United States Department of Agriculture

Animal and Plant Health Inspection Service

Cooperating State Departments of Agriculture

New Pest Response Guidelines

Tomato Leafminer (*Tuta absoluta*)

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Tomato Leafminer

Contents

Figures

Tomato Leafminer

Tables

Acknowledgements

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Cover Image

Image of *Tuta absoluta* courtesy of M.J. van der Straten.

1 Introduction

Tomato Leafminer

Contents

Purpose

Use *New Pest Response Guidelines: Tomato Leafminer* (Tuta absoluta), when designing a program to detect, monitor, control, contain, or eradicate, an infestation of *Tuta absoluta* (Meyrick) in the United States and collaborating territories.

The United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA–APHIS–PPQ) developed the guidelines through discussion, consultation, or agreement with staff members at the USDA-Agricultural Research Service, and advisors at universities.

Any new detection may require the establishment of an Incident Command System to facilitate emergency management. This document is meant to provide the necessary information to launch a response to a detection of the tomato leafminer.

If the tomato leafminer is detected, PPQ personnel will produce a site-specific action plan based on the guidelines. As the program develops and new information becomes available, the guidelines will be updated.

Users

The guidelines is intended as a field reference for the following users who have been assigned responsibilities for a plant health emergency for *Tuta absoluta*:

- PPQ personnel
- Emergency response coordinators
- State agriculture department personnel
- Others concerned with developing local survey or control programs

Contacts

When an emergency program for *Tuta absoluta* has been implemented, the success of the program depends on the cooperation, assistance, and understanding of other involved groups. The appropriate liaison and information officers should distribute news of the program's progress and developments to interested groups, including the following:

- Other Federal, State, county, and municipal agricultural officials
- Grower groups such as specific commodity or industry groups
- Commercial interests
- Academic entities with agricultural interests
- Land Grant universities and Cooperative Extension Services
- State and local law enforcement officials
- Tribal governments
- Public health agencies
- Agricultural interests in other countries
- National, State and local news media
- The public

Initiating an Emergency Pest Response Program

An emergency pest response program consists of detection and delimitation, and may be followed by programs in regulation, containment, eradication and control. The New Pest Advisory Group (NPAG) will evaluate the pest. After assessing the risk to U.S. plant health, and consulting with experts and regulatory personnel, NPAG will recommend a course of action to PPQ management.

Follow this sequence when initiating an emergency pest response program:

1. A new or reintroduced pest is discovered and reported.
2. The pest is examined and pre-identified by regional or area identifier.
3. The pest's identity is confirmed by a national taxonomic authority recognized by USDA–APHIS–PPQ-National Identification System.
4. Existing *New Pest Response Guidelines* are consulted or a new NPAG is assembled in order to evaluate the pest.
5. Depending on the urgency, official notifications are made to the National Plant Board, cooperators, and trading partners.
6. A delimiting survey is conducted at the site of detection.
7. An Incident Assessment Team may be sent to evaluate the site.
8. A recommendation is made, based on the assessment of surveys, other data, and recommendation of the Incident Assessment Team or the NPAG, as follows:
    - ❖ Take no action
    - ❖ Regulate the pest
    - ❖ Contain the pest
    - ❖ Suppress the pest
    - ❖ Eradicate the pest
9. State Departments of Agriculture are consulted.
10. If appropriate, a control strategy is selected.
11. A PPQ Deputy Administrator authorizes a response.
12. A command post is selected and the Incident Command System is implemented.
13. State Departments of Agriculture cooperate with parallel actions using a Unified Command structure.

14. Traceback and trace-forward investigations are conducted.
15. Field identification procedures are standardized.
16. Data reporting is standardized.
17. Regulatory actions are taken.
18. Environmental Assessments are completed as necessary.
19. Treatment is applied for required pest generational time.
20. Environmental monitoring is conducted, if appropriate.
21. Pest monitoring surveys are conducted to evaluate program success.
22. Programs are designed for eradication, containment, or long-term use.

Preventing an Infestation

Federal and State regulatory officials must conduct inspections and apply prescribed measures to ensure that pests do **not** spread within or between properties. Federal and State regulatory officials conducting inspections should follow the sanitation guidelines in the section ***Preparation, Sanitization, and Clean-Up*** on **page 4-2** before entering and upon leaving each property to prevent contamination.

Scope

The guidelines is divided into the following chapters:

1. *Introduction*
2. *Pest Information*
3. *Identification*
4. *Survey Procedures*
5. *Regulatory Procedures*
6. *Control Procedures*
7. *Environmental Regulations*
8. *Pathways*

The guidelines also includes appendixes, a glossary, and an index.

The Introduction contains basic information about the guidelines. This chapter includes the guideline's purpose, scope, users, and application; a list of related documents that provide the authority for the guidelines content; directions about how to use the guidelines; and the conventions (unfamiliar or unique symbols and highlighting) that appear throughout the guidelines.

Authorities

The regulatory authority for taking the actions listed in the guidelines is contained in the following authorities:

- Plant Protection Act of 2000 (Statute 7 USC 7701-7758)
- Executive Order 13175, Consultation and Coordination with Indian and Tribal Governments
- Fish and Wildlife Coordination Act
- National Historic Preservation Act of 1966
- Endangered Species Act
- National Environmental Policy Act

Program Safety

Safety of the public and program personnel is a priority in pre-program planning and training and throughout program operations. Safety officers and supervisors must enforce on-the-job safety procedures.

Support for Program Decisionmaking

USDA–APHIS–PPQ-Center for Plant Health, Science and Technology (CPHST) provides technical support to emergency pest response program directors concerning risk assessments, survey methods, control strategies, regulatory treatments, and other aspects of pest response programs. PPQ managers consult with State departments of agriculture in developing guidelines and policies for pest response programs.

How to Use the Guidelines

The guidelines is a portable electronic document that is updated periodically. Download the current version from its source, and then use Adobe Reader® to view it on your computer screen. You can print the guidelines for convenience. However, links and navigational tools are only functional when the document is viewed in Adobe Reader®. Remember that printed copies of the guidelines are obsolete once a new version has been issued.

Conventions

Conventions are established by custom and are widely recognized and accepted. Conventions used in the guidelines are listed in this section.

Advisories

Advisories are used throughout the guidelines to bring important information to your attention. Please carefully review each advisory. The definitions have been updated so that they coincide with the America National Standards Institute (ANSI) and are in the format shown below.

Address	Address indicates the person or agency to contact, along with their Web site address, email address, telephone number, or other means of contact.
Example	Example provides an example of the topic.
Source	Source indicates the location of information used for writing this section of the guidelines.
Important	IMPORTANT indicates helpful information.
CAUTION	CAUTION indicates that people could possibly be endangered and slightly hurt.
NOTICE	NOTICE indicates a possibly dangerous situation where goods might be damaged.

Boldfacing

Boldfaced type is used to highlight negative or important words. These words are: **never, not, do not, other than, prohibited**.

Lists

Bulleted lists indicate that there is no order to the information being listed. Numbered lists indicate that information will be used in a particular order.

Disclaimers

All disclaimers are located on the unnumbered page that follows the cover.

Table of Contents

Every chapter has a table of contents that lists the heading titles at the beginning to help facilitate finding information.

Control Data

Information placed at the top and bottom of each page helps users keep track of where they are in the guidelines. At the top of the page is the chapter and first-level heading. At the bottom of the page is the month, year, title, and page number. PPQ-Emergency and Domestic Programs-Emergency Programs is the unit responsible for the content of the guidelines.

Change Bar

A vertical black change bar in the left margin is used to indicate a change in the guidelines. Change bars from the previous update are deleted when the chapter or appendix is revised.

Decision Tables

Decision tables are used throughout the guidelines. The first and middle columns in each table represent conditions, and the last column represents the action to take after all conditions listed for that row are considered. Begin with the column headings and move left-to-right, and if the condition does not apply, then continue one row at a time until you find the condition that does apply.

Table 1-1 How to Use Decision Tables

If you:	And if the condition applies:	Then:
Read this column cell and row first	Continue in this cell	TAKE the action listed in this cell
Find the previous condition did not apply, then read this column cell	Continue in this cell	TAKE the action listed in this cell

Footnotes

Footnotes comment on or cite a reference to text and are referenced by number. The footnotes used in the guidelines include general text footnotes, figure footnotes, and table footnotes.

General text footnotes are located at the bottom of the page.

When space allows, figure and table footnotes are located directly below the associated figure or table. However, for multi-page tables or tables that cover the length of a page, footnote numbers and footnote text cannot be listed on the same page. If a table or figure continues beyond one page, the associated footnotes will appear on the page following the end of the figure or table.

Heading Levels

Within each chapter and section there can be four heading levels; each heading is green and is located within the middle and right side of the page. The first-level heading is indicated by a horizontal line across the page, and the heading follows directly below. The second-, third-, and fourth-level headings each have a font size smaller than the preceding heading level. The fourth-level heading runs in with the text that follows.

Hypertext Links

Figures, headings, and tables are cross-referenced in the body of the guidelines and are highlighted in boldface type. These appear in blue hypertext in the online guidelines.

Italics

The following items are italicized throughout the guidelines:

- Cross-references to headings and titles
- Names of publications
- Scientific names

Numbering Scheme

A two-level numbering scheme is used in the guidelines for pages, tables, and figures. The first number represents the chapter. The second number represented the page, table, or figure. This numbering scheme allows for identifying and updating. Dashes are used in page numbering to differentiate page numbers from decimal points.

Transmittal Number

The transmittal number contains the month, year, and a consecutively-issued number (beginning with -01 for the first edition and increasing consecutively for each update to the edition). The transmittal number is only changed when the specific chapter sections, appendixes, or glossary, tables, or index is updated. If no changes are made, then the transmittal number remains the unchanged. The transmittal number only changes for the entire guidelines when a new edition is issued or changes are made to the entire guidelines.

Acknowledgements

Writers, editors, reviewers, creators of cover images, and other contributors to the guidelines, are acknowledged in the acknowledgements section. Names, affiliations, and Web site addresses of the creators of photographic images, illustrations, and diagrams, are acknowledged in the caption accompanying the figure.

How to Cite the Guidelines

Cite the guidelines as follows: USDA–APHIS. 2011. *New Pest Response Guidelines: Tomato Leafminer* (Tuta absoluta). USDA–APHIS–PPQ–EDP-Emergency Management, Riverdale, Maryland.

How to Find More Information

Contact USDA–APHIS–PPQ–EDP-Emergency Management for more information about the guidelines.

2

Tomato Leafminer

Pest Information

Contents

Introduction

Use *Chapter 2 Pest Information* to learn more about the classification, history, host range, and biology of the tomato leafminer, *Tuta absoluta (*Meyrick).

Classification

The tomato leafminer belongs in the phylum Arthropoda, class Insecta, order Lepidoptera, suborder Glossata, superfamily Gelechioidea, family Gelechiidae, subfamily Gelechiinae, tribe Gnorimoschemini, and species *Tuta absoluta*. Use ***Table 2-1*** **on page 2-2** as a guide to the classification of the tomato leafminer and the names used to describe it in the guidelines.

Table 2-1 Classification of *Tuta absoluta*

Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Suborder	Glossata
Superfamily	Gelechioidea
Family	Gelechiidae
Subfamily	Gelechiinae
Tribe	Gnorimoschemini
Genus	*Tuta*
Full Name	*Tuta absoluta* (Meyrick 1917)
Preferred Common Name	tomato leafminer
Other Common Names	lesser tomato leaf miner, tomato leaf miner moth, tomato moth, South American tomato moth, tomato borer, tomato fruit moth (Vargas, 1970), polilla del tomate, traca-do-tomateiro, oruga minadora de hoja y tallo, polilla perforadora, cogollero del tomate, gusano minador del tomate, perforador de las hojas del tomate (CABI, 2011), South American tomato pinworm (Benvenga et al., 2007), gusano minador de la papa (Sanchez and Viana, 1969)

The common name tomato fruit borer has **not** been used for *Tuta absoluta*. Tomato fruit borer has been used for other lepidopteran species such as *Neoleucinodes elegantalis* Guenee (Lepidoptera: Crambidae) and *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) (Agropedia, 2011). *Neoleucinodes elegantalis* is the most important pest in several tomato growing regions of Central and South America, including some Caribbean Islands (Eiras, 2000).

Taxonomic History and Synonyms

The generic assignment of *Tuta absoluta* has been questioned. Povolny split the species among many genera, several of which he described himself and many of which he later synonymized. Other gelechiid taxonomists have questioned the validity of many of these genera. Three of Povolny's genera that included North American species, including *Tuta*, were recently synonymized in the checklist of North American gelechiids by Lee, et al. (2009). However, the publication did not list *absoluta* as a new combination because *absoluta* does not occur in North America (Brown, 2010).

Meyrick described *Phthorimaea absoluta* in 1917 from a single adult male collected in Huancayo, Perú (at 10,650 ft (3,246 m)) (Meyrick, 1917 p. 44-45). Clarke (1965) transferred *absoluta* to *Gnorimoschema* as a new combination and reported it from the Juan Fernandez Islands off the coast of Chile (apparently introduced). Clarke also mentioned specimens reared from potato and tomato from Chile, Perú, and Venezuela.

Povolny (1964) described *Scrobipalpula* in 1964, and transferred *absoluta* to this genus. Becker (1984) included *absoluta* in *Scrobipalpula* in Heppner's Atlas of Neotropical Lepidoptera (Checklist, part I), but did not list it as a new combination. Povolny (1987) described *Scrobipalpuloides* as a new genus and transferred *absoluta* to this genus as a new combination. Povolny (1994) later transferred *absoluta* from *Scrobipalpuloides* to *Tuta* as a new combination.

The genus *Tuta* and its type species, *atriplicella*, were made available by Kieffer and Jörgensen in 1910. Meyrick (1925) subsequently placed the genus *Tuta* in synonymy with *Gnorimoschema*. Hodges considered *T. atriplicella* to be congeneric with the type species of *Phthorimaea*, *P. operculella*, and thus these two genera were synonymized in Hodges and Becker (1990). However, Hodges and Becker (1990) did not mention *absoluta* as a new combination in this work.

