Ministry of Agriculture, Nature and Food Quality

PEST RISK ANALYSIS

Plant Protection Service of the Netherlands

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Tuta absoluta, Tomato leaf miner moth or South American tomato moth

Pest Risk Analysis
Tuta absoluta, Tomato leaf miner moth

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1. Reason for performing the PRA

In 2008 Spain reported several outbreaks of *Tuta absoluta* on tomato plants in Catalonia, Valencia, Murcia and Balearic Islands (EPPO, 2008b), and further outbreaks have since been reported in the Mediterranean region (see 7). In South America *T. absoluta* is the most important pest in tomato (CABI, 2007). It is unknown how the organism was introduced from South America. There is a general prohibition for the import of plants for planting of Solanaceae from third countries, other than European and Mediterranean countries (Annex 3 of 2000/29/EC). However, there is free trade of solanaceous plants (with plant passports) and fruits within the EU. The infested areas in the Mediterranean region form a risk of spread to uninfested areas in the EU.

2. Scientific names and taxonomy

Class:	Insecta
Order:	Lepidoptera
Family:	Gelechiidae
Genus:	Tuta (Syn. Scrobipalpuloides)
Species:	____absoluta (Meyrick, 1917)

3. PRA area

North Western Europe, with particular focus on the Netherlands and UK.

4. International Phytosanitary Status

EU:	Not listed in Plant Health Directive (2000/29/EC); EPPO A1 (2004) (EPPO, 2004)
USA:	Tomato fruits from infested areas are regulated in relation to *T. absoluta* (APHIS, 2007)
Egypt:	Emergency measures (WTO-SPS, G/SPS/N/EGY/37)

5. Host plant range (Worldwide)

Main host plant of *T. absoluta* is tomato (*Lycopersicon esculentum*), but the pest has also been reported on above ground parts of potato (*Solanum tuberosum*), aubergine (*S. melongena*) and several Solanaceae weeds (e.g. *S. nigrum* (black nightshade) and *Datura stramonium*) (EPPO, 2005; CABI, 2007; Pereyra, 2006). For a list of reported hosts see annex 5.1.

6. Host plant range (PRA area)

Lycopersicon esculentum (tomato), *Solanum tuberosum* (potato), solanaceous weeds (e.g. *S. nigrum)*, ornamental Solanaceae (e.g. Petunias and Schizanthus).

7. What is the current area of distribution of the pest?

<u>South America:</u> Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela (EPPO, 2005; CABI, 2007).
<u>EU:</u> present in Spain in Catalonia, Valencia, Murcia, Balearic islands, Andalusia, Aragon, Navarra, Castilla la Mancha, Extremadura and Madrid (EPPO, 2008b; Letter of NPPO Spain to SANCO 11-Aug-2008 & 12-Sept-

2008), present in France on Corsica and Cote d'Azur (EPPO, 2009a, Letter of French authorities to EU Commission, 9-1-2009), Present in Italy in Abruzzo, Calibria, Campania, Lazio, Liguria, Sardegna, Sicilia, Umbria (EPPO reporting service 2009c; d). First sightings in Switzerland (A. Klay, pers. comm.), Malta, Portugal and Greece in 2009 (CIRCA notifications, 2009)
In the Netherlands: intercepted 56 times at 13 packing stations handling tomatoes from infested areas. In a survey of tomato production companies in the neighbourhood of the affected packing stations, the organism was captured 61 times in 24 greenhouses, with one confirmed outbreak in a tomato greenhouse, under official control (last update 25 July 2009).
In the UK: intercepted 58 times at 18 packing stations, with four outbreaks at tomato production companies, under eradication (last update 5th August 2009).
Africa: First sightings in Algeria in March 2008: present under official control (Guenaoui, 2008; EPPO, 2008c). First sightings in Morocco in April 2008: under eradication (EPPO, 2008d). First sightings in Tunisia in March 2009 (EPPO 2009b), First sighting in Libya in July 2009 (*Tuta absoluta* information network, 2009[1]).

8. Does the pest occur in the PRA area (pest status)?

Other than at the outbreak sites (see 7.) *Tuta absoluta* is known not to occur in the Netherlands, confirmed by annual surveys in tomato production and nurseries (last survey 2008). In January 2009, 3 adult *T. absoluta* were captured in a sex pheromone trap located in a vine tomato packaging station. The origin of the finding was almost certainly a consignment of infected tomatoes from Spain. There have since been similar reports of *T. absoluta* in the UK and confirmed outbreaks in both the Netherlands and the UK (see 7. above).

9. Probability of entry (arrival + transfer to a suitable host or habitat)

Five pathways have been identified (Annex 1); the four most important pathways are listed below in order of importance:

No.	Pathway	Probability of entry
1	Tomato fruits from infested areas ▪ Relatively big quantities are moved to the Netherlands and UK, particularly outside the summer season (see Annex 2), although the UK imports and packs tomatoes from known infested areas all year round. ▪ Especially vine tomatoes may contain all stages of the organism. ▪ Medium chance for transfer from sorting and packing companies to tomato production in glasshouses, in cases where companies are separate (majority of companies in NL and some companies in UK). ▪ High chance for transfer in companies that sort, pack and produce tomatoes in one building (very few (<5) companies in NL) or on the same site. In the UK there are major packing operations on production sites, though not in the same buildings.	High
2	Containers and packaging equipment (e.g. crates) and transportation vehicles ▪ Transport equipment associated with tomato fruits from infested areas has been reported as a pathway, with of outbreaks in both NL and the UK being linked to movement of infested crates / containers (see Annex 1).	Medium
3	Plants for planting of tomato or aubergine There is no significant trade in propagation material of tomato and aubergine from infested areas	Low
4	Plants for planting of ornamental *Solanaceae* ▪ Relative small quantities are moved to the Netherlands from infested areas.	Low

[1] http://www.tutaabsoluta.com/ website registered by Russell IPM Ltd. (http://www.russellipm.com/index.php)

- The fact that tomato fruit from infested areas can be a pathway for *T. absoluta* was evidenced by findings of adult moths at a central tomato packaging facility in the Netherlands in January 2009. The origin of the moths was most likely a consignment of infected tomatoes from Spain, that were transported to the packaging company in the Netherlands (Netherlands Plant Protection Service, 2009).
- There is strong evidence for packaging being a pathway for *T. absoluta* in the UK with the first outbreak in a growing crop believed to have been caused by imported packing material from an infested packing operation being sent to a UK tomato producer (Fera, 2009).
- *South America.* The import of solanaceous plants for planting is prohibited; import of tomato fruits could be a pathway, though trade volume to the EU is small and negligible to the NL and UK (see Annex 2).
- *Spain.* Both tomato plants and fruits could be a pathway. Tomato plants for planting need a plant passport, but *Tuta absoluta* is not regulated in the EU. There is no significant trade of tomato plants for planting from Spain to the NL. Ornamental solanaceous plants are traded from Southern Europe to Northern Europe, but data are missing about trade volumes. *T. absoluta* has not been reported on ornamental solanaceous plants in Spain (SEWG, 2008). There are no phytosanitary EU regulations for fruits of tomato and aubergine. The trade volume of tomato fruits from Spain to NL and UK is large (see Annex 2). In the NL, the tomato trading businesses are located in the main greenhouse tomato growing area. However, the probability of transfer from infested consignments of tomato to greenhouses is considered to be medium. In the UK tomato producers are considered at greater risk from infested tomato fruit, due to the close proximity of some packing operations to tomato production and year round import of fruit from infested areas. For a detailed pathway analysis see Annex 1.
- *Algeria.* At present *T. absoluta* has only been recorded on glasshouse tomatoes, but it is feared it will spread to outdoor Solanaceae crops such as tomatoes and aubergines (EPPO, 2008c). Both Solanaceae for planting and fruits could be a pathway. Probability of entry considered low from this origin. There are no NL and UK records for aubergine or tomato fresh produce being supplied from Algeria (EUROSTAT; re-Fresh Directory, 2008) or trade in tomato plants for planting. Trade in ornamental Solanaceae is unknown. It is also unclear what the pathway into Algeria itself was: entry from South American trade or natural dispersal from outbreaks in Spain.
- *Morocco.* In 2008 an outbreak on outdoor tomato crops was observed in one region in Morocco. No further outbreaks were found in other regions. Official status in Morocco: one outbreak, under eradication (EPPO, 2008d). There is a large trade volume of tomatoes from Morocco to the EU, mainly France. For the UK and NL there were 7,100,000 kg and 28,000,000 kg respectively of tomatoes imported from Morocco in 2007 (EUROSTAT data).
- *France.* In January 2009, the French Authorities reported to the EU Commission the presence of *T. absoluta* on Corsica, where it is regarded as established, because it is not only present in tomato production, but also on wild solanaceous plants.
- *Italy.* In 2009 several outbreaks in tomato were reported in Campania, Sardegna, Umbria, Abruzzo, and Sicily, where it has also been sporadically found in aubergine production. There is a significant trade in tomatoes to NL and UK and in 2009 there were several reports of infested consignments of tomato from Italy (UK-FERA and Netherlands Protection Service).

