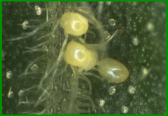
Tuta absoluta - The Tomato Leafminer or Tomato Borer

Recommendations for Sustainable and Effective Resistance Management







IRAC

Insecticide Resistance Management

The Insecticide Resistance Action Committee

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Recommendations for Sustainable and
Effective Resistance Management

September 2011

Foreword

Effective insecticide resistance management (IRM) in conjunction with integrated pest management (IPM) is vital to global crop protection, sustainable agriculture and improved public health, and it is an essential element of responsible product stewardship.

The Insecticide Resistance Action Committee (IRAC) was formed in 1984 and works as a specialist technical group of the industry association CropLife International to provide a coordinated crop protection industry response to prevent or delay the development of resistance in insect and mite pests. There are now IRAC country group committees in many parts of the world researching, and responding to local resistance issues, as well as the parent IRAC International group that provides a coordinating and supporting role at the global level (see also www.irac-online.org).

Developing new insecticides is becoming increasingly difficult and costly, so it is vital to protect those effective products in the market place from the development of resistance. Moreover, with fewer new insecticides being discovered and regulatory pressures reducing the number of older commercial chemistries available, the ‘toolbox’ of usable insecticides is being reduced, making effective IRM more important than ever.

Tuta absoluta, an Aggressive Pest

The tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) is a pest of great economic importance in several countries in Latin America and the Mediterranean basin. Its primary host is tomato, although potato, aubergine, common bean, physalis and various wild solanaceous plants are also suitable hosts.

Tuta absoluta, synonym *Gnoromoschema absoluta* (Clarke, 1962), *Scrobipalpula absoluta* (Povolny, 1964) is characterized by a high reproduction potential. Each female may lay up to 300 creamy-coloured eggs and 10-12 generations can be produced each year. In tomato, it can attack any plant part at any crop stage and can cause up to 100% crop destruction, although the larvae prefer apical buds, tender new leaflets, flowers, and green fruits.

This pest is crossing borders and devastating tomato production in both protected and open fields. Originating from Latin America, *T. absoluta* has recently spread via infested fruits and packaging material to Europe, North Africa and the Middle East. Given its aggressive nature and crop destruction potential, it has quickly become a key pest of concern in these new geographies.

Damage and Symptoms

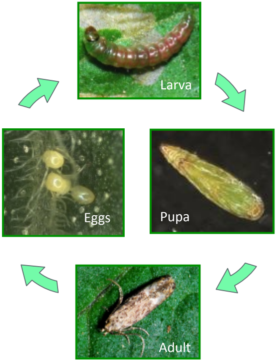
Infestation of tomato plants occurs throughout the entire crop cycle. Feeding damage is caused by all larval instars and throughout the whole plant. On leaves, the larvae feed on the mesophyll tissue, forming irregular leaf mines which may later become necrotic. Larvae can form extensive galleries in the stems which affect the development of the plants. Fruit are also attacked by the larvae, and the entry-ways are used by secondary pathogens, leading to fruit rot. The extent of infestation is partly dependent on the variety. Potential yield loss in tomatoes (quantity and quality) is significant and can reach up to 100% if the pest is not managed.





Insect Description and Life Cycle

Life Cycle



Larval developmental time (days) at different temperatures

14°C	76 days
20°C	40 days
27°C	24 days

Modified from Barrientos et al. (1998)

Tuta absoluta is a micro-lepidopteran insect. The adults are silvery brown, 5-7 mm long. The total life cycle is completed in an average of 24-38 days, with the exception of winter months, when the cycle could be extended to more than 60 days. The minimal temperature for biological activity is 4°C.

After copulation, females lay up to 300 individual small (0.35 mm long) cylindrical creamy yellow eggs, which are often found alongside the rachis. Freshly hatched larvae are light yellow or green and only 0.5 mm in length. As they mature, larvae develop a darker green color and a characteristic dark band posterior to the head capsule. Four larval instars develop. Larvae do not enter diapause when food is available. Pupation may take place in the soil, on the leaf surface, within mines or in packaging material. A cocoon is built if pupation does not take place in the soil. 10-12 generations can be produced each year. *Tuta absoluta* can overwinter as eggs, pupae or adults depending on environmental conditions. Under open-field conditions *Tuta absoluta* is usually found up till 1000 m above sea level.