Povolny (1993) reinstated *Tuta* as a valid genus without giving any morphological basis for doing so. The two genera were again synonymized by Lee et al. (2009) based on similarity of male genitalia of *Tuta atriplicella*, the type species, and *Phthorimaea operculella*. However, a recent study of Gnorimoschemini of Europe (Huemer and Karsholt, 2010) has adopted a conservative approach to recognizing *Tuta* as a valid genus. Thus, *Tuta* is here recognized as the valid genus for the species *absoluta*.

A synonymy that only includes the various named combinations of *absoluta* would be as follows:

Phthorimaea absoluta Meyrick, 1917
- *Gnorimoschema absoluta* Clarke, 1965
- *Scrobipalpula absoluta* Povolny, 1964; Becker, 1984
- *Scrobipalpuloides absoluta* Povolny, 1987
- *Tuta absoluta* Povolny, 1994

Ecological Range

The tomato leafminer is **not** known to occur in the United States. However, Garcia and Espul (1982) erroneously reported that this pest had spread from the United States (California) into Central and South America. A closely related Gelechiid species, the tomato pinworm, *Keiferia lycopersicella* (Walshingham), occupies the ecological niche of the tomato leafminer on tomatoes in the United States (CABI, 2011).

The tomato leafminer is a neotropical oligophagous pest of solanaceous crops (Lietti et al., 2005). It is native to South America (Urbaneja et al., 2007). A recent reference suggested that the tomato leafminer is distributed throughout the South American continent with the exception of the Andean Region at altitudes higher than 1,000 m (Viggiani et al., 2009). However, it is worth noting that the type specimen for *Tuta absoluta* was collected from the Andean region of Perú at an altitude of 10,650 ft (3,246 m) (Meyrick, 1917).

South America—Argentina (Giganti et al., 1993; Pastrana, 2004); Bolivia (Zhang, 1994); Brazil (Pastrana, 2004); Chile (Pastrana, 2004); Colombia (Colomo and Berta, 2006); Ecuador (Povolny, 1994); Panama (USDA, 2011; Russell IPM, 2009a); Paraguay (EPPO, 2011a); Uruguay (Pastrana, 2004); Venezuela (Fernandez and Montagne, 1990a).

Europe—Albania (EPPO, 2009k); Bulgaria (EPPO, 2010a); France (EPPO, 2009a, 2009r); Germany (EPPO, 2010c); Greece (European Commission, 2009), Guernsey (EPPO, 2010h); Hungary (EPPO, 2010f); Italy (EPPO, 2009b, 2009f, 2009h, 2009m, 2009q, 2010d); Kosovo (EPPO, 2010g); Lithuania (Ostraukas and Ivinskis, 2010); Malta (EPPO, 2009n); Netherlands (EPPO, 2009c, 2009e); Portugal (EPPO, 2009l); Slovenia (Knapic and Marolt, 2009); Spain (Potting et al., 2009; Torres-Gregorio et al., 2009; Urbaneja et al., 2007), and Canary Islands (EPPO, 2009p); Russia (Russell IPM, 2009a); Switzerland (EPPO, 2009o); United Kingdom (EPPO, 2009g; EPPO, 2011e).

Africa—Algeria (EPPO, 2008b); Egypt (Russell IPM, 2009a); Libya (Russell IPM, 2009a); Tunisia (EPPO, 2009d); Morocco (EPPO, 2008c); Sudan (Russell IPM, 2009a).

Middle East—Bahrain (Russell IPM, 2009a); Cyprus (EPPO, 2010b); Iraq (Russell IPM, 2009a); Israel (EPPO, 2010e); Jordan (Russell IPM, 2009a); Kuwait (Russell IPM, 2009a); Saudi Arabia (Russell IPM, 2009a); Syria (Russell IPM, 2009a); Turkey (EPPO, 2010i).

Potential Distribution

NAPPFAST (North Carolina State University APHIS Plant Pest Forecasting System) maps were used in this section to describe the potential distribution of the tomato leafminer.

In a cooperative venture, North Carolina State University (NCSU), USDA–APHIS, and the information technology company ZedX, Inc., developed the Web tool known as NAPPFAST. NAPPFAST uses weather, climate, and soil data, to model pest development. The models supply the predictive pest mapping needs of the Cooperative Agricultural Pest Survey (CAPS) program. In addition, the models produce potential establishment maps for exotic pests, which supports the risk assessment activities of the Plant Epidemiology Risk Assessment Laboratory (PERAL).

Figure 2-1 **on page 2-6** was used to describe the relative establishment potential based on the suitability of the climate for *Tuta absoluta* to grow and survive in the conterminous United States. The map was based on 10 years of daily data from NAPPFAST and developmental data for the tomato leafminer (Barrientos et al., 1998). In the color scale, the color blue represents a low likelihood of pest growth and survival, while the color red indicates high likelihood of pest growth and survival.

Figure 2-2 **on page 2-6** also describes the establishment potential and combines host and climatic suitability information for this species. Host data was based on National Agricultural Statistics Service (NASS) data for tomato as primary host (field and greenhouse) and eggplant, potato and tobacco as secondary hosts. Climate suitability was based on 10 years of daily data from NAPPFAST and developmental data for *Tuta absoluta* (Barrientos et al., 1998).

How to Download Risk Maps from NAPPFAST

The risk maps featured in this section can be downloaded from the NAPPFAST Web site. For further information, refer to ***Table 2-2*** **on page 2-5**.

Table 2-2 How to Download Electronic Images from NAPPFAST

If you want to download the following:	Then visit this Web site:	And select this link:
Any host or risk map, including Alaska and Hawaii	http://www.nappfast.org/caps_pests/CAPs_Top_50.htm	CAPS AHP 2011 Top 50 and Pest Matrix

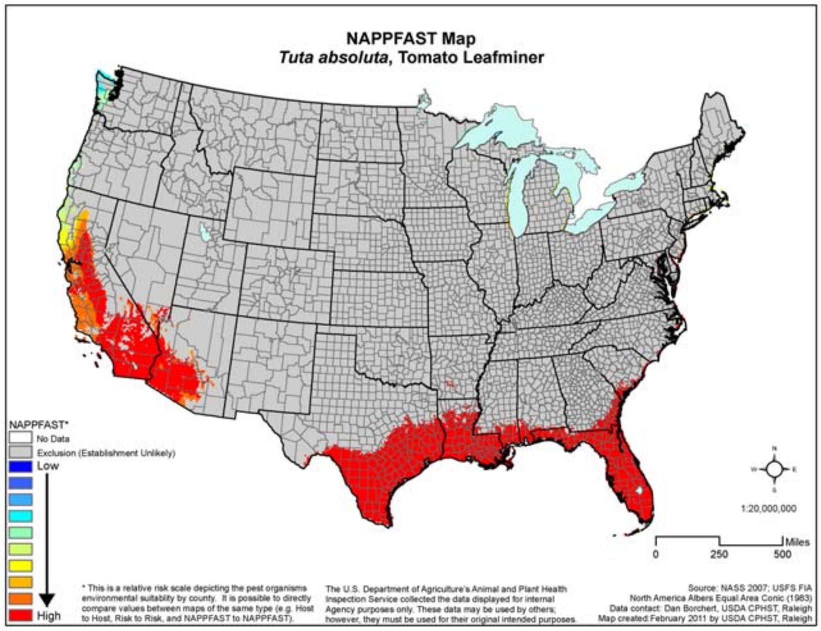

Figure 2-1 NAPPFAST Map of Relative Establishment Potential Based on the Suitability of the Climate for *Tuta absoluta*

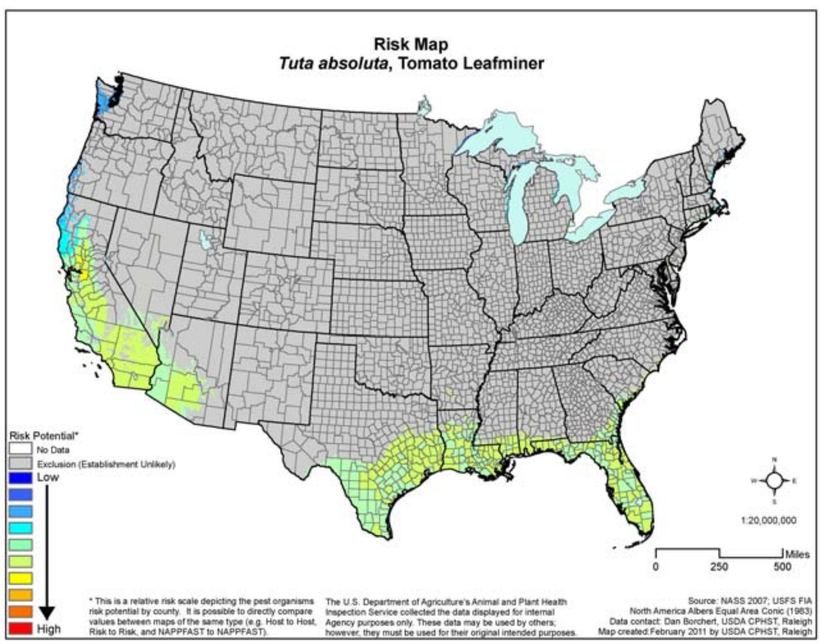

Figure 2-2 NAPPFAST Map of Relative Establishment Potential Combining Host and Climatic Suitability for *Tuta absoluta*

Hosts

Hosts reported for *Tuta absoluta* are listed in ***Table 2-3* on page 2-8**. The hosts were reported from their current distributions, and the host species may not be present in the United States. If pests are introduced into new areas, they may attack native species that have not previously been identified as host plants. Therefore, host species should be surveyed (where applicable) and surveys should be broadened to native species within the host genera.

South America

In South America, the preferred host of *Tuta absoluta* is tomato; the pest lays eggs in all aboveground portions of the plant (leaves, shoots, flowers) including on the fruit (Vargas, 1970). The tomato leafminer is able to complete its development (from egg to adult stage) on *Solanum tuberosum*, *S. melongena*, *S. gracilius*, *S. bonariense* and *S. sisymbriifolium*, but development was interrupted (at larval instars I and II) on *Nicotiana tabacum* and *Solanum pseudo-capsicum* (Galarza, 1984).

A more recent study (Cardozo et al., 1994) reported that *Tuta absoluta* is able to complete development on *Nicotiana tabacum*, and can use *Solanum elaeagnifolium* as an alternate host plant.

Fernandez and Montagne (1990b) conducted host preference studies in a laboratory in Venezuela. They found that the tomato cultivar "Rome Gigante" was the preferred oviposition host and the best host for larval development, when compared to tomato variety Cerasiforme, eggplant, tobacco, *Solanum hirtum*, *Physalis angulata*, *S. americanum,* and potato.

Among its alternate hosts are the weeds *Lycium chilense* (Coralillo), *Solanum nigrum*, *Datura stramonium* (Estay, 2000), *Datura ferox,* and *Nicotiana glauca* L. (tree tobacco) (EPPO, 2005).

Europe

In Europe and other parts of its expanded geographical range, *Tuta absoluta* prefers tomato. It can attack other solanaceous crops such as eggplant (MPAAF, 2009; Viggiani et al., 2009), potato (FREDON-Corse, 2009b; Maiche, 2009), and pepper (MPAAF, 2009), sweet cucumber (pepino) (FERA, 2009b) and Cape gooseberry (Garzia, 2009b). It was reported infesting common bean in Italy (EPPO, 2009i; MPAAF, 2009).

Table 2-3 Hosts in the Families Solanaceae and Fabaceae Reported for *Tuta absoluta*

Host	Common Name	Source
Capsicum annuum L.	pepper	Ministero delle Politiche Agricole Alimentari e Forestali, (2009)
Datura quercifolia Kunth syn*:* *Datura ferox* Kunth	long-spined thorn apple	EPPO (2005)
Datura stramonium L.	jimson weed, devil's trumpet	Vargas (1970)
Lycopersicum puberulum Ph.		Vargas (1970)
Nicotiana tabacum L.	tobacco	Galarza (1984), Fernandez & Montagne (1990b)
Physalis angulata L.		Fernandez & Montagne (1990b)
Physalis peruviana L.	Cape gooseberry	Garzia (2009b)
Solanum americanum Miller	American nightshade	Fernandez & Montagne (1990b)
Solanum bonariense L.		Galarza (1984)
Solanum elaeagnifolium Cav.		Galarza (1984)
Solanum gracilius Herter		Galarza (1984)
Solanum hirtum Vahl		Fernandez & Montagne (1990b)
Solanum lycopersicum L. (*Lycopersicon esculentum* Miller)[1]	tomato	Vargas (1970), Fernandez & Montagne (1990b)
Solanum melongena L.[2]	eggplant	Galarza (1984), Fernandez & Montagne (1990b), Ministero delle Politiche Agricole Alimentari e Forestali (2009), Viggiani et al. (2009)
Solanum muricatum Aiton	sweet cucumber, pepino	FERA, 2009b
Solanum nigrum L.	black nightshade	Vargas (1970)
Solanum pseudo-capsicum L.	Jerusalem cherry	Galarza (1984)
Solanum tuberosum L.[3]	potato	Pastrana (1967), Vargas (1970), Galarza (1984), Fernandez & Montagne (1990b), FREDON-Corse (2009b), Maiche (2009)
Solanum sisymbriifolium Lamb.	sticky nightshade, litchi tomato	Galarza (1984)
Phaseolus vulgaris L.[4]	common bean	EPPO (2009i), Ministero delle Politiche Agricole Alimentari e Forestali (2009)

1 Leaves, shoots, stems, flowers and fruit

2 Leaves and stems; fruit not specified.

3 Leaves and tubers.

4 Represents shift in host plant family from Solanaceae to Fabaceae.

A recent report from France (FREDON-Corse, 2009b) contains photographs of *Tuta absoluta* damage to potato tubers. Viggiani et al. (2009) reported that in Italy the tomato leafminer causes direct and indirect damage to the production of tomato, potato, eggplant, and pepper, although it does not specify if the damage includes damage to fruit.

Life Cycle

Tuta absoluta is a holometabolous insect with a high rate of reproduction. It may be able to complete 12 generations per year depending on environmental conditions (EPPO, 2005). In the laboratory (at a constant temperature of 25°C and 75 percent R.H.), *Tuta absoluta* completes a generation in 28.7 days (Vargas, 1970). Given the field conditions in the Arica Valley in Chile, *Tuta absoluta* could complete seven to eight generations per year at that location (Vargas, 1970). Since this pest can infest hosts grown in protected situations (such as greenhouses) its rapid reproductive rate should be kept in mind. The species can overwinter in the egg, pupal, or adult stage (EPPO, 2005). No information is available on whether this species is capable of diapause.

