Pest status

*Tuta absoluta* is a serious moth pest, primarily in tomatoes but also reported potatoes.

![Fig 1: damage on tomato leaves and fruit by Tuta absoluta](image)

Solanaceous weeds are also a host, including *Solanum nigrum* (black nightshade), which is cultivated as a leafy vegetable crop in East Africa. It is an EPPO quarantine pest within its 50 member states in the European and Mediterranean area.

![Fig 2: damage on potato tubers by Tuta absoluta](image)

If uncontrolled, it can cause 100% crop losses in tomatoes. Severe damage in other crops is not frequently reported. On the equator, with all year round growing conditions the moth will not go into diapause and will probably have 12 overlapping generations per year. In Kenya, a generation may take 3 to 5 weeks to complete, depending on seasonal temperatures and whether the tomatoes are field grown or a greenhouse crop.
**Distribution**

Over the last decade its pest status has increased in importance as it has migrated into new territories. Originally reported in South America and S.E Asia, it is now moving south from the lower Mediterranean shores into Africa. It caused serious economic damage in Ethiopia two years ago and is now present in Kenya.

**Importance of IPM**

Pesticide resistance and lack of awareness of growers of its potential economic impact are two important contributing factors in extreme crop loss cases. Growers need to be able to identify the symptoms of attack by Tuta absoluta and be ready to take immediate action.

However, increasing resistance to chemical pesticides in South America emphasize the importance of an IPM programme in a Resistance Management strategy. Tuta absoluta control should be examined as part of an IPM programme for all pests and diseases of tomatoes.

**Real IPM Resistance Management Workshop for Tomatoes**

Contact your Real IPM Consultant to organize a local Resistance Management Workshop on tomatoes.  info@realipm.com

The workshop covers identification and control of all major pests and diseases in tomatoes and provides growers with the information needed to implement a Holistic IPM programme for tomatoes.

Course fee: 30,000/- per group of up to 30 growers (one day course).
**LEAF DAMAGE SYMPTOMS**

Tuta larvae feed within the leaf lamina, causing severe loss of photosynthetic capability. The leaf lamina remains intact. Tuta feeding creates a wide, irregular mine. Leaf damage can be so severe as to cause defoliation and death of the plant (top left).

Tuta damage should not be confused with mines made by the leafminer fly (*Liriomyza* spp), which are narrower and more circuitous. (centre left)

Leaf scorch at the margin of leaves can be due to guttation of water in the early morning and subsequent high temperatures. This will cause the leaf to ‘burn’. This is not Tuta damage. (bottom left)
FRUIT DAMAGE SYMPTOMS

Eggs are sometimes laid on young fruit near the calyx end.

After maturing the fully fed larvae may exit the fruit and pupate on the fruit stalk.

See the exit hole in the fruit and the pupae at the base of the fruit stalk. (top left)

Eggs may also be laid where two fruits are lying close together. (centre left)

Dark frass (caterpillar excrement) can be seen near the entry hole. The larvae will be found inside the fruit on dissection (bottom left)
LIFE CYCLE

Each female lays up to 260 eggs. Eggs are generally laid, singly, on both surfaces of the leaves and other parts of the plant. (top left)

They are white to yellow in colour and hatch within 4 to 5 days

Young neonate larvae (top right) will feed for a short time outside the leaf, stem or fruit before tunneling into the plant part.

The first instar caterpillar, newly hatched, is the only mobile feeding stage outside of the leaf. It has a cream colour with a dark black/brown head.

It will bore into nearby plant parts, including the stem (below left)

Photo credits: www.tutaabsoluta.com
LIFE CYCLE

There are four instar development stages within the leaf, which change in colour ranging from greenish to light pink. (above)

When the larva is fully mature, within about 2 weeks, it will either pupate within the leaf, on the leaf surface or drop to the soil to pupate. (top right) Pupae are brown in colour and it will take 9 to 11 days for an adult moth to emerge (bottom right)

Photo credits:
www.tutaabsoluta.com
BEHAVIOUR

The mating behaviour of *Tuta absoluta*, like other moths, is mediated by female sexual pheromones, which attract males. The *Tuta absoluta* female pheromone has been synthesized and is used for monitoring and mass-trapping.

*Monitoring*

The pheromone is impregnated into a rubber septa and placed in a trap with a sticky paper or a water tray to kill the adults attracted to this focal point. A new lure must be replaced every 4 to 6 weeks.

*Tuta absoluta* moth numbers increase immediately after the new lure is placed in the field, even if there is no difference in the real number of adults present. This can provide ‘false’ information about the impact of crop protection measures on the local populations of the pest.