10. Probability of establishment

(a) Outdoors - **Not likely**

The organism may multiply outdoors during summer months on suitable solanaceous host plants, including potato, but the organism is not expected to survive winter conditions, although given that this species was first found at 3,500m in Peru further research on this is recommended (see Annex 3 for more details). Development stops between 6 and 9ºC (Barrientos et al. 1998; Bentacourt *et al*., 1996), depending on the life stage. Degree-day calculations indicate that transient field populations (2-3 generations) may occur in July and August (see Annex 3 for more details).

(b) In protected cultivation - **Likely**

The organism can probably survive and establish in greenhouses with continuous tomato production. Several sub-tropical Lepidoptera have established in greenhouses with vegetable production, such as *Chrysodeixis chalcites* and *Duponchelia fovealis* (Malais & Ravensberger, 2002). The mean duration of the life cycle is 40 days at 20 ºC (average temperature in Dutch tomato greenhouses). In a greenhouse with a year round tomato crop, *T. absoluta* could have approximately 9 generations. At most tomato production sites the period between two successive tomato crops is less than 10 days. During this cropless period, *T. absoluta* may survive as adult, egg, larva or pupa. The organism is small (<1 cm) and adults, larvae or pupae may survive in crevices or remaining plant material. There is no information about diapausing abilities of the organism.

(see Annex 3 for more details).

11. How likely is the pest to spread in the PRA area? (*natural and by human assistance*)

- **Natural spread: likely**

The organism is likely to only survive wintertime in greenhouses within tomato crops or other suitable Solanaceous crops. Dispersal from infested greenhouses to uninfested greenhouses may be possible. In the summer months, moths from infested glasshouses may spread to field crops. Transient field populations may enter greenhouses. Moths are attracted to light, which may enhance the entrance into uninfested illuminated greenhouses at night (Matta & Rippa, 1981). In Spain, natural spread is seen as the main reason of establishment of the organism in unaffected areas and islands (SEWG, 2008).

- **Human-assisted spread: moderately likely**

Without changing clothes, the pest may spread by people visiting different glasshouses within a few days. However, growers often take precautions to avoid spread by visitors (e.g. crop advisors) by using overcoats. Likelihood of spread: moderately likely.

Infested plants from young plant nurseries could be a means of spread. In the Netherlands, young plant nurseries use insect screening to prevent entrance of insects into the glasshouse. They also use many pesticides to ensure pest freedom of the crop. Likelihood of spread: unlikely

Assortment and packaging of tomato fruits in the NL usually takes place at central facilities located amid greenhouses for the production of tomato fruits. Bulk transports of tomato fruits for consumption from areas where the pest occurs may enter these facilities and spread to these places of production. The pest may also be spread during transport from a production site to a central packaging facility. Likelihood of spread: moderately likely. In the UK some packing facilities and production greenhouses are in very close proximity on the same site. In these cases spread from an infested packing area is likely. Other growers no longer pack imported material on site any more, reducing the chance of spread, although if packing facilities are again centrally located the likelihood of spread is still moderate.

Tomato fruits are finally sold to the end-consumer. Consumers will eat the tomato fruits or put them in wastebaskets if they are not suitable for consumption. Therefore, it is unlikely that the pest will spread by movement of infested fruits by consumers. Likelihood of spread: unlikely

12. Endangered area

The endangered areas are glasshouse production sites that grow:

- Tomato (ca. 1,500 ha in the Netherlands (CBS, 2009), ca. 200 ha in UK (DEFRA, 2009)).
- Ornamental Solanaceae (< 100 ha in the Netherlands)
- Aubergine (ca. 90 ha in the Netherlands (CBS, 2009))

Field growing potatoes may be infested during summer months (see question 10) but it is not expected that this will lead to significant damage, because the organism can only complete 2-3 life cycles and will not directly affect the tubers.

13. **What is the potential damage when the pest would become introduced?** *(without the use of control measures)*

Potential damage: high

T. absoluta is the most important pest of tomato in South America, both in the field and in greenhouses (EPPO, 2005; CABI, 2007). Both yield and fruit quality can be significantly reduced and crop losses up to 100% have been reported. Also in Spain, crop losses up to 100% have been reported in 2008 (EPPO, 2008b). In areas where the emergency measures were applied the damage levels were considerably lower and integrated crop management (biological control and pollination) was not disrupted (pers. comm. ES-ASPPC, 2009). Unacceptable levels of cosmetic fruit damage may occur in fresh market tomato production due to the mining habit of the organism. Without any control measure the potential damage may be 100%, especially at high population densities at the end of the growing season. However, control measures already applied against other pest insects in Dutch tomato glasshouses will partly control *T. absoluta*. These measures will not be sufficient for full control and the potential damage without any additional control measures may be more than 10% (uncertain). Similar control measures against lepidopteran pests are not currently used in the UK. In case specific control measures are applied, crop losses would still amount to 1-5 % damage.

For a more detailed impact analysis see Annex 4.

14. What is the expected economic impact when the pest would become introduced? *(the use of available control measures included)*

Expected damage: high (uncertainty)
In the Netherlands, Integrated Crop Management (ICM) is common practice at more than 95% of the tomato production sites, with similar management systems in use in the UK. Important components of ICM are pollination with bumblebees and control of several pests with biological control agents. It is uncertain whether the commercially available biological control agents against Lepidoptera will be effective to control *T. absoluta*. In Spain the current integrated crop management practice against *T. absoluta* comprises: biological control with the mirid bugs *Nesidiocoris tenuis* and *Macrolophus caliginosus;* mass trapping with sex pheromone; cultural practices like net screens to prevent entry and if necessary insecticidal control (pers comm. Desmet (2008), Koppert, Spain). It is uncertain whether the ICM methods currently applied in Spain can be easily adapted to Dutch greenhouses. It is also uncertain how quickly these methods may become available for Dutch growers. Presently, the biological control agent used in Spain (*Nesidiocoris tenuis)* is not on the list of biological control agents which are allowed for use in the Netherlands (Vrijstellingenlijst biologische bestrijders en bestuivers Flora- en Faunawet) and the use of the pheromone for mass trapping or mating disruption will need official registration, which can take several years. Restrictions in use of Spanish methods also apply in the UK, where, again, the biological control agent *Nesidiocoris tenuis* is not listed for use (Liaison, 2009).

Because the presence of the organism in a greenhouse may lead to unacceptable levels of cosmetic fruit damage, it seems likely that the first reactions will be intensive insecticidal control. In a worst-case scenario, it is estimated that 13 - 15 extra insecticide treatments are necessary to fully control *T. absoluta* in a Dutch greenhouse, in the UK this may be as many as 18. The estimated costs of these extra insecticide treatments are € 4 million per year for the NL (in the worst-case scenario that all greenhouses would become infested). It is expected that insecticidal control of *T. absoluta* will disrupt ICM practice, because the insecticides that are probably needed to control the pest (Indoxacarb and Spinosad, see annex 4) negatively affect biological control agents and bumble bees. As a consequence, growers will have to revert to labour intensive mechanical pollination and will also have to control other pests using insecticides instead of biological control agents. If the presence of *Tuta absoluta* will make it impossible to use ICM-strategies, the use of chemical pesticides will increase and thereby the probability that pests will develop resistance to these insecticides.