Adults

The sex ratio in field-collected populations in Venezuela was 1 male to 1.33 females (Fernandez and Montagne, 1990a). Adult males live longer than females. In the laboratory, mated males lived 26.47±7.89 days while virgin males lived 36.17±6.55 days. Mated females lived 23.24±5.89 days while virgin females lived 27.81±10.78 days (Fernandez and Montagne, 1990a).

Both genders mate multiple times. The first mating usually occurs the day after adults emerge. Mating occurs at dawn (Vargas, 1970). Studies in Chile revealed that the greatest number of males were captured in pheromone traps during the period 7 to 11 a.m., suggesting that this is the time when males are searching for calling females (Miranda-Ibarra, 1999).

The average preoviposition period for females was 2.4±0.61 days (Fernandez and Montagne, 1990a). Female fecundity can range between 60 to 120 eggs (Torres et al., 2001) but each female can lay up to 260 eggs in a lifetime (CABI, 2011). Oviposition studies in laboratories showed that females can lay eggs for more than 20 days; however, 72.3 percent of the eggs were deposited during the first 5 days and 90 percent in the first 10 days (Fernandez and Montagne, 1990a).

Eggs

Eggs are laid singly (rarely in batches) on all above-ground parts of the host plant.

Larvae

Larvae complete four instars that are well-defined and are of different size and color (Estay, 2000), but variation in the number of instars is well-documented within any species of Lepidoptera (*Table 3-2* **on page 3-4**). After hatching, larvae enter the plant tissue and begin feeding, thus creating mines.

In tomato, young larvae can mine leaves, stems, shoots, flowers, and developing fruit; later instars can attack mature fruit (Vargas, 1970). Larval mines increase in length and width as the larva develops and feeds. In cases of severe attack, all leaf tissue is consumed leaving behind a skeletonized leaf and large amounts of frass. Larvae spin silken shelters in leaves or tie leaves together (Vargas, 1970).

Pupae

Mature larvae purge themselves of food and build a silken cocoon where the larva transforms into a pupa.

Developmental Rates and Day Degrees

The lower developmental (or baseline) temperature for *Tuta absoluta* is 8.14°C. For egg development this temperature is 6.9°C; for larvae it is 7.6°C; and for pupae it is 9.2°. Using the mean baseline temperature of 8.14°C, *Tuta absoluta* requires 459.6 degree days to complete its development.

A degree day is a measurement of heat units over time, calculated from daily maximum and minimum temperatures. Degree days are based on the rate of an insect’s development at temperatures between upper and lower limits for development. The minimum temperature at which insects first start to develop is called the lower developmental threshold, or baseline temperature (Murray, 2008). Degree day requirements to complete egg, larval and pupal development are 103.8, 238.5 and 117.3, respectively (Barrientos et al., 1998).

Laboratory studies in Chile showed that the development of *Tuta absoluta* from egg to adult requires 76.3 days at 14°C (57°F), 39.8 days at 19.7°C (67°F), and 23.8 days at 27.1°C (81°F).

The authors also recorded egg-to-adult survival at these temperatures. At 14°C, 61.9 percent of the cohort survived to adulthood; at 19.7°C, 60.7 percent of the cohort emerged as adults and at 27.1°C, 44.3 percent of the cohort completed development. At 27.1°C, eggs eclosed in 4 to 6 days, larvae completed their development in 11 to 13 days, and pupae emerged as adults in 5 to 8 days. At 19.7°C, eggs eclosed in 7 to 9 days, larvae completed their development in 18 to 22 days and pupae emerged as adults in 9 to 14 days. At 14.0°C, eggs eclosed in 12 to 16 days, larvae completed their development in 33 to 42 days, and pupae emerged as adults in 20 to 28 days (Barrientos et al., 1998).

In laboratory studies in Venezuela, Fernandez and Montagne (1990a) reported that the egg stage of *Tuta absoluta* lasted 4.4 to 5.8 days at a temperature of 24.6°C and a relative humidity of 76.17 percent; larval development was completed in 11 to 15 days at 24.09°C and 70.64 percent R.H.; adult males emerged in 7 to 8 days and females in 6 to 8 days at 26.3°C and 72.3 percent R.H. The sex ratio was 3 males to 4 females, or 1:1.33 male: female.

How to Calculate Day Degree Values

Day degree values are based on the developmental threshold temperature of an insect and are species specific. Threshold temperatures can represent either upper or lower limitations, and may be measurements of air or soil temperature, depending on where the insect lives.

To determine degree day values for a pest, use ***Equation 1*** or ***Equation 2***. For further information, refer to ***Potential Distribution*** on **page 2-4**.

Equation 1	Degree Days = [(Average Daily Temperature) – (Developmental Threshold)]
Equation 2	Degree Days = [(Maximum Temperature + Minimum Temperature)/2] – (Developmental Threshold)

Behavior

Adult *Tuta absoluta* are most active at dusk and dawn, and rest among leaves of the host plant during the day (Fernandez and Montagne, 1990a; Viggiani et al., 2009). Mating usually occurs the day after adults emerge, usually at dawn. Studies in Chile revealed that the greatest number of males were captured in pheromone traps during the period 7 to 11 am, suggesting that this is the time when males are searching for calling females (Miranda-Ibarra, 1999).

Hickel et al. (1991) studied the mating behavior of *Tuta absoluta* in the laboratory and determined the sequence of male mating behaviors can be divided into two phases: long-range female location and short-range courtship.

Long-range female location includes behaviors that eventually lead to the arrival of males in the vicinity of females. Short-range courtship behaviors focus on interactions between the genders that eventually lead to mating. Of the short-range behaviors, male walking while fanning the wings was an essential component of courtship. Duration of copula is variable, sometimes taking 2 to 3 hours or extending to as much as 6 hours.

Both genders mate multiple times. Santos-Silva (2008) reported that males mate more times (up to 12 times in their lifetime) than females. In laboratory studies conducted in Venezuela, adults mated up to 16 times during their lifetime (Fernandez and Montagne, 1990a). However, data from laboratory mating studies may not reflect the true number of matings taking place in the field. We found no information on the number of matings for *Tuta absoluta* under field conditions. Adults, both males and gravid females, exhibit a strong phototactic response (Vargas, 1970).

Adult females lay their eggs singly (rarely in batches). Egg laying takes place throughout the day, but peak oviposition occurs at night (Vargas, 1970). Laboratory studies showed that females can lay eggs for 20+ days; however 72.3 percent of the eggs were deposited during the first 5 days and 90 percent in the first 10 days (Fernandez and Montagne, 1990a). Other references suggest that up to 92 percent of the eggs are laid in the first few days after mating.

The tomato leafminer prefers to lay eggs on the leaves (both sides); however they will oviposit on other aerial parts of the plant such as shoots, stems, flowers and green fruit underneath the sepals that form the calyx. Riquelme (2009) observed no significant differences in the vertical distribution of *Tuta absoluta* eggs on tomato plants, however, females tended to concentrate their egg laying activity on the upper third of the tomato plants after the third week of planting (Riquelme, 2009).

Larvae normally hatch from the eggs in the morning. In laboratory studies conducted in Venezuela, 96.8 percent of a cohort of 94 eggs eclosed between 6 and 9 a.m. (Fernandez and Montagne, 1990a). After hatching, larvae penetrate plant tissue (leaves, shoots or flowers) and begin to feed, forming irregular mines that get longer and wider as the larvae continue to feed. The larvae consume the mesophyll leaving the epidermis intact (Vargas, 1970). Later instars can attack maturing fruit (Vargas, 1970).

Although larvae spend most of their life inside mines, second instars can leave the mines, thus exposing them to predation, well-timed application of pesticides and possibly parasitism. In the laboratory, larvae have been observed leaving their mine and starting a new mine on a different part of the plant (Fernandez and Montagne, 1990a).

When outside of the mines, larvae move quickly and use silken threads to locate to other parts of the plant (Fernandez and Montagne, 1990a). Leaf mines have an irregular shape and may later become necrotic. The galleries in the stems may alter the general development of the plant (EPPO, 2005).

The fruits can be attacked as soon as they are formed, and the galleries bored inside them can be invaded by secondary pathogens leading to fruit rot (EPPO, 2005). Affected fruit lose their commercial value. Larval damage to terminal buds in greenhouse-grown tomatoes in Argentina negatively affects plant architecture and can result in a significant reduction of fruit yield (Botto, 2011b).

Mature larvae purge themselves of food and shorten their body length. Larvae spin a silken cocoon where they transform into pupae. Pupae can be found attached to all plant parts (leaves, main stem, flowers, fruit) as well as in the soil (Torres et al., 2001).

Dispersal

Tuta absoluta caterpillars have been observed walking on leaves outside of their mines. This behavior might be related to the temperature inside the mine, the depletion of food, and/or the accumulation of fecal material (Torres et al., 2001). When outside of the mines, larvae move quickly and spin silken threads to move around safely (Fernandez and Montagne, 1990a). Mature larvae will sometimes exit the plant and move to the soil before pupating (Torres et al., 2001).

Adults have well-developed wings that allow them to disperse, but we found no information concerning their ability to fly.

Damage

Larvae of *Tuta absoluta* mine the leaves, flowers, shoots, and fruit of tomato as well as the leaves and tubers of potato (Pastrana, 2004). After hatching, larvae penetrate apical buds, flowers, new fruit, leaves, or stems. Conspicuous irregular mines and galleries as well as dark frass make infestations relatively easy to spot. Fruits can be attacked soon after they have formed, and the galleries made by the larvae can be colonized by pathogens that cause fruit rot. The damage caused by this pest is severe, especially in young plants. When potato plants have completed the vegetative cycle, larvae of *T. absoluta* mine the tubers underneath the epidermis. Larval feeding can cause the tubers to rot (Pastrana, 1967).

Leaves

After hatching, larvae mine the leaf tissue. The serpentine-shaped mines increase in length and width as the larva develops and feeds. In some cases, especially at the beginning of the infestation, the mines can be mistaken for those caused by leafminers in the family Agromyzidae. In cases of severe attack, the larva consumes all the leaf tissue and leaves behind a skeletonized leaf and copious amounts of frass. It is common for larvae of the second to fourth instar to spin silken shelters in leaves or tie leaves together (Vargas, 1970).

Shoots

Larvae are capable of penetrating and mining tender shoots, usually gaining entry through the apical end or at the angle formed between the petioles and the leaves (Vargas, 1970). Larvae can also pull together new shoots using silk produced by specialized salivary glands.

Flowers and Fruit

Larvae of *Tuta absoluta* can destroy the developing fruit by mining its flesh. Infested fruit will usually fall to the ground. Larvae can attack the flowers, but the most severe damage is found in developing (early instars) or maturing fruit (later instars). The larva usually enters the fruit under the calyx and tunnels the flesh, leaving galleries clogged with frass, that cause the fruit to drop or to rot on the vine. Larvae can also enter the fruit through the terminal end or through other fruit parts that are in contact with leaves, other fruits, or stems.

Economic Impact

Since its introduction into Europe in 2006, *Tuta absoluta* has continued to rapidly spread through the European and Mediterranean regions where it is a serious pest of field and greenhouse grown tomatoes. *Tuta absoluta* is “the major limiting factor for tomato production in South America” (Ferrara et al., 2001). It is a key pest of most greenhouse-grown tomatoes in Argentina (Botto, 2011b), and the key pest of tomato production in Chile (Estay, 2000). Without adequate controls, infestations of *T. absoluta* can result in 90 to 100 percent loss of field-produced tomatoes in Chile (Estay, 2000; Vargas, 1970). *Tuta absoluta* is considered one of the most important lepidopterous pests associated with processing tomatoes in Brazil (Torres et al., 2001).

Larvae of *Tuta absoluta* attack leaves, buds, stems, flowers, calyces, and tomato fruit. In Brazil, Benvenga et al. (2007) found a good correlation between increases in pheromone trap captures and positively infested plants, and decreases in open field tomato production by the end of the season (expressed as marketable boxes of fruit per 1,000 plants). However, in greenhouse-grown tomatoes in Argentina, pheromone traps were useful only for early detection of the pest. Adult males were trapped almost 10 days before the first eggs were found on the plants, and trap captures were not useful in predicting damage levels (Riquelme, 2009).

Tuta absoluta is multivoltine. Robredo-Junco et al. (2008) determined that based on mean temperatures in Ibiza, Spain, *Tuta absoluta* can complete 9 to 10 generations per year in field tomatoes and 12 generations per year in greenhouse tomatoes. Both yield and fruit quality can be significantly reduced by direct feeding by the larvae, and subsequently by secondary pathogens entering the mines and causing fruit rot. Severely attacked tomato fruits lose their commercial value. The tomato leafminer caused up to 100 percent losses in tomato crops planted during the winter in the Province of Valencia (EPPO, 2008a). Damage to terminal buds in greenhouse-grown hybrid tomato plants in Argentina negatively affects plant architecture and results in reduced plant growth and decreased fruit yield (Botto, 2011b).

Tuta absoluta feeds on potato leaves (EPPO, 2005), including those from *Bacillus thuringiensis*-transgenic plants (del Vas et al., 1992), but recent (Russell IPM, 2009b; Maiche, 2009) and historical references report that larvae also attack potato tubers (Pastrana, 1967). In Italy, eggplant was reported to be the second-preferred host of *T. absoluta* after tomato; however, it is unclear if the species attacks only the leaves or if it attacks eggplant fruit. It has been reported on protected tomato and eggplant crops in a number of regions in Italy (Ministero delle Politiche Agricole Alimentari e Forestali, 2009).

Tuta absoluta was also reported on greenhouse peppers and beans in Sicily, Italy (EPPO, 2009i; Ministero delle Politiche Agricole Alimentari e Forestali, 2009) however, there was no mention of the plant parts affected. Also in Italy, Cape gooseberry (*Physalis peruviana*), is reported as a host of *T. absoluta*, however, it is not clear from the report which plant part is affected (Garzia, 2009b).

Environmental Impact

Those plants included on the List of Endangered and Threatened Plants (50 CFR 17.12) that may be attacked by *Tuta absoluta* are listed in ***Table 2-4* on page 2-16**.

