Introduction of the tomato leafminer *Tuta absoluta* into Europe

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Tuta absoluta is a moth originating from South-America causing serious damage on Solanaceae, in particular tomato. Since it was first found in Spain in 2007, it has now been reported in most countries along the Mediterranean Sea, the Middle East and eastern Europe, as well as in countries in Central and Northwest Europe. This article gives an overview of the pest risk analysis for this pest for The Netherlands focussing on pathways for introduction, probability of establishment, economic impact, discovery of indigenous natural enemies and options for Integrated Crop Management.

Keywords: *Tuta absoluta*, tomato, introduced species, pest risk analysis, natural enemies

In September 2007 the Plant Protection Service of The Netherlands received information indicating that *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) had been introduced in Spain. Until then *T. absoluta* was only known from South-America, where it is one of the most damaging pests on tomato. Without control measures the pest can cause entire yield losses. The larvae mine in leaves, stems and fruits of many species of Solanaceae, including potato and eggplant, and a number of wild hosts like the common weed *Solanum nigrum*. The fact that it can establish on non-cultivated plants in- or outside a greenhouse enables it to survive even in absence of a cultivated crop. The mining behaviour also makes the species more difficult to control.

The information on the presence of *T. absoluta* in Spain initiated a pest risk analysis (PRA) by the Plant Protection Service to assess the risk of the species for The Netherlands. A pest risk analysis is the process of evaluating scientific and economic evidence to determine whether a new pest should be regulated and the strength of any official measures to be taken against it.

Pest Risk Analysis and Survey

The PRA focused on four main components: (1) the probability of introduction in The Netherlands, (2) the probability of establishment, (3) the potential economic impact, and (4) pest risk management options to prevent introduction, establishment and economic impact.

Probability of introduction

In the PRA the most important pathways for introduction were considered to be vine tomatoes and propagation material of Solanaceae plants from infested areas in the Mediterranean region, and the carriage equipment associated with these commodities. Large quantities of tomatoes are being imported into The Netherlands from southern Europe every year especially in winter. For example, in December 2009 over 29 million kilogram tomatoes were being imported from Spain. To verify whether *T. absoluta* was transferred along with these tomatoes a survey was started with pheromone traps in packaging facilities where imported tomatoes were processed.

The first check of the traps in January 2009 immediately resulted in the finding of specimens of *T. absoluta*, followed by findings of many more specimens in the next months in most packing facilities (Fig. 2). A visual inspection of the product showed that *T. absoluta* was in particular associated with vine tomatoes; these carry more green parts, in which larvae may mine and pupate. Pupae were often found on the calyx of these tomatoes, but sometimes also in cracks in the fruits. Caterpillars were also found feeding inside tomato fruits (Fig. 1).

Figure 1. Larva of *Tuta absoluta* feeding in tomato fruit.

A similar survey was carried out in greenhouses, to verify whether transfer could take place from packing stations to tomato production sites (Fig. 2). In March the first specimens of *T. absoluta* where caught in pheromone traps in greenhouses and captures peaked between August and October (Fig. 2). These findings demonstrate that *T. absoluta* was introduced in The Netherlands via imported tomatoes and was able to enter tomato greenhouses if packing facilities were nearby. In the Westland area, where many packing facilities are found, *T. absoluta* was found in almost half the number of greenhouses involved in the survey.

These findings demonstrate that the probability that *T. absoluta* escapes from fresh market tomatoes in trade and successfully transfers to tomato production places is high.

Probability of establishment

Threshold temperatures and temperature sums needed for development indicate that *T. absoluta* probably cannot survive winter conditions in The Netherlands, but transient populations in the field may be possible during the summer months (for details see Potting 2009). In The Netherlands, the organism may multiply outdoors during summer months on suitable solanaceous host plants, including potato. A CLIMEX study indicates that in southern Europe climatic conditions are suitable for permanent establishment of outdoor populations (for details see Potting 2009, Desneux *et al.* 2010).

Conditions in a greenhouse growing tomatoes are well suitable for *T. absoluta* to develop and reproduce. In the PRA, it is estimated that in a greenhouse *T. absoluta* can have nine generations per year. Spread of the pest between greenhouses may occur in spring and summer time.