It is expected that *T. absoluta* cannot be completely controlled, especially because of the mining behaviour, and despite specific control measures crop losses are estimated at 1 – 5% (€ 5 – 25 million per year).

For a more detailed impact analysis see Annex 4.

15. Description of possible social impact
The introduction of *T. absoluta* is expected to lead to an increased use of chemical pesticides, which is unwanted by many consumers. On the other hand, most consumers presently buy conventionally grown tomatoes instead of organically grown tomatoes. It is, therefore, expected that social impact of the pest will be limited.

16. Description of environmental damage
Damage to natural vegetation will be limited since the pest is unlikely to permanently establish outdoors (see questions 6 and 10). Increased use of insecticides will lead to an increased impact on the environment which is in conflict with the Dutch policy to decrease the impact of the use of pesticides by 95 % in 2010, as compared to 1998 (Dutch policy document “sustainable crop protection”).

17. Pest Risk Management

Pathway 1: Fruits of tomato and aubergine
EU requirements may have to be adapted to prevent spread of the organism via import and internal movement of 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 moths escaping from the pathway during movement or at the time of unloading, for instance by use of closed packaging conditions, refrigeration or screening.

Pathway 2: Carriage equipment and transportation vehicles
Movement of carriage equipment associated with tomato fruits from infested areas has been 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.

Pathway 3: Plants for planting
EU requirements have to be adapted to prevent spread of the organism via internal movement of plants for planting of Solanaceae. Plants for planting should be produced at a production place or site free from the organism. There is already a general prohibition for the import of solanaceous plants for planting from third countries other than European and Mediterranean countries into the EU.

For more details of pest risk management options see annex 5.

CONCLUSION OF PEST RISK ANALYSIS

Endangered area
The endangered areas are glasshouse productions sites that grow tomatoes or other edible and ornamental Solanaceae.

Probability of entry: High
- The most important pathways are vine tomatoes and propagation material of Solanaceae plants from infested areas in the Mediterranean region, and the carriage equipment associated with these commodities.
- There is a large trade volume of tomato fruits from infested areas to NL and UK and an unknown trade volume of ornamental Solanaceae.
- The probability that the organism escapes from fresh market tomatoes in trade and successfully transfers to tomato production places is medium in cases where these companies are separated and high in cases where these activities are done by the same company.

Probability of establishment - high
- During May - August, temperatures in the Netherlands are high enough for successful development of *T. absoluta* in the field.
- In greenhouses with tomato production, *T. absoluta* can have 9 generations per year. Spread of the pest between greenhouses may occur in spring and summer time.

Economic impact – high (uncertain)
- If no specific control measures are applied against the organism, damage to tomato production can be very high, because also fruits can be mined, which may induce unacceptable levels of cosmetic damage.
- The economic consequences of establishment of the organism for the NL tomato sector can be high: € 5-25 million/year due to crop losses and € 4 million/year due to pest management in a worst-case scenario.
- The additional potential economic impact due to disruption of biological control and pollination is likely to be high (uncertain).
- The limited number of registered active ingredients, combined with the possibility of insecticide resistance could lead to difficulties in pest management of the organism.

UNCERTAINTIES OF PEST RISK ANALYSIS

Section of PRA	Uncertainty	Information needed
Probability of entry	Solanaceae propagation material as pathway for introduction	Specific trade data from infested regions to NL and UK, and data on presence of *T. absoluta* on ornamental Solanaceae in infested regions.
Probabilty of establishment	Variation in reports of altitude, and therefore environmental conditions, under which *T. absoluta* can survive.	More data on limiting factors and potential for *T.absoluta* to survive outdoors.
Economic impact	It is uncertain if *T. absoluta* can be sufficiently suppressed without disrupting ICM –strategies that are commonly used at tomato production sites in NL and UK.	Efficacy of available biological agents against the organism. Range of effective insecticides and frequency of use in relation to disruption of ICM.
Potential impact	The relation between population density and cosmetic damage to tomato fruits	Data for fresh market tomato production
Potential impact	Comparison of NL and UK tomato sector with other northern European countries	Data from other northern European countries
Risk management	Prospect for successful eradication in greenhouses	No reports available

ANNEX 1

Pathway Analysis *T. absoluta*

Pathway	Clarification	Probability of entry (arrival + transfer to suitable host or habitat)
Fruits imported from regions where the pest is present	In the Mediterranean region *T. absoluta* is present in tomato and aubergine production. In this analysis, aubergine fruits are not considered as a pathway, because in Spain *T. absoluta* has not been reported to damage fruits (SEWG, 2008). The larvae of *T. absoluta* can mine in tomato fruits. Pupae may also be found on and in fruits, although this is not common (Torres et al. 2001). The trade in vine tomatoes is increasing. The possibility that the organism is present on vine tomatoes (fruits attached to stem with leaves) is higher compared to loose fruits, because all stages of the organism can be present on the stem or leaves. The fast spread of *T. absoluta* on the mainland of Spain and even the Balearic islands is possibly caused by the transport of infested tomatoes. There is a large volume of trade of tomatoes from Spain to NL and the UK (Annex 2). Tomatoes are traded as (a) pre-packed tomatoes, or (b) bulk / unpacked tomatoes. In cases where consignments of tomatoes are stored near tomato production places, there is a possibility that moths escaping from infested consignments may enter a nearby greenhouse with a tomato crop, mate and lay eggs. In NL there are a few companies that produce tomatoes and sort and pack Spanish tomatoes in the trading season (autumn). In the UK there are major packing operations based at sites for tomato production and tomatoes from known infested areas are imported and packed all year round (Annex 2) The fact that tomato fruits from infested areas can be a pathway for *T. absoluta* was evidenced by numerous findings of adult moths at tomato packaging facilities in the Netherlands (56 times, 265 moths at 13 companies as of 27/7/2009) and United Kingdom (58 times, 18 companies as of 5/8/2009). The origin of the moths were consignments of infected tomatoes from Spain and Italy, that were transported to the packaging companies (Netherlands Plant Protection Service, 2009; UK-FERA, 2009). Tomato consignments are present for several days to weeks at packing stations before being fully processed. If the organism arrives in a late larval stage or as pupa it can develop into a moth at a packing station and escape. Escaped moths may find tomato greenhouses in the neighbourhood of the packing station. This is likely to occur in spring and summer months. In the Netherlands a survey was carried out with pheromone traps at 85 tomato greenhouses in the vicinity (1-2 km) of packing stations. Moths were captured in 24 greenhouses. In the summer, moths escaping from infested consignments may establish transient field populations on suitable (wild) host plants (see annex 3), and disperse from there to greenhouses. Recent experiences in Spain show that field populations on wild hosts are an important source for introductions in greenhouses. One of the recommendations in Spain is to use	The probability of arrival of infested consignments is <u>very high</u>, especially for vine tomatoes. The probability of transfer to a tomato greenhouse is medium where the companies are separate (most cases in the Netherlands), but high where operations are on the same site (including major packing operations in the UK).

	insect proof netting at the side entrances and windows of the (plastic) greenhouse (SEWG, 2008).	
Packaging material and transportation vehicles	Larvae, pupae and moths (<1 cm) could survive in crevices of packaging material/ crates. Pupae are small and produce a sticky cocoon that can easily attach to all kinds of substrates. Especially for soilless cultivation systems, larvae may revert to all kinds of substrates for pupation, such as crates and corrugated cardboard. Trucks that have transported contaminated tomatoes could also be a pathway. In the UK and NL there are two reports of outbreaks in greenhouses that are probably linked to infested packing material delivered to these two companies.	Medium
Plants for planting	*T. absoluta* eggs and first instar mines could be present if nurseries are located in areas where *T. absoluta* occurs. There is no significant trade of tomato plants for planting from South EU to North EU. There is trade in ornamental Solanaceae plant species from South to North EU. There is no information available on trade volumes. *T. absoluta* has not been reported on horticultural Solanaceae in Spain (SEWG, 2008). In general, the probability of establishment in greenhouses in the PRA area that use infested plants for planting is high.	Very low Medium (highly uncertain)
Passenger luggage	Infested fruits and ornamental Solanaceae plants may be introduced by travellers from infested countries. There are no data available for *T. absoluta*, but USA data for *H. armigera* show that this pathway can be important (in: Lammers & MacLeod, 2007). However, the probability that *T. absoluta* will enter a commercial glasshouse from fruits or plants imported by private persons is estimated to be very low.	Very low

ANNEX 2

Trade data (EUROSTAT) and economic key figures for tomato

(A1) EU-25 import (x100 kg) of tomato fruits from South-American countries where *T. absoluta* occurs

AR=Argentina, BO=Bolivia, BRA=Brazil, CHI=Chili, COL=Columbia, EQU=Equador, PER=Peru, PAR=Paraguay, URU=Uruguay, VEN=Venezuela.