Table 2-4 Potential Host Plants of *Tuta absoluta* Included in List of Endangered and Threatened Plants (50 CFR 17.12)[1]

Name		U.S. Location
Scientific	**Common**	
Solanum drymophilum O.E.Schulz[2]	erubia	Puerto Rico
Solanum incompletum Dunal[2]	thorny popolo, popolu ku mai	Hawaii
Solanum sandwicence Hook & Arn[2]	Hawaii horsenettle, `aiakeakua, popolo	Hawaii

1 USFWS (2011).

2 Family Solanaceae.

3 Identification

Tomato Leafminer

Introduction

Use *Chapter 3 Identification* as a guide to recognizing the tomato leafminer, *Tuta absoluta* (Meyrick). Accurate identification of the pest is pivotal to assessing its potential risk, developing a survey strategy, and determining the level and manner of control.

Authorities

Qualified State, County, or cooperating University, personnel may perform preliminary identification and screening of suspect *Tuta absoluta*. Before survey and control activities are initiated in the United States, an authority recognized by USDA–APHIS–PPQ-National Identification Services must confirm the identity of such pests. Submit specimens to the USDA-National Identification Services (NIS).

Reporting

Forward reports of positive identifications by national specialists to PPQ-National Identification Service (NIS) in Riverdale, Maryland, according to Agency protocol. NIS will report the identification status of these tentative and confirmed records to PPQ-Emergency and Domestic Programs (EDP). EDP will report the results to all other appropriate parties.

For further information on reporting and submitting samples, refer to ***How to Submit Insect Specimens*** on **page F-1** and ***Taxonomic Support for Surveys*** on **page G-1**.

Diagnostic Aids

For further information on identification of *Tuta absoluta* and several similar species, refer to the following diagnostic aids:

- ***Field Screening Aid for Tuta absoluta*** on **page B-1**
- ***Diagnostic Aid for Tuta absoluta*** on **page C-1**
- ***Diagnostic Aid for Phthorimaea operculella*** on **page D-1**
- ***Field Screening Aid for Keiferia lycopersicella*** on **page E-1**

Description

Use the morphological characteristics described in this section to identify *Tuta absoluta*.

Adults

Adults are about 1 cm long, with a wingspan of about 1 cm (***Table 3-1*** **on page 3-2**). There is no obvious sexual dimorphism, although the abdomen in male moths is narrower and pointed posteriorly, while that of females is wider and bulkier. Abdominal scales are gray in males and cream colored in females (Vargas, 1970). Adult moths are mottled gray in color (***Figure 3-1*** **on page 3-3**) (Estay, 2000). Antennae are long and filiform (Vargas, 1970).

Taxonomic identification requires dissection of the male genitalia (Vargas, 1970). For further information, refer to the images of genitalia in the screening aids provided by Brambila et al. (2010). Electronic versions of the screening aids are also available at the Web site of the Cooperative Agricultural Pest Survey (CAPS).

Table 3-1 Wing Length of *Tuta absoluta*[1]

Gender	Wing Length (mm)		
	Mean	Range	Specimens
Male	10.10	8.00–11.60	25
Female	10.73	8.00–12.40	27

1 Vargas, 1970.

Figure 3-1 ***Tuta absoluta*** **Mating Adults (E.Saini, Instituto Nacional de Tecnología Agricola, Buenos Aires, Argentina)**

Eggs

Eggs are oval in shape (***Figure 3-2*** **on page 3-3**). Newly-laid eggs are creamy white and turn yellow and then yellow-orange during development (Estay, 2000). When mature, eggs turn dark and the outline of the larval head capsule can be seen through the chorion; this is called the blackhead stage (Vargas, 1970). Eggs are on average 0.383 mm long by 0.211 wide (Vargas, 1970).

Figure 3-2 ***Tuta absoluta*** **Eggs (E.Saini, Instituto Nacional de Tecnología Agricola, Buenos Aires, Argentina)**

Larvae

Head capsule diameter is the best character to differentiate between larval instars. Larvae complete four instars that are well-defined and are of different size (***Table 3-2*** **on page 3-4**) and color (Estay, 2000), but variation in the number of instars is well-documented within any species of Lepidoptera. Larvae are dorso-ventrally flattened and their color changes from creamy white to deep green during development (***Figure 3-3*** **on page 3-4**). The last instar takes on a pinkish coloration. When larvae are ready to molt they stop eating and purge their stomach contents, causing their coloration to return to creamy white.

Table 3-2 Larval Measurements for *Tuta absoluta*[1]

Instar	Body Length, mm		Head Capsule Diameter, mm		Number of Specimens
	Mean	Range	Mean	Range	
1	1.61	1.40–1.90	0.153	0.15–0.18	44
2	2.80	2.45–3.10	0.253	0.24–0.28	37
3	4.69	3.85–5.65	0.399	0.35–0.43	53
4	7.72	5.50–9.20	0.834	0.70–0.98	37

1 Vargas (1970)

Figure 3-3 *Tuta absoluta* Larva (E.Saini, Instituto Nacional de Tecnología Agricola, Buenos Aires, Argentina)

Pupae

Newly formed pupae are greenish and turn dark brown as they mature (***Figure 3-4*** **on page 3-5**) (Estay, 2000). Male pupae are lighter (3.04±0.49 mg) and smaller (length 4.27±0.24 mm and width 1.23±0.08 mm) than female pupae (4.67±0.23 mg; 4.67±0.23 mm and 1.37±0.07 mm) (Fernandez and Montagne, 1990a).

Figure 3-4 *Tuta absoluta* Pupa (EPPO Gallery, http://photos.eppo.org/index.php/album/219-tuta-absoluta-gnorab-)

Similar Species

Two other species that may be found as pests in tomato fields in the United States are the potato tuber moth (*Phthorimaea operculella* Zeller) and the tomato pinworm (*Keiferia lycopersicella*).

Tuta absoluta is most similar to the tomato pinworm primarily because both have light-and-dark banded antennae and labial palps and the color of the forewings is similar. However, the forewings of the tomato leafminer have somewhat more defined dark patches while those of the tomato pinworm are light brown to gray with brownish streaks. In addition, the hindwings of the tomato pinworm have hair pencils on the anterior margin. Genitalic dissection is required for accurate identification of either species.

To confirm identification, it is necessary to carefully examine adult male genitalic structures. For further information on identification of these species, refer to the following diagnostic aids:

- *Diagnostic Aid for Phthorimaea operculella* on **page D-1**
- *Field Screening Aid for Keiferia lycopersicella* on **page E-1**

Electronic versions of the screening aids are also available at the Web site of the Cooperative Agricultural Pest Survey (CAPS).

4

Tomato Leafminer

Survey Procedures

Contents

Introduction

Use *Chapter 4 Survey Procedures* as a guide when conducting a survey for the tomato leafminer, *Tuta absoluta* (Meyrick).

Preparation, Sanitization, and Clean-Up

Conduct the survey at the proper time. The schedule should be on a regular time interval that coincides with weather and temperature conditions most suitable for the tomato leafminer. For further information, refer to ***Developmental Rates and Day Degrees*** on **page 2-10** and ***Timing of Surveys*** on **page 4-20**.

When visiting sites to conduct surveys or to take samples, everyone must take strict measures to prevent contamination between properties during inspections. Before entering a new property, make certain that clothing and footwear are clean and free of pests and soil to avoid moving pests from one property to another. Wash hands with an approved antimicrobial soap.

Survey task forces should consist of an experienced survey specialist familiar with the tomato leafminer and the symptoms of its damage.

Survey Types

Plant regulatory officials will conduct detection, delimiting, monitoring, targeted, traceback, trace-forward, and sentinel site surveys, for *Tuta absoluta*. The survey types are described in detail in this chapter.

Surveyors will also use the following common tools and techniques when surveying for this pest:

- ***Visual Inspection of Plants*** on **page 4-5**
- ***Visual Inspection of Packing Materials*** on **page 4-6**
- ***Visual Inspection in Tomato Fields*** on **page 4-6**
- ***Sweep-Net Sampling*** on **page 4-10**
- ***Pheromone Lures*** on **page 4-11**
- ***Trapping With Pheromone Lures*** on **page 4-12**
- ***Light Traps*** on **page 4-18**

Detection Survey

Use a detection survey to determine whether a pest is present in a defined area where it is not known to occur. The detection survey can be broad in scope, as when assessing the presence of the pest over large areas or it may be restricted to determining if a specific pest is present in a focused area (i.e., a greenhouse).

Statistically, a detection survey is not a valid tool to claim that a pest does not exist in an area, even if results are negative. Negative results can be used to provide clues about the mode of dispersal, temporal occurrence, or industry practices. Negative results are also important when compared with results from sites that are topographically, spatially, or geographically similar.

Procedure

Use the following tools singly or in any combination to detect the presence of *Tuta absoluta*:

1. Check plants for the presence of the pest and its damage. Refer to ***Visual Inspection of Plants*** on **page 4-5**, ***Visual Inspection of Packing Materials*** on **page 4-6**, and ***Visual Inspection in Tomato Fields*** on **page 4-6** for detailed information.
2. Focus on high risk areas where *Tuta absoluta* is more likely to be found. See ***Targeted Survey*** on **page 4-5** and ***Survey Locations*** on **page 4-18** for detailed information.
3. Establish regular sites to inspect along your normal surveying route. See ***Sentinel Site Survey*** on **page 4-5** for detailed information.

Delimiting Survey Following Initial U.S. Detection

Use a delimiting survey to determine the type and extent of control measures to apply. In large areas, locating the source of an infestation could be difficult.

Procedure

Use the procedure in ***Detection Survey*** on **page 4-3** as a guide. Additional surveys should continue in nearby areas in order to determine the full extent of the infestation. Inspections should encompass continually larger areas particularly where hosts are known to occur. Surveys should be most intensive around the known positive detections and any discovered through traceback and trace-forward investigations, if possible.

Traceback and Trace-Forward Surveys

Traceback and trace-forward investigations help surveyors to set priorities for delimiting survey activities after an initial detection. Use traceback investigations to determine the source of an infestation. Use trace-forward investigations to determine the potential dissemination of the pest, through means of natural and artificial spread (commercial or private distribution of infested plant material). Once a positive detection is confirmed, conduct investigations in order to determine the extent of the infestation or suspect areas in which to conduct further investigations.

Procedure

If this pest is found attacking nursery stock, surveyors should compile a list of facilities associated with nursery stock infested with *Tuta absoluta*. The lists will be distributed by the State to the field offices, and are **not** to be shared with individuals outside USDA–APHIS–PPQ and State regulatory cooperators. Grower names and field locations on the lists are strictly confidential, and any distribution of lists beyond appropriate regulatory agency contacts is prohibited.

Each State is only authorized to see locations within their State and sharing of confidential business information may be restricted between State and Federal entities. Check the privacy laws with the State Plant Health Director for the State.

When notifying growers on the list, be sure to identify yourself as a USDA or State regulatory official conducting an investigation of facilities that may have received material infested with *Tuta absoluta*. Speak to the growers or farm managers and obtain proper permission before entering private property. If any sales or distribution has occurred from an infested nursery during the previous six months, surveyors should check nursery records to obtain names and addresses for all sales or distribution sites.

Monitoring Survey

Perform a monitoring survey to determine the success of control or mitigation activities conducted against a pest.

Procedure

At the time of publication, a defined method was unavailable.

Targeted Survey

Conduct targeted surveys at facilities associated with high risk pathways.

Procedure

At the time of publication, a defined method was unavailable.

Sentinel Site Survey

Procedure

At the time of publication, a defined method was unavailable.

Visual Inspection of Plants

This section contains instructions for inspecting plants for infestations of *Tuta absoluta* as well as the damage caused by this pest.

Procedure

1. Inspect potential host plants, and nearby resting places, for resting adults of *Tuta absoluta*.

   Refer to ***Table 2-3*** **on page 2-8** and ***Table 2-4*** **on page 2-16** for lists of potential hosts. If inspecting tomatoes in fields, refer to ***Visual Inspection in Tomato Fields*** on **page 4-6**. If inspecting crops other than tomatoes in fields, continue.

   Refer to the images of adults in ***Figure 3-1*** **on page 3-3** and ***Field Screening Aid for Tuta absoluta*** on **page B-1**.

2. Disturb plants if necessary to incite the flight of adults.
3. Collect samples of *Tuta absoluta* while inspecting potential host plants.
4. Follow the instructions described in ***Processing Samples*** on **page 4-21** when preparing specimens.
5. Submit specimens and plant material to the proper authority. Refer to ***How to Submit Insect Specimens*** on **page F-1** for further information.

Visual Inspection of Packing Materials

Inspect packing materials for the presence of *Tuta absoluta*.

Procedure

At the time of publication, a defined method was unavailable.

Visual Inspection in Tomato Fields

Within-plant distribution studies for *Tuta absoluta* in fresh and processing tomatoes found that most plant damage is concentrated in the apical and medial parts of the plants (Botto et al., 1995; Lietti et al., 2005; Torres et al., 2001). Data suggest that visual inspection of plants should focus in these areas.

Similar Pest Species

Eggs, larvae, and mines, of *Tuta absoluta* can be confused with those of other pests such as *Keiferia lycopersicella*, the ecological equivalent of *T. absoluta* in the United States. In some cases, especially early in an infestation, leaf mines of *T. absoluta* can also be mistaken for those caused by leafminers in the family Agromyzidae (Diptera); however, the latter do not leave solid excrement in the mines. Before initiating a survey, become familiar with other pests in the area.

Guidelines for *Keiferia lycopersicella* Adapted for *Tuta absoluta*

Management guidelines for the tomato pinworm, *Keiferia lycopersicella* in California, suggest that surveyors should use the following technique for *Tuta absoluta* in tomato fields:

1. As soon as tomato seedlings are established, select several random locations throughout the field.
2. At each location, select random 6-foot length of planted row.
3. Examine all foliage in the 6-foot length of row for mines and folded leaf shelters at each location.

4. Record the average number of larvae found per row section and:

If this number of *Tuta absoluta* per 6 feet of row:	Then:	And then:
Less than 1	Repeat the surveys each week.	Continue surveys until the pest is no longer a threat.
1 or more than 1	Begin treatment.	Resume weekly surveys.

Eggs—Look for single eggs on all above-ground parts of the host plant, especially the apical parts. Eggs are difficult to find on plants. Surveyors must be trained.

Refer to the image of eggs in ***Figure 3-2*** **on page 3-3**.