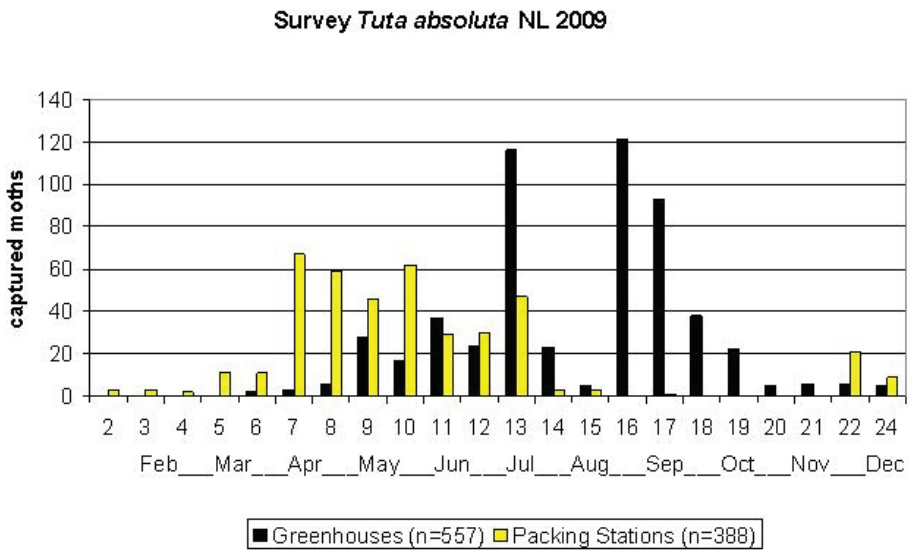

Figure 2. Captures of *Tuta absoluta* in survey in 2009 at packing stations (yellow bars) and tomato production greenhouses (black bars). Indicated are total number of captured moths in pheromone traps in two week periods.

Potential economic impact

Due to the feeding habit of the organism, damage to tomato production can be very high, because also fruits can be mined, which may induce unacceptable levels of cosmetic damage. Tomato is one of the most important crops in The Netherlands, with 1690 ha (2010) acres of greenhouses with tomato with an annual production value of more than €1 billion. Since this production concerns primarily fresh market tomato fruits virtually no cosmetic damage is tolerated and hence potential economic impact can be high.

An additional potential economic impact is possible due to disruption of Integrated Crop Management (ICM) practice. Insecticidal control of *T. absoluta* may disrupt ICM, because the insecticides that are needed to control the pest may negatively affect biological control agents and pollinating bumble bees.

Another aspect of the economic impact is the fact that *T. absoluta* has a quarantine status in several countries, like the USA and Canada. In response to the *T. absoluta* outbreaks in the EU, the authorities of the US and Canada imposed strict import conditions for tomatoes from several EU countries, including The Netherlands.

Pest risk management options

To prevent further spread and establishment of *T. absoluta*, EU requirements should be adapted to prevent spread of the organism via import and internal movement of plants and fruits of Solanaceae, especially vine tomato. Fruits in trade should have no signs of insect damage. In case of fruits originating from infested areas, measures are needed to disinfest fruits or prevent adult moths to escape from the pathway during movement or at the time of unloading, for instance by use of closed packaging conditions, refrigeration or screening.

Furthermore, in the PRA the movement of carriage equipment associated with tomato fruits from infested areas was identified as an important pathway. Importing countries should ensure that crates that are returned to tomato producers from packing operations are sterilised before being returned and workers should be vigilant in cleaning or disposing of all packaging which has contained infested fruit and any vehicles which have been used to transport such fruit to limit the possibility of spread.

Current situation in Europe

Since its introduction in Europe in 2007 *T. absoluta* has spread rapidly (for details see Potting 2009, Desneux *et al.* 2010). Costs for implementing effective pest risk management options to prevent further spread would be high. Given its presence in 2009 in several EU member countries and high costs of official measures that would outweigh the benefits of regulation, an EU quarantine status was not recommended anymore. Therefore *T. absoluta* has no quarantine status in the EU at the moment and there are no official measures in place to prevent the spread of the organism.