To overcome this problem, it is advised that the grower place several lures in a staggered time sequence, so that they are of different ‘ages’ and to use average figures from the trap counts to assess the overall level of the pest on a larger farm area.

Water traps, fitted with these pheromone lures will catch a lot of *Tuta* male moths, but researchers have found that it can also attract non-pest moths such as *Blastobasis lignea* and two species of *Brytropha* spp. This makes it more complicated, for a grower to separate out the different moth species and focus on the information needed for the *Tuta absoluta* alone.

The treatment thresholds for *Tuta absoluta* have not yet been established for use with the female sex pheromone.

*Mass trapping*

The pheromone has been used successfully in ‘high containment’ greenhouses as a mass-trapping tool. This involves using more lures than usually deployed for monitoring. Mass trapping only seems to work well in ‘high containment’ - these are greenhouses, which have heavily screened vents and doors, allowing little moth movement in and out of the crop.

However, mass trapping is not as successful in ‘light containment’ greenhouses or in field crops, which comprise the majority of crop situations. In a low containment greenhouse, the mass trapping was more effective when combined with biological control tools.

The ability of *Tuta* males and females to mate and re-mate at regular intervals appears to reduce the efficacy of mass trapping of males on female

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reproduction in field crops.

Bearing in mind the above cautionary note on the interpretation of pheromone trap data; mass-trapping experiments\(^2\) in Tunisia revealed that there was no significant difference in trap counts with trap densities varying from 20 to 80 traps per hectare. The lack of any statistical difference was considered a result of the high migration of adults from field to field.

Growers should be aware of the risk of attracting Tuta absoluta into field by using pheromone lures. The data on

*Parthenogenic females*

Scientists\(^3\) have also discovered that some female Tuta absoluta are able to reproduce pathogenically (without males). This emphasizes the point that the use of mass trapping needs to be part of a wider IPM programme.

*Mating period*

Females will mate within a day of emerging from the pupae.

Mating usually occurs at dawn. Most males are caught in traps between 7.00 to 11.00 am – when they are naturally searching for females to mate with. (Miranda-Ibarra, 1999). Larvae normally hatch from the egg in the early hours of the morning.

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\(^2\) “The use of the mass trapping technique to control the tomato borer, Tuta absoluta”. Mohamed BRAHAM, Ameni BENDHIEFI and Lassad CHTIWI Centre Régional de recherche en Horticulture et en Agriculture Biologique. 4042. Chott-Mariem. Sousse. Tunisia

\(^3\) Capaross Megido et al (2012)

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\(^4\) “Potential of mass trapping for Tuta absoluta management in greenhouse tomato crops using light and pheromone traps” IOBC-WPRS Bulletin Vol 80. 2012 pp 319-324 A. Cocco et al
**Black sticky traps**

Syngenta Bioline conducted trials in 2013 to test Black Sticky Traps as a new tool for capturing *Tuta absoluta* in tomato crops. High capture rates were achieved.

Correct placement of the traps is critical for success. Traps placed at 15-20cm above the ground captured 5 times as many pest adults as traps placed at 1m above the ground.

Another benefit is that they do not attract predators of the *Tuta absoluta* such as *Nesidiocoris*
**BIOLOGICAL CONTROL**

There are many naturally occurring enemies of *Tuta absoluta*. They play an important regulatory role in the IPM of this pest. Many of these natural enemies are also reared commercially and sold to growers for use in crop protection programmes. There is a lot of information on the use of these biological control agents in greenhouse tomatoes in Europe and South America.

**NATURAL ENEMIES**

Researchers\(^5\) have confirmed that the migration of indigenous local natural enemies of *Tuta absoluta* in the Mediterranean region have been a key factor in the decline in importance of this pest after the initial 2 to 3 years.

*Conserve Natural enemies of Tuta absoluta*

Natural enemies of *Tuta absoluta* already exist in Africa too but may not be present in the field in sufficient numbers, at the time when the adult Tuta moths move into the crop and begin laying eggs. Natural enemies such as predatory mites and bugs as well as parasitic wasps usually migrate into a crop in high numbers, only when there is a lot of the specific prey present. This may be too late to prevent damage occurring.

However, there are many scientific reports of the importance of these natural enemies in stabilizing the *balance of nature* in a region to reduce the risk of epidemics in the medium to longer term.

In the short term - introducing mass-reared natural enemies is one solution to the problem of not having ‘enough’ natural enemies present in the crop before the problem gets too bad. However, both the introduced natural enemies and those, which might migrate into the crop, are sensitive to chemical pesticides, which may have been applied to the crop. Pyrethroids (e.g. alpha cypermethrin, deltamethrin, cypermethrin etc.) can kill up to 75% of many natural enemies and the harmful effect could last for up to 12 weeks after a single spray. This means they cannot contribute to crop protection, because they die when they move into the crop.