Larvae—Look for larvae inside mines in the plant tissue. Look also for puncture holes with excrement, especially on fruit, and serpentine or blotch-shaped mines.

Determine the instar by examining the width of the head capsule, the length and width of the body, and the color. Larval mines increase in length and width as the larva develops and feeds. In cases of severe attack, larvae will consume all the leaf tissue, leaving behind a skeletonized leaf and large amounts of frass.

Refer to the image of a larva in ***Figure 3-3*** **on page 3-4**. Refer to the images of leaf, fruit, and stem damage on tomato (***Figure 4-1*** **on page 4-8**, ***Figure 4-2*** **on page 4-8**, and ***Figure 4-3*** **on page 4-8**) and leaf and stem damage on eggplant (***Figure 4-4*** **on page 4-9** and ***Figure 4-5*** **on page 4-9**). Refer to the images of infested potato tubers in ***Figure 4-6*** **on page 4-9** and ***Figure 4-7*** **on page 4-10**.

Pupae—Look for pupae on leaf tissue, in the soil, or in packing materials when host material is transported.

Refer to the image of a pupa in ***Figure 3-4*** **on page 3-5**.

Figure 4-1 Enlarging Gallery of *Tuta absoluta* with a Larva and Frass Inside (EPPO Gallery, http://photos.eppo.org/index.php/album/219-tuta-absoluta-gnorab)

Figure 4-2 *Tuta absoluta* Damage on Green Tomato (EPPO Gallery, http://photos.eppo.org/index.php/album/219-tuta-absoluta-gnorab-)

Figure 4-3 Larva of *Tuta absoluta* Inside a Tomato Stem (EPPO Gallery, http://photos.eppo.org/index.php/album/219-tuta-absoluta-gnorab-)

Figure 4-4 *Tuta absoluta* Damage on Eggplant (EPPO Gallery, http://photos.eppo.org/index.php/album/219-tuta-absoluta-gnorab-)

Figure 4-5 *Tuta absoluta* on Eggplant in Crete, Greece, August 8, 2009 (Russell IPM Ltd., http://www.tutaabsoluta.com/agriphotos.php?lang=en)

Figure 4-6 Potato Tuber Damage (External) Caused by *Tuta absoluta* (Fredon-Corse, http://www.fredon-corse.com/courriers/lettre250309.htm)

Figure 4-7 Potato Tuber Damage (Internal) Caused by *Tuta absoluta* (Fredon-Corse, http://www.fredon-corse.com/courriers/lettre250309.htm)

Adults— Adults of *Tuta absoluta* rest among host plants during the day and are active at dusk and dawn (Fernandez and Montagne, 1990a; Viggiani et al., 2009). As such, sweep-net sampling as well as disturbing plants to incite adult flight might be useful tools to discover a new infestation in greenhouses and/or fields.

Mating usually occurs the day after adults emerge, in the early morning hours. Mating behaviors of males include the long-range location of females, and short-range courtship. Long-range location relies on the production of pheromone by the sexually receptive female. The pheromone components for *Tuta absoluta* have been identified and used to develop synthetic pheromone lures used in several traps.

For further information, refer to ***Pheromone Lures*** on **page 4-11** and ***Trapping With Pheromone Lures*** on **page 4-12**. Light traps can be used to detect adults as males and gravid females are strongly phototactic (Vargas, 1970).

Sweep-Net Sampling

Sweep-net sampling might be useful in alerting growers and officials to the presence of this pest.

Procedure

Use a sweep-net to collect adults in the crop foliage.

Pheromone Lures

Attygalle et al. (1995) identified (3E, 8Z, 11Z)-3,8,11-tetradecatrien-1-yl acetate (E3Z8Z11-14Ac) as the major component of the female sexual pheromone for *Tuta absoluta*. Field evaluations conducted in Brazil showed that adding the minor component (3E,8Z)-tetradecadien-1-yl acetate (E3Z8-14Ac) to traps baited with the major component did not significantly increase male trap captures in the field (Filho et al., 2000). However, Ferrara et al. (2001) showed that a combination of attractants increased the number of trapped males. Svatos et al. (1996) suggest that the major and minor components should be used in a 90:10 proportion, respectively.

Delta traps baited with pheromone were useful for the early detection of *Tuta absoluta* in greenhouse and field situations in Argentina (Botto and Riquelme, 2000). Both ISCA Technologies (USA) and Russell IPM Ltd. (United Kingdom) manufacture and sell synthetic pheromone lures containing a mixture of both components. Russell IPM rubber septa lures (marketed as Qlure-TUA) are loaded with different amounts of material (mixture of E3Z8Z11-14Ac and E3Z8-14Ac): 0.1mg, 0.3mg and 0.5mg.

Procedure

Pheromone lures can be used in pan traps, Delta traps, McPhail traps, and bucket traps. Pheromone lures should be replaced every 4 to 6 weeks (Russell IPM, 2009f).

Rubber septa lures are loaded with different amounts of synthetic pheromone (0.1 mg, 0.3 mg, and 0.5 mg). The lure with 0.3mg is suitable for most survey applications, while the low load lure (0.1mg) is useful to survey in enclosed buildings such as packing and sorting houses. The high load lure (0.5mg) is suitable for trapping in open fields (Al-Zaidi, 2009).

Table 4-1 Trapping Location and Selection of Pheromone Lure Load

If this trapping location:	Then use this lure load (mg):
Enclosed buildings	0.1
Most survey locations	0.3
Open fields	0.5

Some companies that manufacture and market pheromone lures also market the traps, or else offer complete monitoring systems for *Tuta absoluta*. Notable among these are ISCA Technologies (United States), Russell IPM Ltd. (United Kingdom), Koppert Biological Systems (Netherlands), and PRI *PHERO*BANK (Netherlands).

For further information, contact the EDP-National Survey Supply Coordinator.

Trapping With Pheromone Lures

Pan Traps

Pan traps consist of a plastic container holding water and a pheromone lure. The traps can vary in shape (circular, rectangular), volume of water, and lure placement (***Figure 4-8*** **on page 4-12**, ***Figure 4-9*** **on page 4-13**, ***Figure 4-10*** **on page 4-13**, and ***Figure 4-11*** **on page 4-13**). France has recommended a circular pan trap with a 30-cm diameter (FREDON-Corse, 2009a) that holds 3.5 liters of water (ASOCOA, 2010). The lure is secured above the water with a wire attached at both ends of the container.

Other pan traps have a built-in holding area for the pheromone lure which protects it from direct sunlight. A small amount of vegetable oil or soap should be added to the water (Koppert, 2010) to reduce surface tension so the insect is trapped in the water and not on the surface where it can escape (MEM, 2010). Some pan traps are equipped with a system to help maintain the water level in the trap.

Pan traps with water and detergent are placed at the base of plants mostly in greenhouse situations. Males attracted to the lure will fall in the water and drown. Pan traps with water can capture large numbers of adult males without becoming saturated with insects.

Figure 4-8 Pan Trap with Pheromone Lure from PRI *PHERO*BANK (Wageningen, NL, http://www.pri.wur.nl/UK/products/Pherobank/)

Figure 4-9 Rectangular Pan Trap with Pheromone Lure from OpenNatur (http://www.opennatur.com/es_trampas.html)

Figure 4-10 TUTASAN Pan Trap with Dripper System to Maintain Water Level (Koppert Biological Systems, http://www.koppert.com/products/monitoring/products-monitoring/detail/tutasan-watertrap-2/)

Figure 4-11 Pan Trap with Pheromone Lure and Protective Cage (Russell IPM Ltd., http://www.tutaabsoluta.com/agriphotos.php?lang=en)

Delta Traps

Delta traps consist of a triangular-shaped body (manufactured of paper or plastic) opened at both ends, a removable sticky insert placed inside on the floor of the triangle, and a pheromone lure suspended above the sticky insert (typically using a pin or a basket). Refer to ***Figure 4-12*** **on page 4-14**, ***Figure 4-13*** **on page 4-15**, and ***Figure 4-14*** **on page 4-15** for images of Delta traps.

Paper and plastic Delta traps are available from ISCA Technologies. Paper Delta traps measure 12 by 10 by 18 cm (5 by 4 by 7 in) and plastic traps measure 28 by 20 by 15 cm (11 by 8 by 6 in). Recent trials in France suggest that it is best to place the pheromone lure directly on top the sticky insert (FREDON-Corse, 2009a).

Male moths that follow the pheromone plume and enter the Delta trap can be captured on the sticky insert. In tomato plantings, hang Delta traps on stakes near plant foliage, about 1 meter off the ground. In general, trap location should not be higher than 1 to 2 ft (0.30 to 0.60 m) above the top of the tomato or other host plants because *Tuta absoulta* males fly close to the host plants (Al-Zaidi, 2009). The trapping or retention mechanism in Delta traps (sticky inserts) keep the insects dry in case further specimen examination is needed. However, in heavy infestations, sticky inserts can become saturated with trapped males or moth scales causing them to lose their effectiveness at capturing and retaining additional moths. In these situations, service the traps more frequently.

Pherocon 1-C traps are routinely used in monitoring surveys for the tomato pinworm, *Keiferia lycopersicella* (Zalom et al., 2008). Pherocon 1-C traps operate similarly to Delta traps: they use a pheromone lure and a sticky surface to capture adult males. It might be possible to use this trap to survey for *Tuta absoluta*.

Figure 4-12 Delta Trap with Pheromone Lure to Monitor for *Tuta absoluta* (Russell IPM Ltd., http://www.tutaabsoluta.com/insectprofile.php?lang=en)

Figure 4-13 Delta Trap with Pheromone Lure to Monitor for *Tuta absoluta* (OpenNatur (Barcelona, Spain). http://www.opennatur.com/es_trampas.html)

Figure 4-14 Pherocon 1-C Trap used by USDA Agriculture Research Service (http://www.aphis.usda.gov/plant_health/plant_pest_info/cactoblastis/coopresearch.shtml)

McPhail Traps

McPhail traps consist of two interlocking plastic sections, a clear top and an inverted funnel bottom (***Figure 4-15* on page 4-16**). Fill the donut-shaped trap bottom with water with a small amount of detergent (to break the surface tension), or with water mixed with insecticide.

Important

It is not known whether pesticides can continue to be used in traps in this manner. If so, the inclusion of pesticides in traps will likely depend on the environment in which the traps are located. Surveyors should check with the national program manager, or FIFRA coordinator, for further guidance.

Suspend a pheromone lure inside the trap. Adult males following the pheromone plume will enter the trap through a hole in the trap bottom. Once inside, they fall into the liquid and drown. As is the case with pan traps, McPhail traps can capture large numbers of insects.

For further information, contact the EDP-National Survey Supply Coordinator.

Figure 4-15 McPhail Trap with Compartment for Pheromone Lure (Russell IPM. http://www.russellipm-agriculture.com/solutions.php?id_ctg=29&lang=en)

Bucket Traps

Bucket traps are made of plastic and are available in a variety of colors. The bucket is the main body of the trap and is used to collect all insects that enter the trap. Bucket traps are roughly 21 cm high by 17 cm wide. Place the pheromone lure inside the clear plastic cage on the lid. Place an insecticide, for example a dichlorvos block, inside the bucket.

Important

It is not known whether pesticides can continue to be used in traps in this manner. If so, the inclusion of pesticides in traps will likely depend on the environment in which the traps are located. Surveyors should check with the national program manager, or FIFRA coordinator, for further guidance.

Attach a wire or string to the top lid to hang the trap on a pole or trap stand. Male moths will follow the pheromone plume, enter the bucket trap, and be killed by the insecticide. As is the case with pan traps and McPhail traps, bucket traps can capture large numbers of insects. As such, they can be used for monitoring as well as mass-trapping purposes. Russell IPM recommends the use of Bucket traps in dusty areas.

For further information, contact the EDP-National Survey Supply Coordinator.

Figure 4-16 Bucket Trap (Russell IPM Ltd., http://www.russellipm-storedproductsinsects.com/productdetails.php?corpprd_id=24)

Trap Densities and Servicing Schedules

Trap densities for all pheromone-baited traps used to survey for *Tuta absoluta* in Corse, France were recently published (FREDON-Corse, 2009a). For areas larger than 2500 m^2, 4 traps/ha (2.47 ac) are recommended. For areas smaller than 2500 m^2, only 1 trap is required. These trap densities are based on the fact that the attractant is a pheromone lure and have nothing to do with the trap type (pan trap, Delta trap, or other).

Check traps at least once per week, and count and remove the captured moths. Replace the pheromone lures every 4 to 6 weeks. Replenish or replace the trapping liquids and/or sticky inserts on a regular schedule.

Russell IPM (Al-Zaidi, 2009) has the following guidelines for Delta traps for *Tuta absoluta* in greenhouses and open fields:

Table 4-2 Guidelines for Delta Traps for *Tuta absoluta* in Greenhouses and Open Fields for Survey or Control[1]

If this location:	Then:	And:	For this total:
Greenhouses	1 trap inside the entrance	1 or 2 traps near the warmest part of the greenhouse	4 or 5 traps/ha
Open fields	2 traps near the edge of the field from all four directions to help establish the direction of the infestation	2 or 3 delta traps/ha	8 or 9 traps/ha

1 Russell IPM (Al-Zaidi, 2009).

Guidelines for Tomato Pinworm Adapted for *Tuta absoluta*

Monitoring recommendations for the tomato pinworm, *Keiferia lycopersicella*, in California (using Pherocon 1-C trap, a type of Delta trap) suggest that traps be installed at the time of planting at the density of one per 10 acres (4.04 ha), but with no fewer than 2 traps per field. They also suggest that a trap with no lure be used to serve as a control for lure effectiveness in the field (Zalom et al., 2008).

Another way to control for lure effectiveness is to save pheromone lures from previous batches and use these together with newer batch lures (Robertson, 2011). Service the traps twice per week from planting to harvest. When traps begin to capture males, begin monitoring the foliage for larval damage (Zalom et al., 2008). A similar monitoring approach using Delta or Pherocon 1-C traps could be employed for *Tuta absoluta*.

Refer to ***Table 4-3*** **on page 4-18** for a summary of the French guidelines on the estimated level of risk from infestations of *Tuta absoluta* based on male moth captures (FREDON-Corse, 2009a). For further information on insecticides, refer to ***Control Procedures*** on **page 6-1**.