By September 2010 the species is reported in 20 European countries (Fig. 3). In the more northern countries these are mostly records from greenhouses. The species has also been reported now in many countries in North-Africa and the Middle-East. In all countries with warmer climates major damage has been reported (Desneux *et al.* 2010).

Prospects for integrated control in The Netherlands

The first means in the control of *T. absoluta* is the use of pheromone traps for early detection. Several types of traps are applied (delta traps and water traps). In The Netherlands traps are being placed both in the crops and in the barn from where trucks are being loaded or unloaded. The number of trapped moths in The Netherlands is very low, visual symptoms in crops are rarely found and no significant damage has been reported so far. Since growers are however concerned, in 2009 a project funded by the Product Board for Horticulture was started to investigate the possibilities to control the pest in The Netherlands. This project had two goals: the short-term aim was to identify chemicals, preferably compatible with ICM, that could effectively control *T. absoluta* in case of an outbreak; the long-term aim was to identify biological control options, that would allow growers to continue the system of ICM if *T. absoluta* might establish and become a pest.

For research on effective insecticides tests were carried out with chemical agents in greenhouses of Wageningen UR Greenhouse Horticulture. Test plants were infested by adults from a rearing of *T. absoluta* in cages in well confined

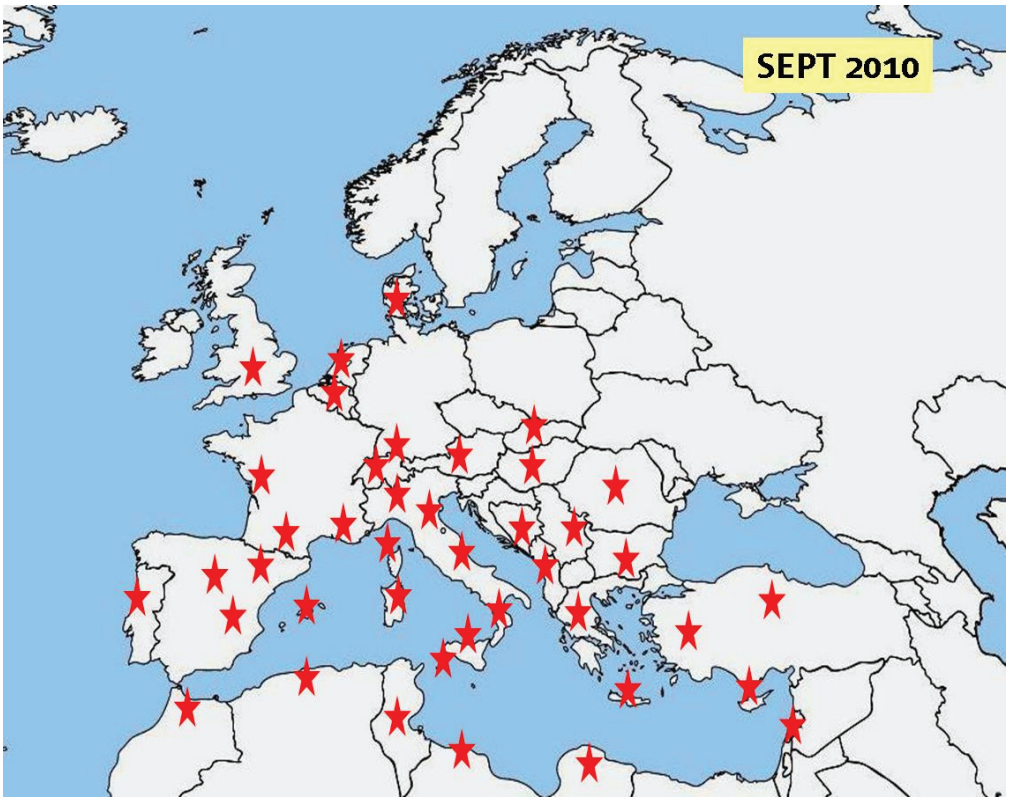

Figure 3. Distribution of *Tuta absoluta* in Europe and the Mediterranean Basin, September 2010.

greenhouses. Results showed that flubendiamide (Fame), spinosad (Tracer) and abamectin (Vertimec) are effective against *T. absoluta*. In the current control practice these insecticides are commonly applied at the end of the cultivation period in order to end with a low pest density. Of these agents only the recently introduced chemical flubendiamide has, as far as known, no side-effects on natural enemies including *Encarsia* and *Macrolophus*.