High Risk of Insecticide Resistance Development in *Tuta absoluta*

Risk for Insecticide Resistance Development:

Pests like *Tuta absoluta*, with high reproduction capacity and short generation cycle, are at higher risk of developing resistance to insecticides. This risk increases significantly when management of the pest relies exclusively on chemical control with a limited number of effective insecticides available. This situation usually leads to an increase in the frequency of use and thus, increased selection pressure for resistance. *T. absoluta* has been a key pest in tomato in Latin America for decades and is resistant to a range of mode of action groups. Because of this resistance history, it is possible that introduced populations may express the same resistance profiles as found in Latin America.

IRAC´s aim is to facilitate networking between the industry and the scientific/advisory community, to promote resistance monitoring, and to advance the development and use of resistance management strategies. This will ensure a longer effective life of the available insecticide portfolio, including new product classes not yet widely used.

Global Resistance Status

Resistance status in Latin America vs. Europe, North Africa, and Middle East:

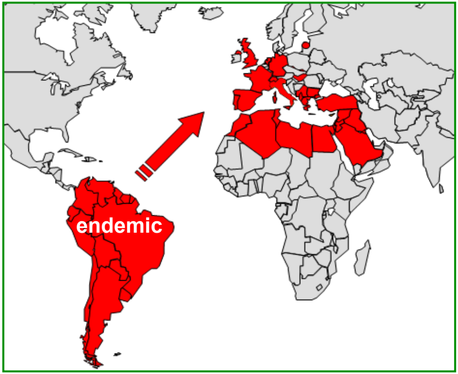
In Latin America, high level and widespread resistance is known to exist in field populations of *T. absoluta*, mainly to organophosphates (MoA group 1B), pyrethroids (MoA group 3A), chloride channel activators (MoA group 6) and benzoylureas (MoA group 15).

The resistance levels appears to be correlated with greater use of these compounds by growers and the resistance profiles seem to shift quickly with the pattern of insecticide use. The more prevalent resistance mechanisms appear to be metabolic in nature (increased activity of specific detoxification enzymes). In addition, there are suggestions that resistance may be polyfactorial and that several genes are involved. In Latin America, resistance has also developed to newer classes of insecticides introduced after the year 2000 (Silva et al. 2011).

Local Evaluation of Insecticidal Efficacy

Local evaluation of the insecticidal efficacy is very important and should be considered as the first step in any local management program:

Populations of *Tuta absoluta* currently present in Europe, the Middle East and North Africa were originally introduced from Latin America, where high levels of resistance have been documented to one or several insecticides. Because of this potential exposure history, it is possible that introduced populations express the same resistance profiles as found in Latin America. As a result, European populations of *Tuta absoluta* may already be moderately or highly resistant to one or more insecticides, even though these may not have been used in the newly infested regions. It is therefore critical that regional technical experts evaluate the efficacy of registered insecticides *before* recommending their use.



Geographical Distribution of *Tuta absoluta*
(reported presence as of Dec. 2010)

Key Management Strategy - Integration of Control Measures

The basis for effective and sustainable management of *Tuta absoluta* is the integration of cultural, behavioural, biological and chemical control.

Key Management Tactics

- Allow a minimum of 6 weeks from crop destruction to planting the next crop to prevent carry-over of the pest from previous crop.
- Between planting cycles, cultivate the soil and cover with plastic mulch or perform solarisation.
- Control weeds to prevent multiplication in alternative weed host (especially *Solanum, Datura, Nicotiana*).
- Prior to transplanting, install sticky traps.
- Use pest-free transplants.
- Seal greenhouse with high quality nets suitable for *T. absoluta.*
- Place pheromone-baited traps to monitor all stages of tomato production, i.e. nurseries, farms, packaging, processing and distribution centers. Start monitoring 2 weeks before planting.
- Inspect the crop to detect the first signs of damage.