Table 4-3 Level of Risk Based on Numbers of Adult Male *Tuta absoluta*[1] Trapped

If this number of adult males trapped (risk):	Then begin mass trapping using:	And apply:
< 10 in 1 month (low)	25 to 40 traps/ha	
< 3 in 1 week (low)		
3 to 30 in 1 week (moderate)	25 to 40 traps/ha	Treatment every 10 days
> 30 in 1 week (high)	25 to 40 traps/ha	Treatment every 10 days

1 Adapted from FREDON-Corse, 2009a.

Light Traps

Males and gravid females exhibit a strong phototactic response (Vargas, 1970). As such, light traps can be used to capture adult males and females of *Tuta absoluta* (Bolkmans, 2009; Laore Sardegna, 2010; Rodrigues de Oliveira et al., 2008). In greenhouses, place light traps near entry doors and use only during sunset and sundown (Bolkmans, 2009). Light traps should not be used in vented greenhouses that do not have proper screening in the openings (Koppert, 2009).

A modified light trap was developed for *Tuta absoluta* capable of capturing thousands of males and a substantial number of females per night (Russell IPM, 2009c). The light trap, Ferolite-TUA, uses a combination of pheromone lures and a specific light frequency that is highly attractive to *Tuta absoluta*. The trap has a reported improved effectiveness (over the standard pheromone trap) of 200 to 300 percent.

Survey Locations

Conduct surveys in fields and greenhouses in which the commercial host plants of *Tuta absoluta* are growing. Refer to ***Table 2-3*** **on page 2-8** for a list of host plants.

High Risk Areas

High risk areas from which *Tuta absoluta* can spread to other areas were recently identified by Russel IPM (Al-Zaidi, 2009).

The list of high risk areas has been modified or broadened to include all commercial hosts of *Tuta absoluta*. Where possible, use pheromone-baited traps with simultaneous scouting for eggs and early signs of damage (Riquelme, 2009). Careful examination of these areas in order to detect the presence of other stages, particularly pupae, is warranted.

According to the guidelines for managing *Tuta absoluta* at tomato packing sites in the United Kingdom, the optimal placement for pheromone traps is in areas where tomatoes are regularly disturbed, such as near packing lines, grading areas, or quality control areas. If tomato consignments are left undisturbed or are covered overnight, moths are not likely to fly about and be attracted and captured in the pheromone traps (FERA, 2009a). These guidelines should be broadened to include all commercial hosts of *Tuta absoluta*.

The areas listed in ***Table 4-4*** **on page 4-20** were identified as high risk.

Table 4-4 High Risk Areas for *Tuta absoluta*[1]

- Nurseries selling seedlings (for transplant) to farmers
    - Compost storage area
    - Every stage of production of seedlings
- Production farms
    - Reception area
    - Sorting and packing
    - Truck loading area
    - Waste disposal area
- Composting facilities recycling plant waste from production farms
    - Raw plants reception area
    - Composting area
    - Compost storage area
- Wholesale vegetable markets
    - Reception area of incoming trucks
    - Stores of bulk vegetables
- Vegetable repacking and distribution centers
    - Reception area on incoming trucks
    - Washing and packing lines
- Food processing/salad packing/vegetable processing plants
    - Reception area of incoming trucks
    - Washing and processing area
- Border crossings
    - Custom inspection area
    - Truck waiting yards

1 Russel IPM (Al-Zaidi, 2009).

Timing of Surveys

Tuta absoluta is a multivoltine species (EPPO, 2005; Vargas, 1970). Given its biology, greenhouse surveys for *T. absoluta* should be conducted year-round, because environmental conditions inside these structures would allow continuous and overlapping generations to develop. Surveys in field grown host plants should begin as soon as seedlings are well-established. Times of the year will vary depending on geographical location.

In addition, because *Tuta absoluta* can develop in solanaceous weed hosts that might be present in growing areas, trapping might continue even when commercial hosts are unavailable, after harvest and before the next planting. Surveys in other risky areas should be conducted year-round. Refer to ***Table 4-4*** **on page 4-20** for a list of areas at high risk for *Tuta absoluta*.

Processing Samples

This section contains instructions for preparing and shipping insect and plant specimens.

Preparing Samples

Preserve *Tuta absoluta* in 70 percent isopropyl alcohol and send for identification and preservation.

Shipping Samples

Call the laboratory prior to shipping the samples via overnight delivery service. Instructions and contact information are located in ***How to Submit Insect Specimens*** on **page F-1** and ***Taxonomic Support for Surveys*** on **page G-1**.

Collecting and Handling Samples and Specimens

Adults—Moths can be captured with a sweep net when disturbing plants to incite adult flight. Captured adults should be transferred to a killing jar with ethyl acetate (killing agent). Adults will be quickly stunned but will be killed slowly. The body will remain limp (unless they are left in the killing jar overnight) in case spreading or removal of genitalia is needed (USDA, 1986). Alternatively, adults can be collected and placed in 95 percent alcohol. Collecting adults and storing them in dry ice will keep them in good shape in case further taxonomic studies are planned.

Larvae and Pupae—For museum quality specimens, larvae and pupae extracted from plant material should be placed in a vial with ethanol at 70 to 80 percent and 5 percent glacial acetic acid. This combination of chemicals (referred to as acetic alcohol) aids in ethanol penetration and keeps specimen tissues relaxed (USDA, 1986). For surveys, glacial acetic acid is not necessary and 70 to 80 percent ethanol alone is all that is needed.

Immature Stages in Plant Material—Place suspect material in a plastic bag and store in a cooler, but not frozen. A photograph should be taken in the field to document the plant materials original state.

Data Collection

Recording negative results in surveys is just as important as positive detections since it helps define an area of infestation. A system of data collection should include an efficient tracking system for suspect samples such that their status is known at various stages and laboratories in the confirmation process. If available, use pre-programmed hand-held units with GPS capability.

Data collected during surveys should include the following:

- Date of survey
- Collector’s name and affiliation
- Full name of business, institution, or agency
- Full mailing address including country
- Type of property (commercial nursery, hotel, natural field, residence)
- GPS coordinates of the host plant and property
- Host species and cultivar
- General conditions or any other relevant information
- Positive or negative results from specimen collection

Cooperation with Other Surveys

Other surveyors regularly sent to the field should be trained to recognize infestations of *Tuta absoluta*.

5 Regulatory Procedures

Tomato Leafminer

Contents

Introduction

Use *Chapter 5 Regulatory Procedures* as a guide to the procedures that must be followed by regulatory personnel when conducting pest control programs against the tomato leafminer, *Tuta absoluta* (Meyrick).

Instructions to Officials

Agricultural officials must follow instructions for regulatory treatments or other procedures when authorizing the movement of regulated articles. Understanding the instructions and procedures is essential when explaining procedures to persons interested in moving articles affected by the quarantine and regulations. Only authorized treatments can be used in accordance with labeling restrictions. During all field visits, please ensure that proper sanitation procedures are followed as outlined in ***Preparation, Sanitization, and Clean-Up*** on **page 4-2**.

Regulatory Actions and Authorities

After an initial unconfirmed positive detection, an Emergency Action Notification may be issued to hold articles or facilities, pending positive identification by a USDA–APHIS–PPQ-recognized authority and/or further instruction from the PPQ Deputy Administrator. If necessary, the Deputy Administrator will issue a letter directing PPQ field offices to initiate specific emergency action under the Plant Protection Act until emergency regulations can be published in the *Federal Register.*

The Plant Protection Act of 2000 (Statute 7 USC 7701-7758) provides for authority for emergency quarantine action. This provision is for interstate regulatory action only; intrastate regulatory action is provided under State authority. State departments of agriculture normally work in conjunction with Federal actions by issuing their own parallel hold orders and quarantines for intrastate movement. However, if the U.S. Secretary of Agriculture determines that an extraordinary emergency exists and that the States measures are inadequate, USDA–APHIS–PPQ can take intrastate regulatory action provided that the governor of the State has been consulted and a notice has been published in the *Federal Register.* If intrastate action cannot or will not be taken by a State, PPQ may find it necessary to quarantine an entire State.

PPQ works in conjunction with State departments of agriculture to conduct surveys, enforce regulations, and take control actions. PPQ employees must have permission of the property owner before entering private property. Under certain situations during a declared extraordinary emergency or if a warrant is obtained, PPQ can enter private property in the absence of owner permission. PPQ prefers to work with the State to facilitate access when permission is denied, however each State government has varying authorities regarding entering private property. A general Memorandum of Understanding (MOU) exists between PPQ and each State that specifies various areas where PPQ and the State department of agriculture cooperate. For clarification, check with your State Plant Health Director (SPHD) or State Plant Regulatory Official (SPRO) in the affected State.

Tribal Governments

USDA–APHIS–PPQ also works with federally-recognized Indian Tribes to conduct surveys, enforce regulations and take control actions. Each Tribe stands as a separate governmental entity (sovereign nation) with powers and authorities similar to State governments. Permission is required to enter and access Tribal lands.

Executive Order 13175, Consultation and Coordination with Indian and Tribal Governments, states that agencies must consult with Indian Tribal governments about actions that may have substantial direct effects on Tribes. Whether an action is substantial and direct is determined by the Tribes. Effects are not limited to current Tribal land boundaries (reservations) and may include effects on off-reservation land or resources which Tribes customarily use or even effects on historic or sacred sites in States where Tribes no longer exist.

Consultation is a specialized form of communication and coordination between the Federal and Tribal governments. Consultation must be conducted early in the development of a regulatory action to ensure that Tribes have opportunity to identify resources which may be affected by the action and to recommend the best ways to take actions on Tribal lands or affecting Tribal resources. Communication with Tribal leadership follows special communication protocols. For additional information, contact PPQ's Tribal Liaison.

To determine if there are federally-recognized Tribes in a State, contact the State Plant Health Director (SPHD). To determine if there are sacred or historic sites in an area, contact the State Historic Preservation Officer (SHPO). For clarification, check with your SPHD or State Plant Regulatory Official (SPRO) in the affected State.

Overview of Regulatory Program After Detection

Once an initial U.S. detection is confirmed, holds will be placed on the property by the issuance of an Emergency Action Notification. Immediately place a hold on the property to prevent the removal of any host plants of *Tuta absoluta*.

Traceback and trace-forward investigations from the property will determine the need for subsequent holds for testing and/or further regulatory actions. Further delimiting surveys and testing will identify positive properties requiring holds and regulatory measures prescribed.

Record-Keeping

Record-keeping and documentation are important for any holds and subsequent actions taken. Rely on receipts, shipping records and information provided by the owners, researchers or manager for information on destination of shipped plant material, movement of plant material within the facility, and any management (cultural or sanitation) practices employed.

Keep a detailed account of the numbers and types of plants held, destroyed, and/or requiring treatments in control actions. Consult a master list of properties, distributed with the lists of suspect nurseries based on traceback and trace-forward investigations, or nurseries within a quarantine area. Draw maps of the facility layout to located suspect plants, and/or other potentially infected areas. When appropriate, take photographs of the symptoms, property layout, and document plant propagation methods, labeling, and any other information that may be useful for further investigations and analysis.

Keep all written records filed with the Emergency Action Notification copies, including copies of sample submission forms, documentation of control activities, and related State issued documents if available.

Issuing an Emergency Action Notification

Issue an Emergency Action Notification to hold all host plant material at facilities that have the suspect plant material directly or indirectly connected to positive confirmations. Once an investigation determines the plant material is **not** infested, or testing determines there is **no** risk, the material may be released and the release documented on the EAN.

Regulated Area Requirements Under Regulatory Control

Depending upon decisions made by Federal and State regulatory officials in consultation with a Technical Working Group, quarantine areas may have certain other requirements for commercial or research fields in that area, such as plant removal and destruction, cultural control measures, or plant waste material disposal.

Any regulatory treatments used to control *Tuta absoluta* or herbicides used to treat plants will be labeled for that use or exemptions will be in place to allow the use of other materials.

Establishing a Federal Regulatory Area or Action

Regulatory actions undertaken using Emergency Action Notifications continue to be in effect until the prescribed action is carried out and documented by regulatory officials. These may be short-term destruction or disinfestation orders or longer term requirements for growers that include prohibiting the planting of host crops for a period of time. Over the long term, producers, shippers, and processors may be placed under compliance agreements and permits issued to move regulated articles out of a quarantine area or property under an EAN.

Results analyzed from investigations, testing, and risk assessment will determine the area to be designated for a Federal and parallel State regulatory action. Risk factors will take into account positive testing, positive associated, and potentially infested exposed plants. Boundaries drawn may include a buffer area determined based on risk factors and epidemiology.

Regulatory Records

Maintain standardized regulatory records and databases in sufficient detail to carry out an effective, efficient, and responsible regulatory program.

Use of Chemicals

The PPQ *Treatment Manual* and the guidelines identify the authorized chemicals, and describe the methods and rates of application, and any special application instructions. For further information refer to ***Control Procedures*** on **page 6-1**. Concurrence by PPQ is necessary before using any chemical or procedure for regulatory purposes. No chemical can be recommended that is not specifically labeled for *Tuta absoluta*.

6

Tomato Leafminer

Control Procedures

Contents

Introduction

Use *Chapter 6 Control Procedures* as a guide to controlling the tomato leafminer, *Tuta absoluta* (Meyrick). Consider the treatment options described within this chapter when taking action to eradicate, contain, or suppress the tomato leafminer.

Because of its biology and behavior, *Tuta absoluta* is a challenging pest to control. *Tuta absoluta* produces several broods each year. After emergence, larvae can either tie together leaves or young shoots to create a shelter from which to feed (Pastrana, 1967), or immediately penetrate the young fruit, leaves, buds, or stems where they feed and develop.

Pupation occurs inside galleries, in dried plant material, or in soil. Effective chemical control is difficult because *Tuta absoluta* feeds internally. Its ability to produce many offspring also facilitates the development of pesticide resistance. For these reasons, a combination of control methods has been used in South America and Europe for containment or eradication of the tomato leafminer.

Control methods include mass-trapping of adults, well-timed pesticide applications, and a variety of cultural controls such as removal and destruction of infested plants, scheduled host-free periods, and removal of wild hosts in the vicinity of places of production. Integrated pest management (IPM) is being developed in several South American countries where *Tuta absoluta* is a serious pest of tomato. Biological control methods are being investigated in most countries where *Tuta absoluta* is present.

