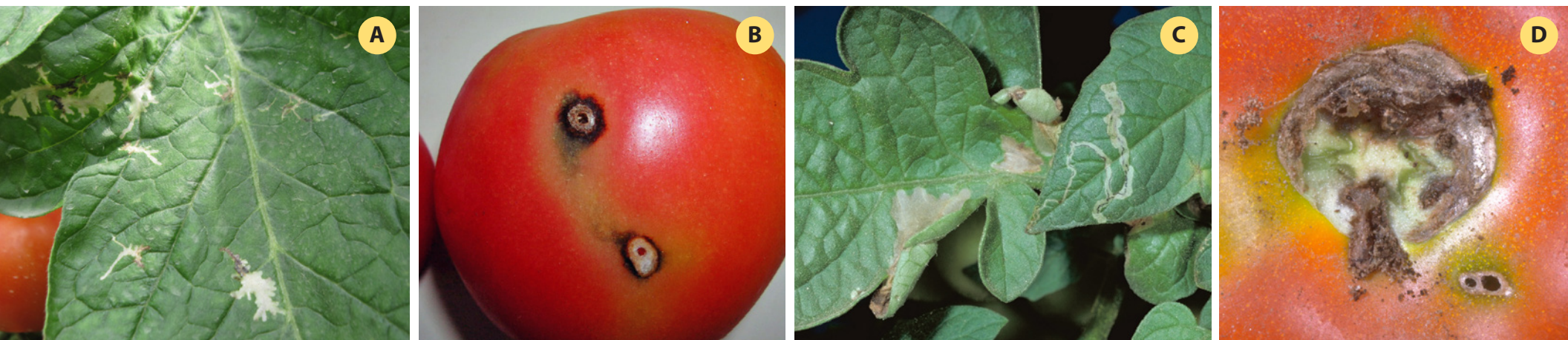


Figure 3. A. *Tuta* mines. Photo: J. Arno. B. *Tuta* fruit damage. Photo: J. Riudavets. C. Tomato pinworm mines. Photo: Jack Kelly Clark. D. Tomato pinworm damage. Photo: Jack Kelly Clark.

HOST PLANTS

Tuta absoluta prefers to feed, develop, and reproduce on tomato, but it can also use other solanaceous host plants (Desneux et al. 2010, 2011). *Tuta* will oviposit and develop on tomato, potato, black nightshade, eggplant, sweet pepper, jimsonweed, and deadly nightshade (Pereyra and Sanchez 2006; Desneux et al. 2010, 2011; Bawin et al. 2015). However, the number of eggs laid may be lower on some of the alternate hosts compared to tomato (Bawin et al. 2015). The rate of larval development may be slower and larval survival may be lower on some of the non-tomato crop plants and weed hosts (Bawin et al. 2015).

Figure 4.
Tuta eggs.
Photo: J. Arno.



LIFE CYCLE

Tuta adults are small, grayish moths that are $\frac{3}{16}$ inch long. The male moths live on average 26 days and female moths live 24 days at 77°F (Fernandez and Montagne 1990). The female moths begin laying eggs 2 to 3 days after emergence (Fernandez and Montagne 1990) and may lay between 60 and 260 eggs in their lifetime (Torres et al. 2001; CABI 2011). *Tuta* females deposit their eggs either singly or in small clusters on the surface of leaves, stems, buds, flowers, and fruit (fig. 4) (Coelho et al. 1984; Torres et al. 2001). The newly laid eggs are cream colored to bright yellow and darken as the eggs mature (Imenes et al. 1990). The eggs hatch in 4 to 6 days at 80.6°F (Barrientos et al. 1998).

The newly emerged larvae burrow under the epidermis of the plant part on which the egg is laid. On leaves, stems, buds, and flowers, larval feeding creates mines that increase in length and width as the larva grows (Vargas 1970). Late second instar and third instar larvae can occasionally be found moving about the surface of the plant, possibly searching for additional food resources. This movement exposes these larvae to a variety of mortality agents (Miranda et al. 1998). In a heavily infested leaf, the leaf tissue is completely consumed and becomes skeletonized (fig. 5). Late second instar and third instar larvae can occasionally be found outside of the mine, moving about the plant for a short period of time before



Figure 5. Leaf mines from *Tuta*.
Photo: Marina Lee.

Figure 6. *Tuta* larva. Photo: A. Mussoll.



Figure 7. *Tuta* pupa. Photo: J. Arno.



burrowing back into the plant tissue. On fruit, the larva burrows into the fruit and feeds within a gallery (Vargas 1970). The larvae are cylindrical in shape with a distinct head and legs (fig. 6). A larva completes four larval instars in 18 to 22 days at 80.6°F (Barrientos et al. 1998).

Prior to pupation, the fourth, or last, larval instar leaves the mine or fruit gallery and either drops to the soil surface or travels to the edge of a leaf, where it spins a silken cocoon in which to pupate (Vargas 1970; Barrientos et al. 1998). The pupa is oblong and brown (fig. 7) (Imenes et al. 1980). Adults emerge from the pupae in 5 to 8 days at 80.6°F (Barrientos et al. 1998).

The newly emerged female *Tuta* moths release a pheromone to attract a male moth for mating approximately a day after emerging from the pupae. This typically occurs around dawn (Vargas 1970). Female *Tuta* moths begin ovipositing about a day after mating (Fernandez and Montagne 1990). The moths are most active at dusk and dawn. During the day, they can be found resting on leaves and other plant parts. The moths are not considered strong fliers, although they may fly for short distances to find suitable hosts (Desneux et al. 2010).