For biological control of whiteflies in tomato, introduction of the predacious bug *Macrolophus pygmaeus* (Rambur) (Heteroptera: Miridae) is common practice. Spanish research showed that it may control both whiteflies and *T. absoluta*, if their numbers build up well. The bug attacks eggs and young caterpillars of *T. absoluta*, but since populations build up slowly, early and multiple introductions are needed (Urbaneja *et al.* 2009). In Dutch greenhouses no detailed observations have been done on the effect of *Macrolophus pygmaeus* on *T. absoluta*, since pest numbers were too low.

In 2009 high levels of parasitism by naturally occurring larval parasites were detected in Morocco, Spain and Italy (Desneux *et al.* 2010), which indicate that native natural enemies are adapting to this new pest. The severe infestations of *T. absoluta* in southern Europe have apparently provoked the population development of indigenous parasitoids. Some producers of natural enemies have started rearings of *Necremnus artynes* (Walker), *Necremnus tidius* (Walker) or both (Hymenoptera: Eulophidae) to introduce these on the Mediterranean market in 2011. The distribution of *N. artynes* and *N. tidius* is not restricted to the Mediterranean area. This may result in biological control without the need of introduction of natural enemies from the original area of distribution of the pest (classical biological control).

The research project of Wageningen UR Greenhouse Horticulture focussed on the occurrence of indigenous natural enemies in The Netherlands. This was investigated by taking tomato plants infested with eggs of *T. absoluta* outdoors in a nature reserve in Kinderdijk. Kinderdijk is distant from any tomato growing location and large numbers of Microlepidoptera are found frequently, as well as large numbers of parasitic wasps. Both eggs and developing caterpillars are possible subjects for parasitism or predation. Parasitoids and predators were recorded during the tests; the plants were put in cages again before caterpillars started pupation, to prevent escape of *T. absoluta* into the environment. Parasitic wasps showed interest in the younger leaf miners and two ectoparasitoids developed successfully: *Elachertus inunctus* Nees and *Pnigalio soemius* (Walker) (Hymenoptera: Eulophidae) (identification by Christer Hansson, Lund University, Sweden). *Elachertus inunctus* (Fig. 4) is a parasitoid of several microlepidoptera species; *Pnigalio soemius* is a generalist parasitizing on many leafmining species of microlepidoptera, Diptera and Coleoptera. Apart from parasitic Hymenoptera, predators were also found on the outdoor tomato plants: *Dicyphus errans* (Wolff) (Heteroptera: Miridae) occurred regularly during summer and *Heterotoma* sp. (Heteroptera: Miridae) was observed occasionally.

Figure 4. Adult of *Elachertus inunctus*.

Future research will show which natural enemies perform best in Dutch greenhouse tomato. Dutch growers will continue with the introduction of *M. pygmaeus*, but they are always interested in new developments in biological control.

Conclusions

Given its rapid spread in Europe and North-Africa *T. absoluta* can be considered a true invasive pest. The Pest Risk Analysis by the Plant Protection Service concluded that the impact of the species did qualify it for the EU quarantine list, but given its establishment in Spain and Italy and the costs involved to prevent further distribution to other countries this was not an option anymore. By now the economic impact of the species is huge in southern Europe, North-Africa and the Middle-East. In The Netherlands no significant damage has been reported so far, apart from the restrictions for export of tomato to the USA and Canada. Recent research shows that a wide variety of natural enemies may play a role in the control of *T. absoluta*. This indicates that, if damage would increase in The Netherlands, the prospects for maintaining the ICM system are good.

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