Main export country is Colombia, main EU-importer is France (>90%) and Spain.

PERIOD/ PARTNER	ARG	BOL	BRA	CHI	COL	EQU	PER	PAR	URU	VEN	Total
2000	38		569	154		141					902
2001			764		2						766
2002	4		748		1					102	855
2003	10		1036	1	974					302	2323
2004	9		898		3367					289	4563
2005			1055	231	4537	20				100	5943
2006			788	291	1449					120	2648
2007	0	0	98	0	896	0	105	0	0	17	1116
Total (x100kg)	61	0	5956	677	11226	161	105	0	0	930	19116

(A2) EU-25 import of aubergines (x100 kg) from South-American countries where *T. absoluta* occurs

PERIOD/PARTNER	ARGENTINA	BRAZIL	PERU	URUGUAY
Jan.-Dec. 2000				
Jan.-Dec. 2001				
Jan.-Dec. 2002		0		2
Jan.-Dec. 2003	30			
Jan.-Dec. 2004	82	1		
Jan.-Dec. 2005			10	
Jan.-Dec. 2006	210			
Jan.-Dec. 2007		0		

(B) Monthly trade volume of Spanish tomatoes and aubergines to the Netherlands

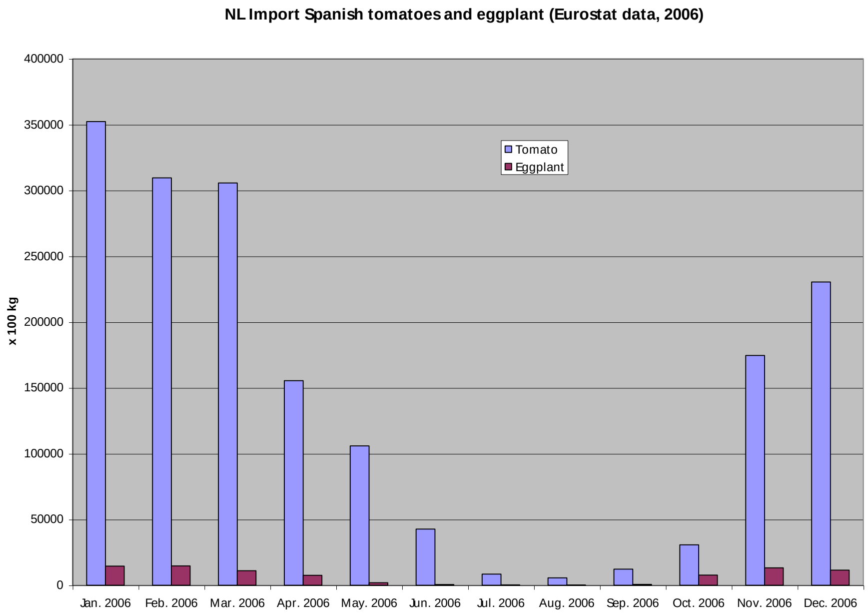


Table: UK tomato imports 2003 – 2005 & 2007 (tonnes)						
Year / From	2003	2004	2005	2006	2007	sum
Spain *	172,576	182,985	180,949		159,842	696,352
Netherlands	127,868	149,201	170,941		174,763	622,773
Italy *	9,101	20,357	10,488		14,430	54,376
Germany	8,205	14,110	15,839		16,186	54,340
Poland	179	4,323	18,448		26,793	49,743
France *	5,206	5,151	8,156		8,622	27,135
Belgium	4,593	4,813	3,905		6,245	19,556
Morocco *	258	150	1,413		7,168	8,989
Israel	2,902	1,591	1,599		1,906	7,998
Portugal	887	1,100	1,497		1,343	4,827
Ireland	1,613	414	1,051		1,156	4,234
Greece	15	372	1,073		1,613	3,073
Senegal	287	608	643		1,046	2,584
Turkey	334	766	659		486	2,245
Egypt	202	277	334		383	1,196
South Africa	342	176	176			694
Denmark	6		10		207	223
Côte d'Ivoire	74					74
Iceland	27	8				35
Australia		22				22
Namibia			20			20
Jordan					20	20
Austria			19			19
TFYR of Macedonia					18	18
Occ. Palestinian Terr.					16	16
Cyprus			16			16
Bulgaria					16	16
Tunisia *		10			2	12
USA	5	1				6
Saudi Arabia	6					6
Mexico		6				6
Antigua and Barbuda					3	3
Czech Rep.					2	2
Argentina *	1					1
sum	334,687	386,441	417,236		422,266	

Sources: 2003- '05 = http://faostat.fao.org/
2007= http://comtrade.un.org

Key: * = Countries where *T. absoluta* is known to occur.

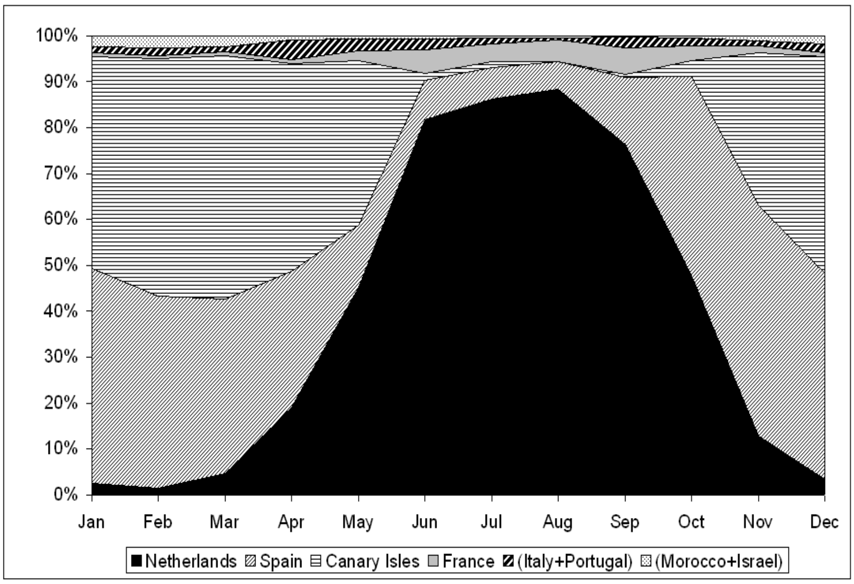


Figure 2.1
Sources of tomatoes as a proportion of tomatoes imported from the UKs major suppliers on a monthly basis (1993 – 1997).