Biological control

Oil trap

Sticky trap

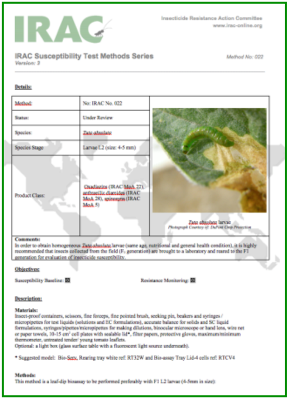
Key Management Strategy - Integration of Control Measures

Key Management Tactics

- As soon as more than 3-4 moths per trap are captured each week, start mass trapping of moths.
- For mass trapping of moths, use sticky traps or water + oil traps (20-40 traps/ha) baited with pheromone.
- Keep using pheromone traps for at least 3 weeks after removing the crop; this catches remaining male moths.
- Remove and destroy attacked plant parts.
- Establish populations of effective biological control agents (*e.g. Nesidiocoris tenuis, Necremnus, Trichogramma, Macrolophus, Pseudoapanteles, Podisus, Nabis / Metarhizium*).
- Use locally established thresholds to trigger insecticide applications.
- Select insecticides based on known local effectiveness and selectivity.
- Rotate insecticides by MoA group, using a window approach (see page 13 & 14).
- Use only insecticides registered for control of *T. absoluta* or lepidopteran leaf miners and always follow the directions for use on the label of each product.
- Maintain population levels below economic threshold.

Evaluation of Insecticide Susceptibility – IRAC Method No. 022

Evaluation of Insecticide Susceptibility: IRAC has a standard "leaf-dip" larval bioassay method to assess susceptibility of field populations to insecticides. Please, refer to IRAC method No. 022 on the IRAC Website (www.irac-online.org).



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IRAC Susceptibility Test Methods Series
Version: 3

Method No: 022

Details:

Method:	No: IRAC No. 022	
Status:	Under Review	
Species:	*Tuta absoluta*	
Species Stage	Larvae L2 (size: 4-5 mm)	
Product Class:	Oxadiazine (IRAC MoA 22), anthranilic diamides (IRAC MoA 28), spinosyns (IRAC MoA 5)	*Tuta absoluta* larvae *Photograph Courtesy of: DuPont Crop Protection*

Comments:
In order to obtain homogeneous *Tuta absoluta* larvae (same age, nutritional and general health condition), it is highly recommended that insects collected from the field (F_0 generation) are brought to a laboratory and reared to the F1 generation for evaluation of insecticide susceptibility.

Objectives:

Susceptibility Baseline: ☒ Resistance Monitoring: ☒

Description:

Materials:
Insect-proof containers, scissors, fine forceps, fine pointed brush, seeking pin, beakers and syringes / micropipettes for test liquids (solutions and EC formulations), accurate balance for solids and SC liquid formulations, syringes/pipettes/micropipettes for making dilutions, binocular microscope or hand lens, wire net or paper towels, 10-15 cm^2 cell plates with sealable lid*, filter papers, protective gloves, maximum/minimum thermometer, untreated tender/ young tomato leaflets.
Optional: a light box (glass surface table with a fluorescent light source underneath).

* Suggested model: Bio-Serv, Rearing tray white ref: RT32W and Bio-assay Tray Lid-4 cells ref: RTCV4

Methods:
This method is a leaf-dip bioassay to be performed preferably with F1 L2 larvae (4-5mm in size):

Insecticide Resistance Management (IRM): The recommendations for sustaining the effectiveness of available insecticides is centred on integration of as many pest management tools as possible, use of insecticides only when needed based on established thresholds, and rotation of effective insecticides with different modes of action (MoA).

Mode of Action Window Approach

Mode of Action Window Approach:

- The basic rule for adequate rotation of insecticides by mode of action (MoA) is to avoid treating consecutive generations of the target pest with insecticides in the same MoA group, by using a scheme of "MoA treatment windows".
- A treatment window is here defined as a period of 30 consecutive days, based on the minimum duration of a single generation of *T. absoluta*.
- Multiple applications of the same MoA or different MoA's may be possible within a particular window (follow label for maximum number of applications within a window and per crop cycle).
- After a first MoA window of 30 days is completed and if additional insecticide applications are needed based on established thresholds, different and effective MoA's should be selected for use in the next 30 days (second MoA window). Similarly, a third MoA window should use different MoA's for the subsequent 30 days etc.
- The proposed scheme seeks to minimize the selection of resistance to any given MoA group by ensuring that the same insecticide MoA group will not be re-applied for at least 60 days after a window closes, a wise measure given the potential of a longer life cycle based on temperature fluctuations throughout the growing season.
- This scheme requires a minimum of three effective insecticide MoA groups but ideally more MoA groups should be included, if locally registered and effective against *T. absoluta*.