Mass produced natural enemies can be expensive to produce and therefore the grower must be aware of the importance of using compatible pesticides that do not kill the introduced natural enemies or those which may try to migrate into the crop from the local environment.

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\(^5\)Prospects for the biological control of *Tuta absoluta* in tomatoes of the Mediterranean basin Alberto Urbaneja\(^1\)*, Joel González-Cabrera\(^3\), Judit Arnó\(^2\) and Rosa Gabarra\(^2\)

Article first published online: 25 JUN 2012 Society of Chemical Industry

[www.realipm.com](http://www.realipm.com)
Holistic IPM programme for tomatoes

*Tuta absoluta* crop protection strategies must not be considered in isolation. The chemical pesticide, which a grower sprays for whitefly or thrips, also needs to be compatible with the natural enemies of *Tuta absoluta*. The crop protection programme for all tomato pests and diseases needs to be compatible with the natural enemies of *Tuta absoluta*. There needs to be a holistic approach to the Tuta invasion.

Kenyan produced IPM solutions

The good news is that it is possible to use biological control agents already mass-produced in Kenya for all the pests and diseases in tomatoes. All that is needed, is an Extension of Label Registration for these products so that growers can immediately implement a full IPM programme in tomatoes. Real IPM is conducting in-house experiments with key tomato growers to confirm the efficacy of their products on tomatoes. Information on IPM is already available in the Real IPM one-day training course on ID and control of pests and diseases in tomatoes.

Which natural enemies are important?

The recent *Tuta absoluta* Symposium at KARI (July 2014) identified a number of natural enemies and bio-pesticides, which would be useful in an IPM programme for *Tuta absoluta*. The sensitivity of these natural enemies to chemical pesticides is detailed in the Table below.

*Nesidiocoris*

This bug is indigenous in Kenya and is also commercially reared and has been widely released in Spain against *Tuta absoluta* in tomato crops. It has also been recorded in S.E Algeria.

However, caution is recommended as it has been recorded as causing serious economic damage to tomato plants if it is present in large numbers in a tomato crop, when their prey (whitefly, caterpillars etc.) have been controlled. *Nesidiocoris* is known to also feed on plants themselves, particularly the growing points and trusses. Natural migrations of *Nesidiocoris* are unlikely to be of any risk to tomato crops, because the numbers of bug will be much lower than a large inundative release of a commercial product.

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6 "Complex of natural enemies and control methods of the exotic invasive pest *Tuta absoluta* (Lepidoptera: Gelechiidae) in Southern Algeria" A. Dahliz et al (INRAA), BP 17, Touggourt (Algeria)

7 HDC Project PC 203 (2010) Rob Jacobson
**Macrolophus spp**

Both *Macrolophus pygmaeus* and *M. caliginosus* have been observed feeding on young Tuta caterpillars. Macrolophus can be a common insect in natural vegetation and has been recorded as becoming established inside tomato greenhouses in Northern Europe. Both *Nesidiocoris* and *Macrolophus* have been observed in Kenya.

![Nesidiocoris adult (left) Macrolophus (right)](image)

**Trichogramma – caterpillar egg parasitoid**

A number of Trichogramma species are mass reared in Europe and recent trials have identified *T. achaeae* (below) as being the most effective. They must be released in very high numbers however to be effective. *Trichogramma* is normally introduced onto crops as an irradiated Ephestia caterpillar egg – parasitized by the Trichogramma wasp. These wasps are extremely sensitive to broad-spectrum chemicals and can only be used in a spray programme that has been carefully designed to conserve *Trichogramma*.

![Trichogramma laying egg into a caterpillar egg (left)](image)

*Trichogramma* parasitoids may not[^8] build up populations on the *T. absoluta*-tomato system, but *Trichogramma* parasitoids can be used in combination with *M. pygmaeus* to enhance biological control of the pest in tomato crops.

[^8]: Journal of Economic Entomology 106(6):2310-2321. 2013 Suitability of the Pest—Plant System *Tuta absoluta* (Lepidoptera: Gelechiidae)—Tomato for *Trichogramma* (Hymenoptera: Trichogrammatidae) Parasitoids and Insights for Biological ControlAnaïs Chailleux, Antonio Biondi, Peng Han, Elisabeth Tabone, and Nicolas Desneux
Amblyseius spp

Both Amblyseius swirski and A. cucumeris have been observed feeding on very young Tuta caterpillars. In laboratory studies these and other predator mites have fed upon the eggs of Tuta absoluta. However, they are generalist predators and cannot complete their life cycle on Tuta eggs alone. If used as part of an IPM strategy for Tuta absoluta, they will probably have to be used prophylactically as a control for whitefly or thrips, respectively.

