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Holistic Pest Management for Tomato Leaf Miner, *Tuta absoluta*

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Introduction

Tomato (*Solanum lycopersicum*) are among the most extensively grown vegetable crops. Tomato are extremely nutritious, with high levels of Vitamin A and C, and hence serve a significant role in food security and nutrition. They are often consumed raw and are a fundamental element in many cuisines, sauces, salads, and beverages. Common tomato pests include whiteflies, american bollworm (*Helicoverpa armigera*), aphids, leaf miners, red spider mites, thrips and nematodes (CABI, 2015). Wilts, blights, leafspots, and mildew are all diseases that can impact tomato output. *Tuta absoluta*, often known as tomato leafminer, is an invasive insect pest that has recently severely impacted tomato crops.

T. absoluta is a small but very damaging pest that mostly targets tomato and other solanaceous plants. The insect is presently the greatest limiting factor in tomato output across the world. Without proper treatment, *T. absoluta* infestations can result in tomato production losses of up to 100%. *T. absoluta* mines the leaves of tomato crops, causing extensive harm. These mines are created by larvae (caterpillars). Leaf mines are broad, silvery, and eventually become brown and necrotic. Leaf necrosis can cause leaf death or premature leaf loss. Mines in the fruit can potentially cause fruit rot.

Symptoms and nature of damage

T. absoluta may infest tomato plants at any stage of growth, including seedlings and mature plants. The larvae damage the leaves, stems, flowers and fruits. The larvae eat in between leaf tissues, forming irregularly shaped mines (Figure 1). The mines grow in length and diameter as the larvae mature. When population levels are

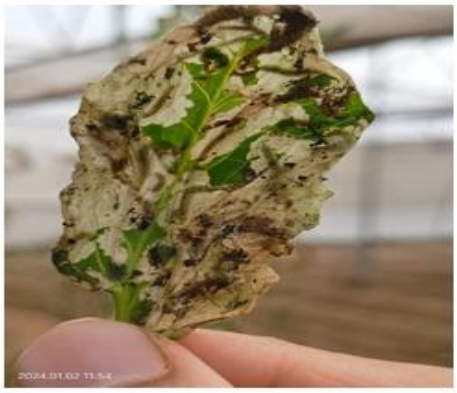

Figure 1: *T. absoluta* caterpillar eating away the green part of the leaf.

Figure 2: Tomato leaves drying up due to damage by *T. absoluta*

Figure 3: Blemishes on tomatoes as a result of *T. absoluta* damage lead to loss in market value.

Figure 4: Tomatoes rotting as a result of secondary infection following initial attack by *T. absoluta* larvae

high, leaf mines combine, causing whole leaves and stems to become brown and die (Figure 2).

This lowers photosynthetic ability, resulting in lower crop output. As the larvae eat, they discharge a large amount of frass. *T. absoluta* larvae often enter shoots at the apical end or the angle produced between the petioles and the leaves. The larva normally penetrates the fruit under the calyx and burrows into the flesh, clogging the galleries with frass. *T. absoluta* causes cosmetic harm to tomato fruits (Figure 3), while entrance holes serve as routes for viruses that cause fruit rot (Figure 4).

Integrated pest management methods for *T. absoluta*

1. **Monitoring**

Description: Place pheromone traps and sticky traps in desired locations around nurseries and fields at least two weeks before planting tomato crops (Figure 5).

Impact: Monitoring establishes early pest presence of the pest and provides information on pest populations.

How it works: Male moths are trapped in pheromone traps, when they are looking for females to mate with. Pheromone traps give an early warning of *T. absoluta* infestation, which is critical for decision making (Rwomushana *et al.*, 2019).

1. **Mass trapping**

Description: Place pheromone traps at densities of 20 to 25 traps

per greenhouse. Continue trapping for 3 weeks after harvest.
Impact: Long term reductions in the *T. absoluta* population

How it works: Pheromone traps attract and kill moths (Figure 6). The elimination of a large proportion of male moths reduces mating incidences and consequently, the number of viable eggs. With less or no hatching of *T. absoluta* eggs, the population is significantly reduced. Light traps use a specific wavelength of light in combination with sex pheromones to attract both male and female moths into a water-based trap (Witzgall *et al*., 2010

Figure 5: Delta trap in greenhouse, trap height is adapted according to the height of the plant

Figure 6: *Tuta absoluta* moths caught by sticky insert of a Delta

3.**Screenhouse**
Description: Grow tomatoes in net-houses or in greenhouses.

Impact: The use of nets can cause a 70% decrease in chemical sprays by farmers and a 35 - 70 percent increase in marketable yields of tomato (Figure 7).

Figure 7: Tomato grown in a net house

4. **Biological control**
Description: Use of natural enemies to control T. absoluta. Examples include larval parasitoid (Dolichogenidea gelechiidivoris), egg parasitoids (Trichogramma cacoeciae, Trichogramma bourarachae) and predatory mirid bugs (Nesidiocoris tenuis).
Impact: Reduction in leaf damage in greenhouse tomato after releasing adult parasitoids. Reductions of 87% and 78% in leaf damage, in greenhouse tomato, after releasing 25,000 adults of parasitoid Trichogramma cacoeciae or Trichogramma bourarachae respectively. Predatory mirid Nesidiocoris tenuis decreased the density of T. absoluta eggs in greenhouses. Dolichogenidea gelechiidivoris has an average parasitism rate of over 60%.
How it works: Parasitoid eggs develop inside T. absoluta larvae, and finally emerge as adult wasps, thereby killing T. absoluta larvae. Mirid bugs feed on T.

absoluta eggs and larvae (Rwomushana et al., 2019).

5. **Biopesticide**

Description: Utilizing pesticide formulations that consist of a microorganism (e.g. a bacterium, fungus, virus or protozoan) as the active ingredient.

Impact: The Entomopathogenic fungus Beauveria bassiana and Metarhizium anisopliae caused female moth mortality of 37% and 68%, respectively. Bacillus thuringiensis var. kurstaki is effective against T. absoluta larvae.

How it works: Metarhizium anisopliae infects the 4th instar larvae and adults of T. absoluta, which results in mortality and consequently reduces pupation and adult emergence. Three excellent M. anisopliae isolates are compatible with T. absoluta pheromone lure (TUA-Optima®), with potential to be used for autodissemination through "attract and infect" approach. Bacillus thuringiensis is able to infect all the larval instars of T. absoluta (Akutse et al., 2020).

6. **Field Sanitation**

Description: Destroy infected plants. Collect and dispose debris after harvest. Leave a minimum of 6 weeks after harvest and destruction of the tomato crop until planting the next crop. Check transplants for presence of tomato leafminer damage before field planting. Remove alternative hosts, e.g. Datura Solanum, and Nicotiana species.

Impact: Reduced infestation.

How it works: Destroying infected plants and plant parts helps to limit the possibility for the pest at a particular life-stage to develop to the next, and thus controlling the pest population. Inspecting transplants confirms there are no eggs, larvae or pupae that might develop and spread (Rwomushana et al., 2019).

7. **Crop rotation**

Description: Plant non-solanaceous crops after a tomato crop. Avoid overlapping tomato crops.

Impact: Prevents pest build up

How it works: Lack of a host plant breaks life cycle of Tuta absoluta (Rwomushana et al., 2019).

8. **Chemical control**: Spinetoram 11.70 % SC @ 9ml/10 litre of wate

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