Mode of Action Window Approach

Example: Insecticide Mode of Action (MoA) "Window" Approach – 150 Day Cropping Cycle

0-30 days	30-60 days	60-90 days	90-120 days	120-150 days
MoA x	Do not apply MoA x		MoA x	Do not apply MoA x
Do not apply MoA y	MoA y	Do not apply MoA y		MoA y
Do not apply MoA z		MoA z	Do not apply MoA z	

Sequence of Mode of Action (MoA) Windows throughout the season →

Notes:

•Within a "window" (MoA x, y or z in the diagram above) more than one application of the same MoA or different MoA's can be applied if necessary and depending on label advice, as long as these MoA's are not re-applied for 60 days as indicated above.

•Following the "window rotation scheme" example above, use as many effective MoA groups as locally registered and available and always follow product labels for specific directions of use.

•For a comprehensive list of existing insecticides classified by MoA group visit the IRAC website (http://www.irac-online.org/teams/mode-of-action).

Insecticide MoA Groups for the Control of *Tuta absoluta*

Group	Mode of Action	Chemical Class	Common Names (e.g.)
1B	Acetylcholinesterase (AChE) inhibitors	Organophosphates	Chlorpyrifos, Methamidophos
3A	Sodium channel modulators	Pyrethroids	Bifenthrin, Cyfluthrin, *beta*-Cyfluthrin, *gamma*-Cyhalothrin, *lambda*-Cyhalothrin, Cypermethrin, *alpha*-Cypermethrin, *beta*-Cypermethrin, *zeta*-Cypermethrin, Delthamethrin, Esfenvalerate, Etofenprox, *tau*-Fluvalinate, Fenpropathrin, Permethrin
5	Nicotinic acetylcholine receptor (nAChR) allosteric modulators	Spinosyns	Spinetoram, Spinosad
6	Chloride channel activators	Avermectins, Milbemycins	Abamectin, Emamectin benzoate
11	Microbial disruptors of insect midgut membranes and derived toxins		*Bacillus thuringiensis aizawai, Bacillus thuringiensis kurstaki*
13	Uncouplers of oxidative phosphorylation via disruption of the proton gradient	Pyrroles	Chlorfenapyr
14	Nicotinic acetylcholine receptor (nAChR) channel blockers	Nereistoxin analogues	Cartap
15	Inhibitors of chitin biosynthesis, type 0	Benzoylureas	Diflubenzuron, Flufenoxuron, Lufenuron, Novaluron, Noviflumuron, Teflubenzuron, Triflumuron,
18	Ecdysone receptor agonists	Diacylhydrazines	Chromafenozide, Methoxyfenozide, Tebufenozide
22A	Voltage-dependent sodium channel blockers	Oxadiazine	Indoxacarb
22B	Voltage-dependent sodium channel blockers	Semi-carbazone	Metaflumizone
28	Ryanodine receptor modulators	Diamides	Chlorantraniliprole, Flubendiamide
UN	Compounds of unknown or uncertain MoA	Tetranortriterpenoid	Azadirachtin

Notes on the MoA Groups for the control of *Tuta absoluta* are on the next page

Notes on the MoA Groups for the control of *Tuta absoluta:*

The list on the previous page includes all insecticide groups that have at least one registration for control of *Tuta absoluta*. Not all listed products are registered or available in all countries. In addition, efficacy levels may vary by region and should be evaluated locally, prior to their inclusion in local management programs. Always follow the directions for use on the product label.

Photographs:

Photographs are courtesy of Bayer CropScience, DuPont and CropLife International

References:

Barrientos ZR, Apablaza HJ, Norero SA & Estay PP (1998): Threshold temperature and thermal constant for development of the South American tomato moth, *Tuta absoluta* (Lepidoptera, Gelechiidae). *Ciencia e Investigacion Agraria* **25**, 133 –137 (in Spanish).

Silva G A, Picanço M C, Bacci L, Crespo A L B, Rosado J F, Guedes R N C. (2011): Control failure likelihood and spatial dependence of insecticide resistance in the tomato pinworm, *Tuta absoluta*. *Pest Management Science* DOI 10.1002, ps.2131

Further information is available from the IRAC website at:
www.irac-online.org

or by email at:
enquiries@irac-online.org

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