Amblyseius feeding on a thrips juvenile.

(right)

Real IPM Kenya, mass produces a range of Amblyseius predatory mites.

Entomo-pathogenic nematodes (epns)

Insect killing nematodes are mass-produced commercially and have been used in high value protected crops against a range of pests. The high cost of epns may limit the practical benefit of this expensive biological control in outdoor tomatoes or protected tomato crops, at certain times of year.

BIO-PESTICIDES

Bio-pesticides are biological crop protection products manufactured from naturally occurring fungi, bacteria and viruses.

Metarhizium anisopliae

Scientists have recorded\(^9\) complete control of Tuta absoluta pupae in laboratory bioassays with another commercial Metarhizium isolate at $5.58 \times 10^9$ viable conidia per liter. Scientists in Algeria\(^10\) have reported similar results with Metarhizium.

The eggs and early instars of Tuta absoluta were also readily infected and killed by

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\(^10\)“Complex of natural enemies and control methods of the exotic invasive pest Tuta absoluta (Lepidoptera: Gelechiidae) in Southern Algeria”  A. Dahliz et al (INRAA), BP 17, Touggourt (Algeria)
*Metarhizium anisopliae*. In studies\textsuperscript{11} carried out in Turkey, scientists compared the efficacy of *Beauveria bassiana* and *Metarhizium anisopliae* on *Tuta* eggs and first instar larvae; these entomo-pathogens provided from 42 – 67% and 92 to 100% control of *Tuta* larvae respectively. Only *Metarhizium* seemed to be effective against the *Tuta* egg stage – providing 92% control, whilst *Beauveria* provided only 12.5% control of *Tuta* eggs. These results show the potential of *M. anisopliae* to control pupae of the tomato leafminer in integrated pest management programs.

The commercial isolate Met69 is Registered in Kenya, South Africa Ethiopia and Ghana. It is produced in two formulations: a total fermented product and a pure spores-in-oil product.

![Fruit fly adult infected with Metarhizium (left)](image)

Since Met 69 is able to kill fruit fly, thrips, whitefly and mealybug – a prophylactic programme for these pests is likely to help prevent ad-hoc establishment of *Tuta absoluta* in the crop.

*Bacillus thuringiensis*

The mode of action of *Bacillus thuringiensis* is by contact and ingestion of a lethal dose by the caterpillar. Therefore the only life stage that is likely to be affected by *Bacillus thuringiensis* is the first instar, free -living stage.

Due to the many over-lapping generations of *Tuta absoluta*, this will require a very intensive spray programme to be provide sufficient cover of the vulnerable life stage. This raises questions of resistance management and cost-effectiveness of the programme.

\textsuperscript{11}Effects of entomopathogenic fungi, *Beauveria bassiana* (Bals.) and *Metarhizium anisopliae* (Metsch.) on larvae and egg stages of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). İnanlı, C.; Yoldaş, Z.; Birgüçü, A. K.Ege Üniversitesi Ziraat Fakültesi Dergisi 2012 Vol. 49 No. 3 pp. 239-242
**COMPTAIBLE SPRAY PROGRAMMES**

If a compatible pesticide programme is used, the above natural enemies may move into the crop and contribute to crop protection. For more information about these natural enemies attend the Real IPM one-day IPM in tomatoes training.

**Resistance to chemical pesticides**

There are widespread records$^{12}$ of resistance of Tuta absoluta in South America and elsewhere to a range of insecticides including spinosad, abamectin, bifenthrin, cartap, deltamethrin, diflubenzuron, indoxacarb, permethrin, teflubenzuron and triflumuron.

A resistance management strategy for Tuta absoluta is critical in the search for a sustainable solution to Tuta absoluta in the medium to long term.

The new active ingredient which is likely to be the mainstay of the IPM programme is chlorantraniliprole (trade names: Renaxypyr, Coragen) from Dupont. At present there are no records of resistance of Tuta absoluta to this active ingredient. Because it is also known to be compatible with natural enemies, it is critical that an IPM programme is designed to protect the activity of this active ingredient. Possible resistance management strategies could be:

1. Label restrictions on the total number of sprays to be permitted per season per crop.
2. Enforced recommendations to alternate the active ingredient with an alternative chemical product from an entirely different IRAC chemical group [www.irac-online.org](http://www.irac-online.org). But the product with which Coragen is alternated must ALSO be compatible with natural enemies.
3. Tank mix critical chemicals such as Coragen with a bio-pesticide such as Metarhizium – to provide both a synergistic effect (greater than the individual products applied separately) and also part of a resistance management strategy.