ANNEX 3

(3A) Suitability of NL climate in field and greenhouse for establishment of *Tuta absoluta*

Table 3.1 Threshold temperatures and temperature sums needed for development of different life stages of *T. absoluta*

DD= Day Degrees

	Bentacourt et al. (1996)		Barrientos et al. (1998)	
Egg	9.7 °C	72 DD	6.9 °C	104 DD
Larva	6.0 °C	267 DD	7.6 °C	239 DD
Pupa	9.1 °C	131 DD	9.2 °C	117 DD
Egg-Adult			8.1 °C	460 DD

1. In South America, *T. absoluta* has a neotropical distribution (Moore, 1983). Development stops between 6-9 °C (table 3.1). In the current area of distribution *T.absoluta* is generally considered to not occur in colder climates, e.g. in the Andes not above 1000m (Garcia, 192; EPPO, 2005). However, it should be noted that findings have been made at higher altitudes than this, the holotype having being taken in Peru at 3500m (Povolny, 1975). No data are known on minimum temperatures. Based on the generally accepted distribution, and threshold temeperatures for development, it could be assumed that the species can survive temperatures only slightly below zero and only for a short period. This would mean it would be unlikely that the organism could survive winter conditions in the Netherlands or the UK and, hence, be very unlikey to establish outdoors. The records of *T.absoluta* being found at higher altitudes in Peru do bring an element of uncertainty into this, however, and further research into its limiting factors and potential to survive outdoors all year round is recommended. Transient populations in the field may be possible during the summer months.
2. Assuming that eggs are deposited in the field in May, Day Degree (DD) calculations demonstrate that temperatures in May-August are sufficient for successful development of *T. absoluta* and the organism can have two generations (fig 3.1a). In very warm summers, such as in 2006, three generations may be possible (fig 3.1b). Details of the method of DD calculation can be found in caption of figure 3.1.

3. The average temperature in a greenhouse with tomato production is about 20 °C. Using the same DD calculation method as mentioned above, it is estimated that *T. absoluta* can have 9 generations in a greenhouse with year round tomato production.

Conclusion

1. In the months May-August, temperatures in the PRA area are high enough to enable successful development of *T. absoluta* in the field.
2. *Tuta absoluta* can probably not survive wintertime outdoors.
3. In greenhouses with tomato production *T. absoluta* can have 9 generations.

Fig 3.1 Degree Day calculations for Tuta absoluta

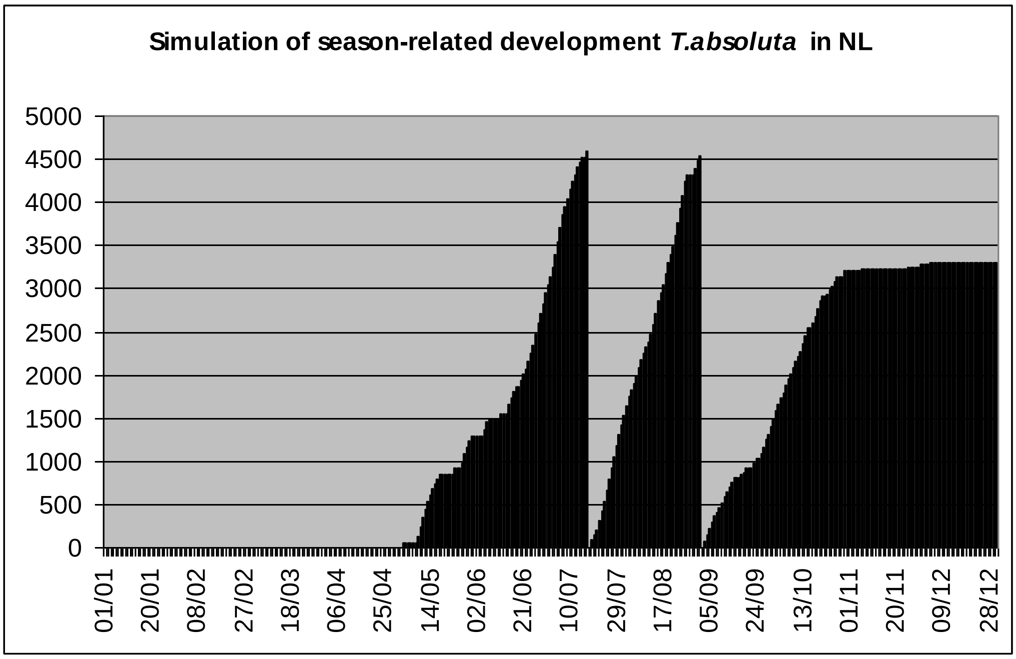
Degree Day (DD) calculations were made to estimate the number of possible generations of *T. absoluta* in the field using the following formula:

(MaxMeanTemp + MinMeanTemp) / 2 – MinDevelopmentTemp

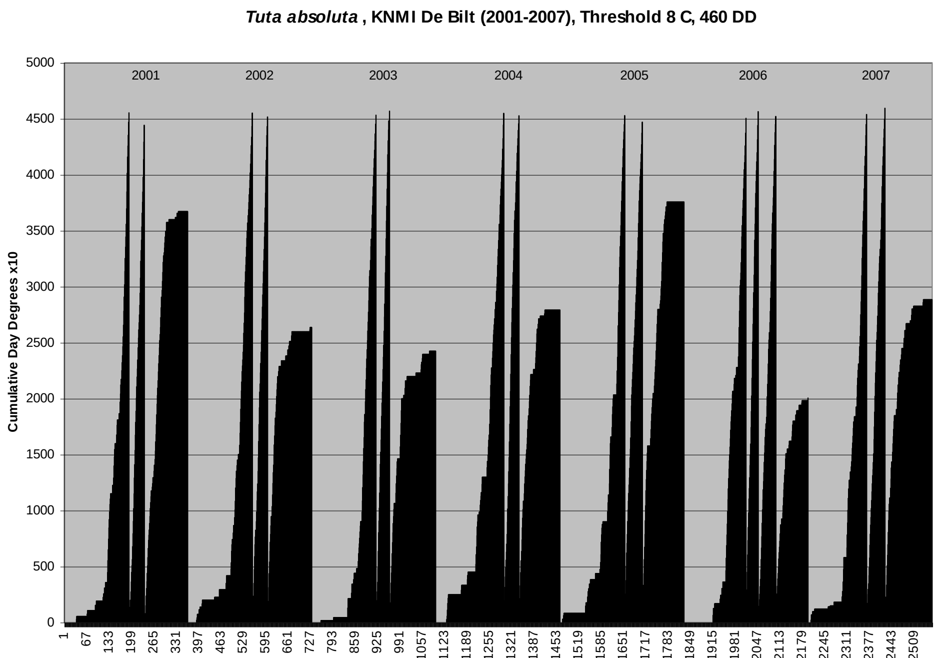
For *T. absoluta* the development threshold for egg to adult is 8 °C and 460 DD are needed to complete development (Barrientos et al. 1998). Daily temperature data (2001-2007) used for the calculations were from KNMI (Royal Netherlands Meteorological Institute). In figure (**A**) cumulative DD are indicated with start date May 1st. If the cumulative DD is above 460 DD, it is assumed that adults emerge and Cumulative DD is set to zero. Figure A is based on temperature data of 2007.

Figure (**B**) indicates Cumulative DD for years 2001-2007. Start date for calculations is January 1st of each year. In all years at least two generations could be completed outdoors in the Netherlands.