Development from egg to adult requires 76 days at 57.2°F and 24 days at 80.6°F (Barrientos et al. 1998). Under warm environmental conditions, *Tuta* can complete up to 12 generations per year, but fewer can be expected in California. A degree-day model has been devised for *Tuta*; the lower developmental or baseline temperature for development from egg to adult is 46.7°F

(Barrientos et al. 1998). Development from egg to adult requires 827.3 Fahrenheit degree-days above 46.7°F (Barrientos et al. 1998).

DAMAGE

Tuta larvae damage tomato plants by feeding in mines on leaves, stems, apical buds, and flowers and in galleries inside the fruit. In leaves, the larvae feed just below the leaf's surface and remove the plant cells responsible for photosynthesis. The mines may become so large that the leaf becomes skeletonized, reducing the plant's ability to photosynthesize and produce fruit (Desneux et al. 2010). The feeding on the buds and flowers can result in abscission of buds and flowers, reduction of plant growth, poor plant architecture, and a loss of fruit set (Desneux et al. 2010). Fruit may be attacked at any stage, and the galleries created by the larvae may be invaded by pathogens resulting in rotting fruit (Desneux et al. 2010).

Tuta absoluta damages both processing and fresh-market tomatoes. Yield loss caused by loss of leaf tissue or by direct larval feeding on the fruit is the most obvious economic damage imparted by *Tuta*. Management costs may also increase once *Tuta* is present because growers must monitor for the presence of *Tuta* and possibly increase the number of insecticide applications made to a crop. In addition, some processing tomatoes may be downgraded or not accepted by processors because of the presence of *Tuta* in a load of fruit. The California Department of Food and Agriculture (CDFA) has set standards for the quality of processing tomatoes, and any load that has "worm" damaged tomatoes "in excess of two percent

by weight” can be rejected (CDFA 2016). Quarantines and other restrictions on the movement of tomato fruit and plants may be imposed both within California and the United States and with trading partners. This means that growers in affected areas may need to apply additional management measures before harvesting and moving fruit, may not be able to move fruit out of the area unless they comply with regulatory restrictions that may be enacted, or may experience a temporary loss of markets for their fruit outside of California.

MONITORING AND MANAGEMENT

Since *Tuta absoluta* has yet to be detected in California or elsewhere in the United States, no specific monitoring or management guidelines have been developed. However, it is useful to relate experiences from other regions that it has invaded.

In the 1970s and 1980s, *Tuta* began to spread throughout the tomato growing regions of South America (Desneux et al. 2010). At that time, growers predominantly used insecticides to manage *Tuta* densities, and applications were made every 7 to 14 days (Lietti et al. 2005). This quickly led to insecticide-resistant populations of *Tuta* (Siqueira et al. 2000; Lietti et al. 2005). Current pest management programs rely on conservation of natural enemies, removal of alternate host plants, timing the insecticide applications based on *Tuta* pheromone trap catches and a degree-day development model, and consideration of the expected risk of damage to the tomato crop (Desneux et al. 2010). Pheromone trap catches were shown to be correlated with pest infestations and crop damage in one study (Benvenega et al. 2007). This approach substantially reduced *Tuta* management costs in infested areas of South America and reduced the impact of the insecticide applications for *Tuta* on other insect pests (Desneux et al. 2011).

Research on the role of natural enemies on the population dynamics of *Tuta* has shown that indigenous arthropod predators and insect parasitoids attack *Tuta* eggs and larvae shortly after invasion into a new area (Zappala et al. 2013). These natural enemies are mostly generalist feeders and are being opportunistic

in using *Tuta* as a food source. Research is currently underway to exploit this opportunistic behavior of several species of the arthropod predators and insect parasitoids using multiple approaches, such as conservation or releases of the appropriate species of natural enemies (Zappala et al. 2013). Several of the species being studied are either found in California or have closely related species found in California.

Tuta absoluta was accidentally introduced into Spain in late 2006 (Urbaneja et al. 2007); despite quarantines, insecticide treatments targeting *Tuta*, and strict adherence to regulations, *Tuta* spread throughout the tomato-growing areas of Europe and North Africa in about 5 years (Desneux et al. 2010). It is thought that movement of *Tuta* was assisted by commercial trade of tomato plants and fruit despite the regulations. Eggs, very young larvae, or pupae may be present on tomato plants or in the fruit and escape detection since these life stages are extremely difficult to detect during inspections of plants or fruit. Tomato packing crates and other harvesting equipment may also harbor pupae or adult *Tuta*. Further, the insect may be moved by private individuals on infested plant material from home or community gardens (Desneux et al. 2010). Once present in an area, the moths can fly for short distances or possibly be carried by wind currents (Desneux et al. 2010). Similar scenarios could occur should *Tuta* be introduced into California.

IF YOU THINK YOU MIGHT HAVE FOUND *TUTA* IN CALIFORNIA

If you suspect that you have found *T. absoluta*, place the suspect insect in a sealed container and contact your local county agricultural commissioner’s office for identification. If the insect is confirmed to be *T. absoluta*, the extent of the infestation will be delineated and the appropriate regulatory actions will be taken to minimize the spread of *Tuta* from the infested site. Detection of *Tuta* very soon after its initial introduction into California will assist regulators and growers in implementing management tactics intended to limit the spread and impact of this pest.

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