**Understanding the Tuta Chemicals**

**Spinosad** (Tracer) Dow Chemicals

Spinosad is an insecticide derived from naturally occurring soil fungi, permitted in organic and conventional crop protection. High volume sprays of spinosad have proved$^{13}$ effective against *Tuta absoluta* larvae within the leaf. Death of Tuta larvae occurred within 6 days. Preliminary studies$^{14}$ have indicated that spinosad can provide control for up to 5 weeks, after being applied in hydroponic tomatoes through the irrigation system. No pesticide residue tests have been carried out on the fruits

$^{12}$Arthropod Pesticide Resistance Database [www.pesticideresistance.org](http://www.pesticideresistance.org)
$^{13}$HDC Project PC 203 (2010) Rob Jacobson
$^{14}$HDC Project PC 203 (2010) Rob Jacobson
following this practice and it has not been tested in field grown tomatoes.

However, spinosad is known to be harmful to important natural enemies of *Tuta absoluta*, namely *Macrolophus*, *Nesidiocoris* and *Orius*. Spinosad is also harmful to parasitoids of whitefly and aphids, as well as the predatory mites *Phytoseiulus* and *Amblyseius*.

The sensitivity of natural enemies varies according to the mode of application and the natural enemy. See Real IPM Pesticide Sensitivity Chart.

**Chlorantraniliprole (trade names Renaxypyr, Coragen) Dupont**

*Coragen* is compatible with most of the relevant natural enemies for *Tuta absoluta* and beneficial insects for economically important tomato pests. It is reported as effective against eggs and neonates. See Real IPM Pesticide Sensitivity Chart.

**Broad-spectrum insecticides**

Pyrethroids and organophosphate insecticides are not compatible with beneficial insects. Pyrethroids are known to kill many parasitic wasps and predatory mites (more than 75%) and this harmful effect can last for up to 10 weeks, after a single application.

Organo-chlorines, such as endosulfan have been banned for use in the EU due to their harmful effect on the environment and spray operators.

**Pesticides alone are NOT the solution**

*Think before you spray*. At the *Tuta absoluta* Symposium, an anxious grower cast an air of foreboding over the other tomato growers present. He clearly explained that he had lost 100% of his crop, in spite of spraying everything he could on the crop. Seek experienced advice from recognized IPM practitioners on the design of a sustainable IPM programme.

How the pesticides are applied also make a difference on the cover of the crop with the active ingredient. Make sure that you know how to calibrate the sprayer and apply the correct volume of water to optimize the cover. More water is not always better – especially when insecticides with contact action are applied. Get your spray operators re-trained by qualified trainers.
PHYSICAL CONTROLS

If the tomatoes are grown inside greenhouses, there is some scope\textsuperscript{15} in physical exclusion of the *Tuta absoluta* and other flying pests such as bollworm, thrips and whitefly. Screening of vents in the roof and sides of greenhouses and the disciplined use of double entry doors, can reduce migration of pests into the greenhouse. Outward facing fans inside the double entry porch can blow back any flying insect pests, which might otherwise be ‘sucked’ into the crop on thermal currents when the outside door opens.

Aggressive de-leafing

The eggs of *Tuta absoluta* are laid on leaves and may take from 3 to 6 weeks to complete a life cycle, depending on the temperature. The obvious symptoms of Tuta presence are the large mines in the leaves. These infested leaves need to be removed before the caterpillar inside the leaf is able to pupate and become an egg-laying adult moth.

This method should be used with some caution, if the grower is also relying on the parasitic wasp, *Encarsia formosa*, for biological control of whitefly. Most of the mature (black) parasitized whitefly scales will also be on the lower (older) leaves, where the larger Tuta mines will also be observed.

\textsuperscript{15}HDC Project PC 203 (2010) Rob Jacobson
<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Trade Name</th>
<th>Macrophus % death</th>
<th>Trichogramma persist wks</th>
<th>Amblyseius % death</th>
<th>Metarhizium % death</th>
<th>Phytoseiulus % death</th>
<th>Encarsia % death</th>
<th>Persist wks</th>
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Key: % death = percentage of natural enemy which could die after one application of the pesticide or bio-pesticide
Persist wks = the number of weeks after ONE spray of the pesticide or bio-pesticide that the harmful effect will persist.

For more comprehensive information attend the Real IPM one-day training on IPM in Tomatoes [www.realipm.com](http://www.realipm.com)
Contact Real IPM for training on IPM management programmes for crops affected by Tuta absoluta.

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