A

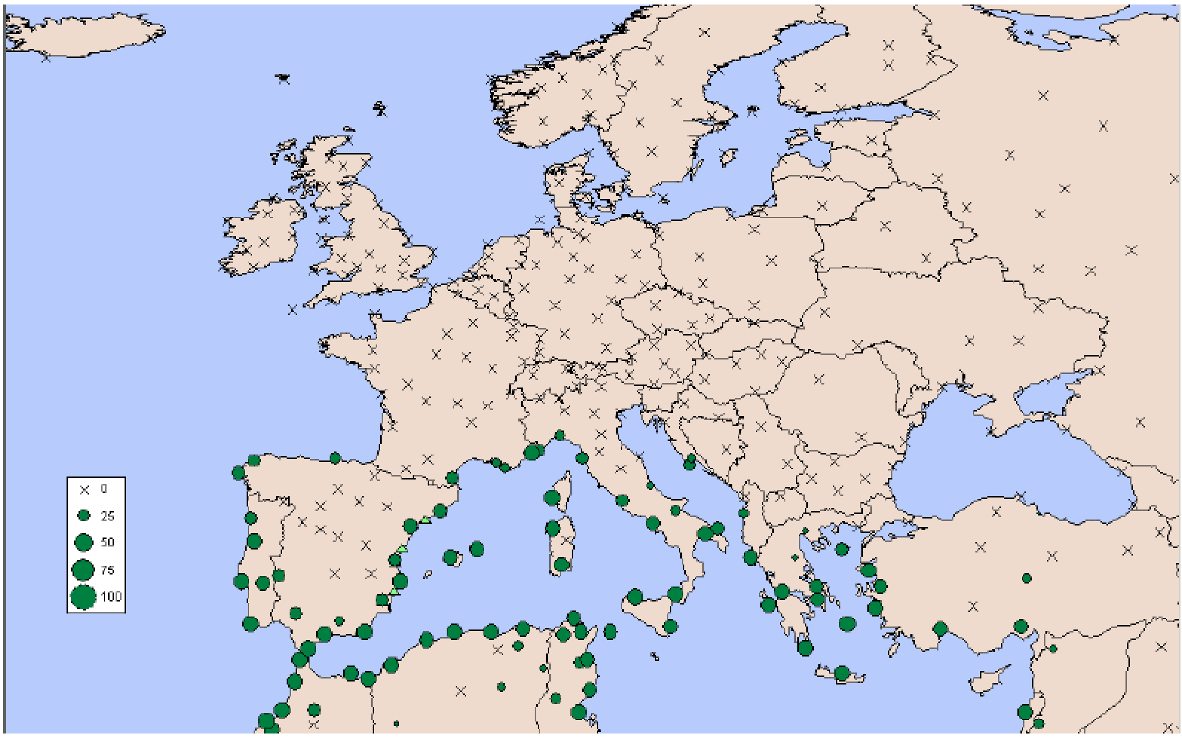


B



(3B) Suitability of EU climate in field for establishment of *Tuta absoluta*

Data kindly provided by José María Guitián Castrillón (TRAGSATEC, ES).



CLIMEX(v3) map of Europe indicating Ecoclimatic Indices (EI) for *T. absoluta*. Crosses indicate an EI of zero. Dots indicate EI's greater than zero. The larger the dot, the larger the EI and the more suitable the climate at that location.

Results demonstrate that sustainable populations of *T. absoluta* in the field can be expected in the Mediterranenan area only.

Parameters used in Climex model[1]:
Moisture index: SM0=0.1; SM1=0.4; SM2=0.7; SM3=2
Temperature index: DV0=8; DV1=20; DV2=25; DV3=35
Cold Stress: TTCS=3; THCS=-0.001; DTCS=15; DHCS=-0.001; TTCSA=0; THCSA=0
Heat Stress: TTHS=35; THHS=0.0015; DTHS=0; DHHS=0
Dry Stress: SMDS=0.1; HDS=-0.01
Wet Stress: SMWS=2; HWS=0.002
Day Degree Accumulation above DV0: DV0=8; DV3=35; MTS=7
Day Degree Accumulation above DVCS: DVCS=8; *DV4=100
Day Degree Accumulation above DVHS: DVHS=35
Degree-days per generation: PDD=460

[1] for details see www.hearne.com.au/products/climex/attachments

ANNEX 4
Economic impact analysis (NL)

1. Economic key figures for tomato

	NL[1]	UK[2]
Tomato production	675,000 (x1000 kg)	85,100 (x1000 kg)
Import tomato	250,000 (x1000 kg)	421,200 (x1000 kg)
Export tomato	820,000 (x1000 kg)	4,600 (x1000 kg
Production value	€ 526 million	£ 86 million
Tomato Area (greenhouses)	1,481 ha	209 ha

1 (Salm, 2007)
2 DEFRA, 2009 – Basic Horticultural Statistics – 2009: Data from 2007 quoted.

Tomato area Spain – field	33,683 ha
Tomato area Spain – greenhouse	11,868 ha
Import Spanish tomatoes into NL	164,703 (x1000 kg); represents 66% of total import NL
Peak months of tomato import	Nov-Dec-Jan-Feb-Mar
Import Spanish tomatoes into UK	159, 842 (x1000 kg); represents 38% of total import UK (Comtrade, 2007)
Peak months of tomato import from Spain	Oct-Nov-Dec-Jan-Feb-Mar-Apr, though all year round for beef tomatoes (re-Fresh, 2008)

2. Economic damage to tomato crop

Tuta absoluta can attack all parts and stages of the tomato plant: leaves, stems and tomato fruits. Damage is produced when the larvae make feeding mines affecting the photosynthetic capacity of the plant and enabling attack by secondary pathogens. Furthermore, injury made directly to the fruits produced for the fresh market results in an unmarketable product. The organism is a major pest of tomato in South America (Torres et al., 2001) and crop losses of 50-100% have been reported, both here and also in Spain (EPPO, 2008b).

The tomato production system in greenhouses in the Netherlands and UK differs from that in South America and partly from that in Spain, where tomatoes for the fresh market are mainly produced in plastic greenhouses without heating. Another part of the tomato production in these countries is produced in the open field for processing, and is labour and input extensive. These production systems, especially for processing tomatoes, allow for some yield loss , and pest management practices are based on economic threshold levels (Benvenga et al., 2007). In contrast, the economic damage level of fresh market tomato fruits from greenhouses is very low, because (virtually) no cosmetic fruit damage is allowed.

In the Netherlands, several lepidopteran pest species are present at tomato production sites, such as *Chrysodeixis chalcites* and *Spodoptera exigua*. In general a tomato grower applies 3-5 insecticide treatments against lepidopteran larvae (Information obtained from crop advisors of Brinkman B.V. and Nic. Sosef B.V., the Netherlands, 2008). Insecticide treatments against lepidopteran pests in tomato crops have not been specifically recorded in recent surveys of pesticide usage in the UK (Garthwaite *et al*., 2007).
Tuta absoluta has several qualities that render the species difficult to control. It has a short generation time, it is very flexible in pupation site, and larvae mine inside plant tissues, including fruits. The mining habit will probably decrease the efficacy of insecticide application since the insecticides will not hit larvae that mine in fruits. Also, because larvae can mine in fruits, unacceptable levels of cosmetic damage may occur in fresh market tomato production. Recent experience in Spain shows that *T. absoluta* can be present at low to moderate levels without damaging the fruits. According to SEWG (2008) the main reasons are: (1) the organism prefers leaves for oviposition; (2) leaves are more susceptible to being attacked by larvae than fruits; (3) the Systems Approach eastablished by the Agreement of the Spanish Plant Protection Committee is successfully controlling the potential damage of the pest.

In greenhouse production systems with good scouting systems and properly timed insecticide treatments, it may be possible to control *T. absoluta* at the same level as for *C. chalcites* and *S. exigua.* However, because *T. absoluta* larvae can also mine in fruits while *C. chalcites* and *S. exigua* do not, unacceptable levels of cosmetic damage may occur in fresh market tomato production. Thus, even with a properly executed control system against *T. absoluta*, fruit damage levels of 1-5% may be expected, because of the mining habit of the larvae and the lack of insecticides that are effective against adults and fit into an integrated crop management system. For these reasons, it will be difficult to limit yield losses below 1%. The expected damage levels of 1-5% are lower than those reported in the present area of distribution where damage levels can exceed 50% (Torres et al., 2001; EPPO 2008b). However, the pest is unlikely to establish outdoors in the Netherlands or UK, and it is, therefore, assumed that the pest can be easier controlled in Dutch and UK glasshouses than in its present area of distribution where a continuous influx of the pest is possible from outside the production site. Damage levels of 1-5% would imply an estimated economic loss of 5-25 million € per year for the fresh market tomato sector in the Netherlands (with a total production value of 526 million, see annex 4.1).

3. Economic damage due to extra control measures

In the Netherlands, more than 95% of the tomato growing companies apply integrated crop management. ICM is based on pollination with bumblebees *(Bombus terrestris)* and pest management with biological control agents (parasitic wasps, predators and entomopathogenic nematodes). Biological control is applied against whiteflies, dipteran leaf-miners, mites and Lepidoptera (see table 4.1 for overview). Similar management systems are used in the UK.
To avoid side effects of insecticide treatments on bumblebees and natural enemies, only a part of the available insecticides can be used in integrated crop management (Biobest, 2008; Koppert, 2008). In the Netherlands only Turex, Xen Tari and Runner can be used against lepidopteran lavae without side-effects on beneficial agents (see table 4.2). Other products, sometimes used against Lepidoptera, are Steward, Tracer and Nomolt. These products are generally avoided, because they disrupt the practice of pollination with bumblebees and biological control. Broad-spectrum insecticides, such as Deltamethrin, cannot be used in integrated crop management, because no beneficial agents can be used for 2-3 months after application.