A successful IPM program will consider chemical, biological and cultural techniques to reduce pest populations.

Overview of Emergency Programs

APHIS-PPQ develops and makes control measures available to involved States. Environmental Protection Agency-approved treatments will be recommended when available. If the selected treatments are not labeled for use against the pest or in a particular environment, PPQ's FIFRA Coordinator is available to explore the appropriateness in developing an Emergency Exemption under Section 18, or a State Special Local Need under section 24(c) of FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act), as amended.

The PPQ FIFRA Coordinator is also available upon request to work with EPA to hurry approval of a product that may not be registered in the United States or to obtain labeling for a new use-site. The PPQ FIFRA Coordinator is available for guidance pertaining to pesticide use and registration.

Treatment Options

All treatments listed in the guidelines should only be used as a reference to assist in the regulatory decisionmaking process. It is the National Program Manager's responsibility to verify that treatments are appropriate and legal for use. Upon detection and when a chemical treatment is selected, the National Program Manager should consult with PPQ's FIFRA Coordinator to ensure that the chemical is approved by EPA for use in the United States prior to application.

Treatments can include any combination of the following options:

- Sanitation and other cultural control methods
- Application of insecticides

Eradication

Eradication is the first action to consider with the introduction of a new pest. Eradication may be feasible under some conditions, but if it fails then other strategies will be considered. Eradication may be feasible when the following conditions exist: pest population is confined to a small area, detection occurs soon after the introduction, or pest population density is low.

If an infestation of *Tuta absoluta* is discovered that meets the above named conditions, eradication will be attempted. Measures will include but may not be limited to removal and destruction of all infested plant material, removal of host material within 2 miles (3.2 km) of the find, and treatment of the soil and surrounding vegetation with an approved pesticide after removal of the infested plants.

Cultural Control

Sanitation

Populations of *Tuta absoluta* can carry over on infested plants left in greenhouses or fields after harvest or can arrive at these sites via the movement of infested plants. Production nurseries, tomato production sites, and tomato packing sites should follow strict sanitation guidelines to prevent the arrival and spread of *Tuta absoluta*.

Nurseries and Greenhouse Tomato Production—Installing double self-closing doors and covering windows and other openings with 1.6 mm (or smaller) insect mesh can prevent entry or exit of adult *Tuta absoluta* in greenhouses (7 CFR § 319, 2009; InfoAgro Systems, 2009). Pots, carts and greenhouse tools should be inspected and thoroughly cleaned before moving them to other areas.

Inside the greenhouse, plants should be routinely examined: leaves and stems should be checked for evidence of eggs, mines, larvae, frass, and other damage. The underside of fruit calyces and the fruit itself should be checked for the presence of small heaps of frass that indicate larval entry holes (Mallia, 2009). Infested plants or plant parts should be removed, especially at the beginning of cultivation, and residues should be disposed of carefully, ensuring that they are stored in sealed containers until they are sent to a waste management facility (InfoAgro Systems, 2009).

Solanaceous weeds in the vicinity of infested greenhouses should be removed and destroyed, to prevent the build-up of a potential population reservoir (Koppert, 2009). Greenhouse workers should check their clothing before moving to other greenhouses for the presence of eggs, larvae, and resting adults of *Tuta absoluta*.

Field Grown Tomatoes—Destruction and incorporation of crop residues after harvest effectively interrupts the life cycle of *Tuta absoluta* by killing the immature stages present in the plant material. Mechanical harvesting and tilling equipment should be cleaned using high pressure washing or steam after use in infested fields. Clean and inspect all harvesting containers, field boxes, carts, etc., before moving them to other areas.

Solanaceous weeds in the vicinity of infested areas should be removed and destroyed to prevent build-up of a potential population reservoir (Koppert, 2009). If at any time during the growing cycle *Tuta absoluta* is detected, remove and securely destroy (by plowing, burning, etc.) the whole plot to interrupt the pest life cycle and spread (Russell IPM, 2009b).

Vegetable Packing Stations—The United Kingdom has published best practices guidelines for managing *Tuta absoluta* at tomato packing sites since these could provide a pathway for movement of the pest to the open environment (FERA, 2009a). Strict waste management procedures are employed so that no plant waste is left uncovered and exposed. Larvae, pupae and adults might hide in plastic or cardboard packing materials in tomato grading areas.

To mitigate the risk, packing sites are encouraged to regularly examine and clean grading containers and/or use plastic bags in grading containers and replace the bags daily. Tomato crates that are returned to suppliers should be cleaned to prevent introduction of *Tuta absoluta* to growing sites. Alternatively, non-returnable tomato packing boxes can be used and should be assembled and stored in an area of the packing station away from infested crates (Sixsmith, 2010). Inspection measures at packing stations call for examination of fruit with calyces for evidence of larval mining.

In particular, vine (or truss) tomatoes should have stems and calyces examined, and this should be a priority over the examination of fruit. At all times, windows and other openings should be kept covered with 1.6 mm (or smaller) mesh to prevent the entry or exit of moths (InfoAgro Systems, 2009). Tomatoes awaiting packaging should also be protected with insect-proof mesh or plastic tarpaulin. As before, solanaceous weeds should be removed and destroyed, to prevent the build-up of a potential population reservoir.

Transport Vehicles for Movement of Tomatoes—Vehicles should be inspected to ensure that accidental movement of immature stages or adults does not occur. If any insects are found they should be destroyed. Tomatoes transported from places of production to packing or processing stations should be safeguarded during movement using insect mesh, tarps, or plastic.

Destruction of Wild and Cultivated Hosts

Wild Hosts—Wild host plants growing within 50 meters (165 ft) of infested fields, greenhouses, and packing stations, should be removed and destroyed to prevent build-up of *Tuta absoluta* populations. Wild solanaceous hosts of *Tuta absoluta* present in the United States include black nightshade (*Solanum nigrum*), silver nightshade (*Solanum elaeagnifolium*), jimson weed (*Datura stramonium*), long-spined thorn apple (*Datura quercifolia*, syn: *Datura ferox*), and tree tobacco (*Nicotiana glauca* Graham) (EPPO, 2005). They occur throughout most of the continental United States, including California and Florida, where most U.S. tomatoes are grown (USDA, NRCS, 2011).

Cultivated Hosts—In addition to tomato (*Solanum lycopersicum*), cultivated host plants present in the United States include potato (*Solanum tuberosum*), eggplant (*Solanum melongena*), sweet cucumber (*Solanum muricatum*), pepper (*Capsicum annuum*) and bean (*Phaseolus vulgaris*) (FERA, 2009b). The last host represents a shift in host plant family for *Tuta absoluta* from Solanaceae to Fabaceae.

Recently, beans were identified as hosts of *Tuta absoluta* in Sicily, Italy (EPPO, 2009i). To date, most European outbreaks have been reported on tomato, but there are reports of significant damage to eggplant in Italy (Ministero delle Politiche Agricole Alimentari e Forestali, 2009) and potatoes in France (Maiche, 2009). Irrespective of damage to other crops, solanaceous hosts should not be used in rotation with tomato in order to prevent any carry-over of the pest (Koppert, 2009).

Other Cultural Controls

Cultural control methods for *Tuta absoluta* include crop rotation with non-solanaceous crops, plowing, adequate fertilization and irrigation, destruction of infested plants and post harvest plant debris, and disposing of infested residues. Additional cultural methods to decrease populations of *Tuta absoluta* have been reported.

In greenhouse crop production, soil solarization during at least 4 to 5 weeks eliminates pupae that remain on the ground (InfoAgro Systems, 2009).

In open fields, MARM (2008a) recommended a 6-week host-free period between cultivation of susceptible crops in the same area. The period should be increased to 8 weeks during the winter to account for slower *Tuta absoluta* rates of development. The host-free period can be reduced if additional strategies to destroy pupae in the soil are used together with this method (MARM, 2008).

In the United States, a crop rotation with a host-free period is essential for reducing *Keiferia lycopersicella* (tomato pinworm) populations in tomato crops (Zalom et al., 2008), and the following guidelines may also help to suppress *Tuta absoluta* populations. The host-free period for *K. lycopersicella* should be scheduled at least once per year, and its duration should be as long as possible. Host-free periods are most effective when practiced area-wide, so cooperation among growers is important (Le Strange et al., 2000; Stansly, 2009).

Growers should also avoid both early and late-season tomato crops if pinworm is present in their fields. If high pinworm populations are present during the first planting and a second crop has been planted in an adjacent field, consideration should be given to shredding and disking the first crop. If two crops are grown in the same field, refuse from the first crop must be destroyed as soon as harvest is complete (Zalom et al., 2008).

Also in field situations, conventional and center-pivot irrigation is favored over soil irrigation since these methods disturb eggs, larvae and pupae, and can increase mortality in field populations (Embrapa, 2006). This approach may not be practical in the United States since field tomatoes are typically grown using drip or furrow irrigation which minimizes fruit rot and decay organisms (Hartz et al., 1994; Le Strange et al., 2000).

Managing Insecticide Resistance

The non-judicious application of insecticides can lead to the development of resistance. In Bolivia and Chile, *Tuta absoluta* was reported to be resistant to organophosphates in the early- to mid-1980's. More recently, laboratory studies of resistance in field strains of *T. absoluta* in Argentina revealed reduced efficacy of deltamethrin and abamectin (Lietti et al., 2005). Resistance to cartap, abamectin, permethrin and methamidophos (Siqueira et al., 2000a, 2000b), and acephate and deltamethrin (Branco et al., 2001), has been reported in Brazil.

The newer insecticide classes have provided good activity against the tomato leafminer (IRAC, 2009a). However, the modes of action need to be conserved by implementing resistance management. In practice, alternation, sequence, or rotation of compounds with different modes of action, usually provides a sustainable and effective approach to managing insecticide resistance (IRAC, 2009c).

Insecticides have been organized into mode of action (MOA) groups based on how they work to kill insects.

Procedure

One of the key steps in resistance management is to minimize the continuous use of pesticides with the same MOA classification. This classification system makes it easy for farmers and farm advisors to understand which pesticides share the same MOA without having to know the biochemical basis. The MOA classification thus provides growers, advisors, extension staff, consultants and crop protection professionals with a simple guide to the selection of insecticides for use in an effective and sustainable insecticide resistance management strategy.

Refer to ***Table 6-1*** **on page 6-8** for a list of the MOA groups of the insecticides that are used to control *Tuta absoluta*.

Table 6-1 Mode of Action Groups for Managing Insecticide Resistance in *Tuta absoluta*[1]

MOA Group	Description
1	Acetylcholinesterase (AChE) inhibitors
2	GABA-gated chloride channel antagonists
3	Sodium channel modulators
4	Nicotinic acetylcholine receptor (nAChR) agonists
5	Nicotinic acetylcholine receptor (nAChR) allosteric activators
6	Chloride channel activators
7	Juvenile hormone mimics
11	Microbial disruptors of insect midgut membranes
13	Uncouplers of oxidative phosphorylation via disruption of the proton gradient
14	Nicotinic acetylcholine receptor (nAChR) channel blockers
15	Inhibitors of chitin biosynthesis, type 0
18	Ecdysone receptor agonists
21	Mitochondrial complex I electron transport inhibitors
22	Voltage-dependent sodium channel blockers
28	Ryanodine receptor modulators
Unknown	Unknown or act on multiple targets

1 IRAC, 2009b.

Similar Species

The tomato pinworm (*Keiferia lycopersicella*) occupies the ecological niche of *Tuta absoluta* in U.S. tomatoes. The pesticides that are used to control tomato pinworm may also be effective against *T. absoluta*. Refer to ***Table 6-2* on page 6-9**.

Table 6-2 Insecticides Registered in Florida to Control *Keiferia lycopersicella* on Tomato[1]

MOA Group [2]	Common Name	Class
1A	methomyl, carbaryl	carbamate
1B	methamidophos	organophosphate
3A	beta-cyfluthrin, gamma-cyhalothrin, lambda-cyhalothrin, zeta-cypermethrin, esfenvalerate, fenpropathrin, permethrin	pyrethroid
4A	thiamethoxam	neonicotinoid
5	spinosad, spinetoram	spinosyn
6	abamectin, emamectin benzoate	avermectin
11	*Bacillus thuringiensis* var. *kurstaki*	microbial
22A	indoxacarb	oxadazine
28	chlorantraniliprole	diamide
Uncertain	azadirachtin	azadirachtin

1 Olson et al., 2009.

2 IRAC, 2009c.

Insecticides

Historically, *Tuta absoluta* has been controlled with chemicals. Organophosphates and pyrethroids were used during the 1970’s and 1980’s until new products introduced in the 1990’s (such as abamectin, spinosad, tebufonzide, and chlorfenpyr) became available (Lietti et al., 2005). At least 12 classes of insecticides control *Tuta absoluta* (IRAC, 2009a, 2009b).

Control failures with organophosphates and pyrethroids in South America (Salazar and Araya, 2001) prompted research on the resistance status of *Tuta absoluta* (Lietti et al., 2005; Siqueira et al., 2000a, 2000b); however, newer classes of insecticides are providing good control of this pest (IRAC, 2009a). This section describes pesticides used in current outbreaks and also mentions insecticides used to control *Keiferia lycopersicella* (tomato pinworm), a gelechiid moth that occupies the ecological niche of *Tuta absoluta* in the United States.

Indoxacarb, spinosad, imidacloprid, deltamethrin, and *Bacillus thuringiensis* var. *kurstaki,* were applied for the control of larval infestations in Spain (FERA, 2009b; Russell IPM, 2009b). Chlorpyrifos and pyrethrins were used in Italy (Garzia et al., 2009a). Abamectin, indoxacarb, spinosad, imidacloprid, thiacloprid, lufenuron, and *Bacillus thuringiensis* (Bt), were recommended for outbreaks in Malta (Mallia, 2009). Indoxacarb and Bt were recommended for use in France (FREDON-Corse, 2009a). In Brazil, abamectin, cartap, chlorfenapyr, phenthoate, methamidophos, spinosad, and indoxacarb, were recommended for use in the south, southeastern, and savannah tomato-growing regions, while chlorfenapyr, phenthoate, and spinosad were recommended for use in the northeastern region (IRAC, 2007). In Argentina, Bt and triflumuron were recommended for control of *Tuta absoluta* larvae as part of an IPM program that also included parasitoids (Riquelme, 2006).