It is uncertain if the available biological control agents against Lepidoptera (table 4.1) are effective against *T. absoluta*. The leaf-mining habit of the organism may hamper the efficacy of larval predators and entomopathogenic nematodes and it is unknown if the commercially available egg parasitoid *Trichogramma brassicae* will attack *T. absoluta* eggs. In Brazil, *Tichogramma pretiosum* is used for biological control of *T. absoluta* (Medeiros *et al*., 2006). In Spain the mirid bug *Nesidio tenuis* is used for biological control of *T. absoluta*. This natural enemy establishes itself within 3-4 weeks in greenhouses, where it predates on eggs of *T. absoluta* and gives, in general, adequate control of *T. absoluta*, if it is combined with mass trapping with pheromones and cultural practices, such as screening to prevent moth introduction (see Annex 5 for more details on the control measures in Spain). *Nesiodio tenuis* is not registered as a biological control agent in the Netherlands. However, the related mirid bug *Macrolophus caliginosus* is registered. It is uncertain if *M. caliginosus* is as effective as *N. tenuis* in Spain. *M. caliginosus* needs several months to establish in Dutch greenhouses, whereas *N. tenuis* in Spanish greenhouses establishes and is effective within 3-4 weeks (pers. comm. K. Desmet, Koppert, Spain, 2008). Pheromone traps used to control a pest (mass trapping) need registration in the Netherlands and registration may take several years. Most tomato production sites do not have screens to prevent moth introduction. For these reasons, it is expected that insecticides are needed for sufficient control in Dutch tomato glasshouses, and by comparison also in the UK.

Insecticides allowed for use in commercial tomato glasshouses and which are effective against larvae of *T. absoluta* are Steward (indoxacarb) and Tracer (spinosad) (pers. comm. K. Desmet, Koppert, Spain, 2008). Application of these insecticides will partly disrupt existing integrated crop management systems. Disruption of the integrated crop management system will have serious economic impact, because (a) bumblebees cannot be applied for pollination during a period of about 3 days after application (Table 4.2) and companies have to revert to labour intensive mechanical pollination during this period, and (b) biological control is disrupted and pesticides have to be applied against pests which are usually controlled biologically . Insecticides based on deltamethrin are presently the only available ones against adults of *T. absoluta* but are very harmful to biological control agents (Table 4.2). Most growers will not use deltamethrin unless there is no other option for control.

Assuming that, in a worst-case scenario, total eradication is not possible by application of insecticides and the pest will be present in the glasshouse throughout the year, 9 generations have to be controlled per year (in a

greenhouse). This would mean that about 18 insecticide applications (2 applications per generation for the total greenhouse area) are necessary to control *T. absoluta*, which implies that in NL 13-15 extra insecticide applications are necessary if *T. absoluta* is present in a greenhouse, given the fact that 3-5 insecticide applications are already applied against other lepidopteran species.
The cost of these extra 13-15 insecticide applications would be around € 2500/ha:

€ 80 (labour) + € 100 (insecticide) = € 180 /ha for each treatment
Per season: 13-15 x € 180 = € 2340 – 2700 /ha
Total for NL sector: 1481 (ha) x 2500 (€/ha) = € 3.7 million per year.

In the UK, in 2007, the only chemical active used which may help control *T. absoluta* without serious detrimental effects on beneficials was *Bacillus thuringiensis* (Garthwaite *et al*., 2007) and it is unclear what the efficacy of this would be on a leaf mining larvae (Table 4.2). This implies that in the UK 18 additional insecticide applications may be required to control *T. absoluta*.

4. Difficulty in controlling future outbreaks
Recently, the registration of several insecticides has been withdrawn at the EU level, limiting the available options for lepidopteran control in tomato production, with or without ICM. For example, methomyl may not be sold any more since 19-3-2008; though it may be used until 19-3-2009 (CTGB, 2008).
Several reports of the development of insecticide resistance are known from South America (Lietti *et al*. 2005; Siqueira *et al*. 2000, 2001). Siqueira *et al*. (2000) have shown differences among Brazilian populations of *T. absoluta*, in susceptibility to abamectin, cartap, methamidophos, and permethrin, which could indicate resistance development. Resistance to abamectin and deltamethrin has been reported in Argentina (Lietti et al. 2005). The efficacy of insecticidal control could be of concern, given the history of insecticide resistance.

5. Conclusion economic impact
The expected yield loss is 1-5% despite control measures. It is expected that relatively much effort will be needed to control the pest (more than against pests currently present in the PRA area), and insecticides will need to be applied that will (partly) disrupt current integrated crop management systems. The limited number of available registered active ingredients increases the chance of insecticide resistance development, which may lead to failure of pest management in the future.
Thus, the total expected costs are:

- 1-5% yield loss (uncertain)
- extra costs for crop protection: up to € 4 million per year in NL (worst-case scenario: all tomato greenhouses become infested and 13 – 15 extra insecticide treatments are needed)
- partial disruption of ICM and associated extra costs for insecticidal control (not estimated),
- extra labour costs for physical pollination (not estimated).

Table 4.1 Overview of main biological control agents applied in integrated tomato production in the Netherlands.

Biological control agent	Group	Target pest	*T. absoluta* as target
Encarsia formosa	Parasitic wasp	Whiteflies	
Eretmocerus eremicus	Parasitic wasp	Whiteflies	
Macrolophus caliginosus	Predatory mite	Whiteflies / Lepidoptera (eggs)	Plausible
Phytoseiulus persimilis	Predatory mite	Mites	
Feltiella acarisuga	Predatory gallfly	Mites	
Aphidoletes aphidimyza	Predatory gallfly	Aphids	
Trichogramma brassicae	Parasitic wasp	Lepidoptera (eggs)	Plausible
Aphidius ervi	Parasitic wasp	Aphids	
Dacnusa siberica	Parasitic wasp	Dipteran leaf-miners	
Diglyphus isaea	Parasitic wasp	Dipteran leaf-miners	
Steinerma carpocapsae	Nematode	Lepidoptera	Unknown

Table 4.2 Overview of registered insecticides targeted against Lepidoptera in tomato production in the Netherlands, with an indication of side effects on beneficial agents and approximate costs per ha (excluding labour; based on 1400 l/ ha). Side effects data from Biobest (2008), Koppert (2008), approximate insecticide costs from Dillo (2008, Personal Communication)

Active ingredient *Name product*	**Target stage**	**Side Effects**	**Remarks**	**Costs / ha**
Methoxyfenoxide *Runner*	Young larvae	Safe	Ecdysis	€ 75
Bacillus thuringiensis. *Turex 50 WP* *Xen Tari WG*	Young larvae	Safe	Efficacy on leafmining Lepidoptera probably low	€ 40 € 105
Indoxacarb *Steward*	Larva all stages	Medium	No information on effects on biological control agents Removal of Bumble bee colony for 3 days	€ 67
Pyrethrine/ Piperonylbutoxide *Spruzit vlb.*	Larva / Adult	Very Harmful	8-12 weeks after application side effects on biological control agents Removal of Bumble bee colony for 3 days	€ 110
Teflubenzeron *Nomolt*	Young larvae	Harmful	Benign to most biological agents Very harmful to Bumblebees	€ 184
Spinosad *Tracer*	Larva	Medium	Medium effect on biological control agents Removal of Bumble bee colony for 3 days	€ 155
Deltamethrin *Decis Micro/EC*	Larva, Adult	Very Harmful	8-12 weeks after application side effects on biological control agents Removal of Bumble bee colony for 1-2 days	€ 33
Methomyl *Methomex 20LS* *May be used until 19-3-2009*	Larva	Very Harmful	8-12 weeks after application side effects on biological control agents Very harmful to Bumble bees	€ 58

ANNEX 5
Biology, control and pest management options

1. **Biology.**
   The duration of the different life stages of *T. absoluta* are CABI(2007); EPPO(2005):
   - Egg: 6 days,
   - 4 larval stages: total 20 days,
   - pupa: 10 days,
   - adult moth: Variable life stage records: 7-8 days (Fernandez & Montagne, 1990); 21-22 days (Goncalves-Gervasio et al., 1999).

   The larval stages penetrate into leaves, stems and tomato fruits and create conspicuous mines and galleries. All stages of the tomato plant can be attacked. The 3rd and 4th larval stage is very mobile and can also be found outside mines (Torres et al., 2001).
   T. absoluta can feed on aerial parts of potato. Tubers of potato, however, are not affected. Control options for potato and aubergine are not considered here.

   Reported host range

Tomato	*Lycopersicon esculentum*	CABI(2007); EPPO(2005)
Aubergine	*Solanum melongena*[1]	CABI(2007); EPPO(2005)
Potato	*Solanum tuberosum*[2]	CABI(2007); EPPO(2005)
Black nightshade	*Solanum nigrum*	CABI(2007); EPPO(2005)
Jimsonweed	*Datura stramonium*	CABI(2007); EPPO(2005)
Tree tobacco	*Nicotiana glauca*	CABI(2007); EPPO(2005)
Wild tomato	*Lycopersicon hirsutum*	CABI(2007); EPPO(2005)
	Solanum lyratum	CABI(2007); EPPO(2005)
	Solanum elaeagnifolium	CABI(2007); EPPO(2005)
	Lycopersicon puberulum	CABI(2007); EPPO(2005)
	Datura ferox	CABI(2007); EPPO(2005)
Beans	*Phaseolus vulgaris*[4]	EPPO(2008d); EPPO(2009-08-01)
	Capsicum annuum[3]	Guenaoui (2008)

   [1] In Spain and Italy, *T. absoluta* is sporadically reported on aubergine, but there are no indications of significant damage .
   [2] On potato only found on leaves, not on tubers
   [3] There unofficial reports of the incidental presence of *T.absoluta* on peppers, but there are no indications of significant damage .
   [4] Reported in 2009 on *Phaseolus vulgaris* plants on Sicily (IT)

2. **Insecticides.** In Dutch greenhouses with tomato production, insecticides are already applied against larval Lepidoptera (such as *Chrysodeixis chalcites* and *Spodoptera exigua*) approximately 3-5 times per year. Registered products used are: Steward (Indoxacarb); Nomolt (Teflubenzeron), Runner (Methoxyfenoxyde), Tracer (Spinosad) and Turex (Bt). In UK greenhouses there are no records of regular insecticide use against Lepidoptera, but Teflubenzeron and Bt are recorded as having been used in 2007 (Garthwaite *et al*., 2007). Limited information is available regarding the effectiveness of the insecticides against leaf-mining larvae of *T. absoluta,* especially the first two larval stages. Preliminary research in Spain has demonstrated that Nomolt, Xen Tari and Runner are not very effective against *T. absoluta*. Tracer (Spinosad) and Steward (Indoxacarb) are effective against larval *T. absoluta (*pers. comm. K. Desmet*).* Insecticides based on deltamethrin and methomyl (may be used until 19-3-2009) could be used to control adult *T. absoluta.* However, these contact-insecticides are not compatible with integrated crop management because they have serious side effects on natural enemies and pollinators (bumble bees). Integrated crop management is applied in more than 95% of tomato greenhouses (in NL). Tracer (Spinosad) and Steward (Indoxacarb) can be used in ICM, although there is still some impact on biological control and pollination.

3. **Biological Control.** More than 20 species of parasitic wasps have been described for *T. absoluta* (Luna *et al*., 2007). Several reports of biological control of *T. absoluta* are known from South America, especially

with the egg parasitoid *Trichogramma (*Medeiros *et al, 2006)*. In Spain, preliminary reports indicate that the predator *Macrolophus* spp. has a visible effect on *T. absoluta* population dynamics. In both NL and the UK, *Trichogramma* (egg parasitoid), *Macrolophus* (predator) and *Steinernema* (parasitic nematode) are commercially available as biological control options against Lepidopteran pests (see table 4.1; Liaison, 2009). The efficacy of these biological control agents against *T. absoluta* is unknown, although the prospects for *Trichogramma* and *Macrolophus* are good.
The sex pheromone of *T. absoluta* has been identified and is commercially available. It is very effective in monitoring. Mating disruption or mass trapping with the sex pheromone in a greenhouse could be an option but will need official registration.

4. **Other control options.** Other measures that could be used to prevent establishment and spread of *T. absoluta* are: crop rotation with unsuitable host plants; tomato crop removal during a significant period when temperatures are below 10 °C; phytosanitary secure removal and destruction of infested plant material; cleaning of vehicles and carriage equipment which may have been in contact with infested fruit

5. **Current *T. absoluta* control practice in Spain**
In 2008, the Spanish Plant Protection Committee in coordination with all the Spanish Autonomous Regions (Comunidades Autónomas) established temporary emergency measures for the control of *T. absoluta*. Some Autonomic Regions (i.e. Comunitat Valenciana , Illes Balears , and Región de Murcia) have released additional regulatory actions against *T. absoluta* in their Official Bulletins (SEWG, 2008). Until January 2009, farmers could get financial compensation for the control measures carried out against *T. absoluta* for the following crops: tomato, pepper, potato and aubergine (EU notices from member states: 2008/C 159/04).
The following measures should be applied for control of *T. absoluta:*
- Two pheromone traps per ha tomato crop should be placed and checked at weekly intervals for monitoring the presence of *T. absoluta*.
- There is an obligation to report the presence of *T. absoluta* and to keep record of the control measures carried out. Infested fruits and plant parts should be destroyed.
- At low population densities (1-3 captured moths/week) mass trapping with pheromone baited water traps (15-20 traps/ha) should be applied, biological control with the egg predator *Macrolophus caliginosus* should be initiated and all infested plant material should be removed in a phytosanitary sound manner. The greenhouse tunnel should be checked for holes, the entrances should be covered by insect proof screening and double doors should be placed.
- At moderate population densities (4-30 moths/week) treatments with azadirachtine or *Bacillus thuringiensis* should be applied for 1-3 weeks in addition to the control practices for low population densities.
- For high population densities (>30 moths/week) additional treatments with indoxacarb (max. 6 treatments) or spinosad (max 3 treatments) should be applied. Technical assistance should be sought.
- After harvest the crop residues should be removed in a phytosanitary secure manner and outside the greenhouse wild *T. absoluta* host plants (*Solanum nigrum* and *Datura stramonium*) should be removed to prevent population build-up.

6. **Pest Risk Management**

(a) Prospects for continued exclusion

EU
There is a large trade volume of tomatoes from ES (as well as other infested countries) to NL and the UK. To prevent introduction of the organism into greenhouses, consignments of tomatoes should be pest free. There is an unknown trade volume of ornamental or propagation material of solanaceous species from infested countries to NL and UK. To prevent introduction of the organism into greenhouses, plants for planting of Solanaceae should be pest free.
An EU quarantine status can have a large impact on trade and packing industries, particularly since the organism is already present in several EU member states that trade large quantities to other EU countries.

Third countries
There is a general prohibition for the import of solanaceous plants to the EU from third countries other than European and Mediterranean countries (Annex 3 of 2000/29/EC). There are no restrictions for the import of solanaceous fruits but the trade volume is very low.

(b) Prospects for eradication
The success of eradication depends on how widely the pest is distributed when it is found for the first time. Eradication seems impossible when the pest is able to survive outdoors on weedy host plants as is the case in Spain. The organism is expected not to establish permanently in the field in the Netherlands or the UK. However, outbreaks may occur in greenhouses with tomato or aubergine production. Successful eradication of incidental outbreaks in greenhouses is probably possible, with strict insecticidal control and/or crop removal. There is no information available on examples of successful eradication in greenhouses.

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