Spain authorized the temporary use of four additional pesticides for the control of *Tuta absoluta*. Chlorantraniliprole, flubendiamide, emamectin, and metaflumizone were authorized for a period of not more than 120 days beginning March 15, 2010 (MARM, 2010). Temporary use was granted because existing control methods were insufficient to control *Tuta absoluta* in some parts of Spain.

According to the National Pesticide Information Retrieval System (NPIRS), EPA registration is current in the United States for the pesticides mentioned above except for cartap, phenthoate, and triflumuron (NPIRS Public, 2011; accessed 01/20/11). Furthermore, registered products are authorized for use on U.S. tomatoes except for chlorpyrifos, lufenuron, metaflumizone, and thiacloprid.

The insecticides used to control *Tuta absoluta* outside the United States were summarized in ***Table 6-3*** **on page 6-11**, and ***Table 6-4*** **on page 6-11**. It is necessary to consult with the individual States to confirm which products are registered for use on U.S. tomatoes (NIPC, 2009).

Table 6-3 Insecticides Used to Control *Tuta absoluta* Outside the United States and Registered on Tomato Fruit in the United States[1]

MOA Group [2]	Common Name	Country (Reference)
1B	methamidophos	Brazil (IRAC, 2007)
3A	deltamethrin	Spain (FERA, 2009b; Russell IPM, 2009b)
4A	imidacloprid	Malta (Mallia, 2009); Spain (FERA, 2009b; Russell IPM, 2009b)
5	spinosad	Brazil (IRAC, 2007); Malta (Mallia, 2009); Spain (FERA, 2009b; Russell IPM, 2009b)
6	abamectin	Brazil (IRAC, 2007); Malta (Mallia, 2009)
6	emamectin	Spain (MARM, 2010)
11	*Bacillus thuringiensis*	Argentina (Riquelme, 2006); France (FREDON-Corse, 2009a); Malta (Mallia, 2009); Spain (FERA, 2009b; Russell IPM, 2009b)
13	chlorfenapyr	Brazil (IRAC, 2007)
22A	indoxacarb	Brazil (IRAC, 2007); France (FREDON-Corse, 2009a); Malta (Mallia, 2009); Spain (FERA, 2009b; Russell IPM, 2009b)
28	chlorantraniliprole flubendiamide	Spain (MARM, 2010)
Uncertain	azadirachtin	Spain (van Deventer, 2009)

1 NPIRS, 2011.

2 IRAC, 2009c.

Table 6-4 Insecticides Used to Control *Tuta absoluta* Outside the United States and Not Registered on Tomato Fruit in the United States[1]

MOA Group[2]	Common Name	Country (Reference)	Comments
1B	chlorpyrifos	Italy (Garzia et al., 2009a)	EPA-registered for use on other crops but **not** tomato
4A	thiacloprid	Malta (Mallia, 2009)	EPA-registered for control of insects on pome fruit
15	lufenuron	Malta (Mallia, 2009)	EPA-registered for control of termites in outdoor/indoor settings
22B	metaflumizone	Spain (MARM, 2010)	EPA-registered as flea control for pets

1 NPIRS, 2011.

2 IRAC, 2009c.

Indoxacarb

Indoxacarb selectively targets lepidopteran pests and is effective at controlling outbreaks of *Tuta absoluta* (FERA, 2009b; Picanço, 2006; Sixsmith, 2009). Indoxacarb is a reduced risk pesticide (EPA, 2000) that enters the insect through the cuticle or digestive system and acts by blocking sodium channels in the nervous system. Indoxacarb allows most predators and immature parasitoids to survive; however, wet residues are toxic to bees and adult parasitoids (Grafton-Cardwell et al., 2005).

Low impact on honeybees was reported for dry residues of indoxacarb (Moncada, 2003).

Spinosad

Spinosad, an aerobic fermentation product of the soil bacterium *Saccharopolyspora spinosa* Mertz & Yao, provides effective control of lepidopteran (as well as dipteran and thysanopteran) pests and has low toxicity to non-target organisms (Thompson et al., 2009). Spinosad activates nicotinic acetylcholine receptors which excite the insect nervous system leading to involuntary muscle contractions, tremors, and paralysis. Entry is via the cuticle or digestive system.

Spinosad is highly toxic to bees although toxicity is considered negligible once residues have dried completely.

Spinetoram is a second-generation spinosyn. It is registered in the United States for tomato pinworm on tomato and product literature indicates it is effective against *Tuta absoluta* (DowAgrosciences, 2006).

Abamectin

Abamectin, a natural fermentation product from the soil bacterium *Streptomyces avermitilis* (ex Burg et al.) Kim and Goodfellow, has good translaminar action, penetrating the leaf surfaces of the host plant (Salvo and Valladares, 2007). Abamectin attacks the nervous system of insects and mites causing paralysis within hours. It is primarily a stomach poison although there is some contact activity. It is used against mites and leafminers (Salvo and Valladares, 2007) and spares some of the major leafminer parasitoids and some predaceous mites, although it is still highly toxic to bees.

The University of California recommends abamectin for control of the tomato pinworm in IPM programs (Zalom et al., 2008). Emamectin benzoate is a second-generation avermectin analog that is significantly more potent than abamectin when used at lower doses (Jansson et al., 1996).

Chlorfenapyr

Chlorfenapyr has been used to control *Tuta absoluta* in Brazil (IRAC, 2007). It is a pro-insecticide that is converted to the active metabolite in the midgut of insects and mites (Yu, 2008). The metabolite affects the ability of cells to produce ATP which results in the death of the insect. Chlorfenpyr is registered in the United States for control of tomato pinworm on greenhouse grown tomatoes, peppers, sweet cucumber, and eggplant (CDMS, 2010). It is effective against larvae and nymphs of spider mites, whiteflies, thrips, leafminers, and aphids in numerous crops (Yu, 2008). It is predominantly a stomach poison but has contact activity as well. It is also toxic to bees and beneficial insects (Yu, 2008).

Neonicotinoid Insecticides

Imidacloprid and thiacloprid are neonicotinoid insecticides (Yu, 2008), which mimic the action of acetylcholine in insects causing hyperexcitation and death. Neonicotinoid insecticides are toxic to a wide spectrum of sucking and chewing insects but relatively nontoxic to humans. Imidacloprid, the most widely used insecticide of the group, is systemic, has long residual activity, but is primarily effective against sucking insects (Yu, 2008). In the United States, imidacloprid is used to control aphids, Colorado potato beetle, and whiteflies on tomato. Thiacloprid is **not** registered for use on U.S. tomatoes, but it is registered for control of insects on pome fruit, including leafminers and all stages of the codling moth (*Cydia pomonella* (L.)) (CDMS, 2010).

Chlorantraniliprole

Chlorantraniliprole is a relatively new insecticides for the control of lepidoptera and selected other species (Dupont, 2008; Lahm, 2009). It controls pests through a new mode of action via activation of insect ryanodine receptors. The insecticide binds to these receptors in muscle cells, causing the release of calcium ions. Depletion of calcium results in immediate insect paralysis and death. Because of the new mode of action, chlorantraniliprole controls pest populations that are resistant to other insecticides (Lahm, 2009). Chlorantraniliprole also has negligible impact on key parasitoids, predators, and pollinators, at field use rates (Dupont, 2008; Lahm, 2009).

Chlorantraniliprole is registered for control of tomato pinworm on tomato in the United States and product literature also indicates that it is effective against *Tuta absoluta* (Dupont, 2008). Chlorantraniliprole has both larvicidal and ovicidal activity and shows excellent root uptake and translocation in tomatoes, which continues for up to 28 days from a single soil application. It also has exceptional translaminar activity, offering 100 percent larval control of tomato fruitworm, *Helicoverpa zea* (Boddie), 18 days after a single foliar application. Chlorantraniliprole has low toxicity to bees, and once the foliar residues have dried the hazard is insignificant.

Bacillus thuringiensis

Bacillus thuringiensis var. kurstaki (Btk) is a Lepidoptera-specific microbial that, when ingested, disrupts the midgut membranes. For larval control, neutral solutions of Btk should be applied to crops once per week at the end of the day (FREDON-Corse, 2009a). The leaf epidermis presents a significant barrier to control with chemical or microbial insecticides (Salvo and Valladares, 2007). As such, Btk may not be effective once *Tuta absoluta* larvae enter plant parts (Sixsmith, 2009). Btk is registered for use on tomatoes in the United States.

Azadirachtin

Azadirachtin is the key insecticidal ingredient found in neem tree (*Azadirachta indica* A. Juss.) oil. It is structurally similar to ecdysones, insect hormones that control metamorphosis. It is thought to act as an ecdysone blocker interfering with the insect's ability to molt (EXTOXNET, 1995). Azadirachtin is effective on larvae (all instars) and pupae. After ingestion, insects stop feeding; however, death may not occur for several days.

Azadirachtin has been recommended for use as a preventive spray and for light infestations (< 30 adult catches per week) of *Tuta absoluta* in Spain (Servicio de Sanidad Vegetal-Murcia, 2008; van Deventer, 2009). In the United States, azadirachtin is registered for use on tomatoes to control tomato pinworm. This product has low toxicity to pollinating bees, butterflies, and parasitic wasps.

Thiamethoxam

Thiamethoxam is a newer, systemic neonicotinoid insecticide that also controls a wide range of chewing and sucking insects. It is registered as a seed and soil treatment, and as a foliar on a number of crops. Thiamethoxam is registered as a soil treatment for tomato pinworm on tomato, pepper, and eggplant (CDMS, 2010).

Flubendiamide

Flubendiamide performs similarly to chlorantraniprole and is also registered for use on U.S. tomatoes; however, the Florida Vegetable Production Handbook recommends flubendiamide for the control of tomato fruitworm. One difference between chlorantraniliprole and flubendiamide is that the activity of flubendiamide is limited to Lepidoptera larvae while chlorantraniliprole controls both larvae and eggs (Lahm, 2009). Other differences include broader insecticidal activity of chlorantaniliprole over flubendiamide, including control of Coleoptera, Diptera, and Isoptera, and registration of chlorantaniliprole on U.S. potatoes in addition to fruiting vegetables. Chlorantraniliprole also exhibits systemic properties and is registered for soil applications.

Other Insecticides

The organophosphates chlorpyrifos and methamidophos and the pyrethroid deltamethrin are broad-spectrum insecticides effective against a wide range of pests. In the United States, methamidophos and deltamethrin are registered for control of tomato pinworm on tomato. Chlorpyrifos is banned for use on tomatoes in the United States (EPA, 2006). Most organophosphates and pyrethroids are highly toxic to bees and beneficial insects.

Fumigation

Follow the guidelines in the USDA–APHIS–PPQ Treatment Manual (PPQ, 2009d) for using methyl bromide fumigation to treat tomatoes from Chile that are potentially infested with *Tuta absoluta*.

Irradiation

Laboratory studies on the effect of gamma radiation on life stages of *Tuta absoluta* were conducted in Brazil (Arthur, 2002). The lethal dose for *T. absoluta* eggs was found to be 100 Gy; the dose preventing larvae from completing development was 200 Gy; the dose for pupae that prevented adult emergence was 300 Gy. Overall, a dose of 300 Gy was found to be lethal to all stages of *T. absoluta*. The dose that resulted in sterile adults when pupae were treated with gamma radiation was 200 Gy.

Additional studies by Arthur reported that the lethal dose of gamma radiation for eggs of *Tuta absoluta* is 70 Gy (Groppo and Arthur, 1997). The discrepancy between the 1997 and 2002 report could be due to experimental design. In the 2002 paper, radiation dosages tested were in increments of 50 Gy. As such, 70 Gy would have not been used in that set of experiments. Arthur and Groppo (2007) further reported that the sterilizing doses for treated females and treated males out-crossed to untreated adults of the opposite gender are 150 and 200 Gy, respectively. Laboratory studies on the effect of X-rays on life stages of *T. absoluta* are being conducted in Argentina (Cagnotti et al, 2010).

The effects of gamma irradiation on different stages of *Tuta absoluta* were summarized in ***Table 6-5*** **on page 6-16**.

Table 6-5 Summary of Gamma Irradiation Effects on *Tuta absoluta*[1]

Stage	Dose (Gy)	Outcome
Eggs	100	Lethal
Larvae	200	Incomplete development
Pupae	200	Sterile adults
Pupae	300	Adult emergence prevented
Adults, male	200	Sterility
Adults, female	150	Sterility

1 Conditions: Cobalt-60 Gammacell- 220 irradiator at a dose rate of 1.11 kGy per hour (Aurthur, 2002; Arthur and Groppo, 2007).

Integrated Pest Management

Integrated pest management (IPM) programs are being developed in several countries to manage infestations of *Tuta absoluta*. Most IPM programs include the monitoring of pest populations, effective methods of prevention and control, and the use of pesticides when needed. Biological control is also implemented if available.

In Spain, IPM for *Tuta absoluta* includes the following management tools (Robredo-Junco and Cardeñoso-Herrero, 2008):

- Mass-trapping of adults prior to planting
- Clearing of crop residues from planting soil
- Application of imidacloprid in irrigation water 8 to10 days after planting
- Application of spinosad or indoxacarb when *T. absoluta* is detected
- Elimination of crop residues immediately after the last fruits have been harvested (Robredo-Junco and Cardeñoso-Herrero, 2008)

In Argentina, IPM for *Tuta absoluta* in greenhouse tomatoes has been tested at INTA (Instituto Nacional de Tecnología Agropecuaria) over the last 10 years with positive results (Botto, 1999; 2011). The strategy includes the following:

- Monitoring for early detection of adults using pheromone traps and visual inspection of plants, primarily for eggs
- Inundative releases of *Trichogrammatoidea bactrae*, initiated when the first adults are trapped and/or the first eggs are observed
- Use of *Bacillus thuringiensis* in conjunction with (or after) release of egg parasitoids to control larvae
- Compatible pesticides based on safe pesticide usage if necessary

- Crop rotation with non-host plants
- Cultural control practices in the greenhouse and surrounding environment (Botto, 1999; 2011)

Population Monitoring

Pheromone-Baited Traps

Use traps baited with synthetic sex pheromone for monitoring populations of *Tuta absoluta* in open fields, greenhouses, and packing sites. Sex pheromone-baited traps will capture only adult males. The sex pheromone of *T. absoluta* has been isolated and identified. The main compounds are (3E, 8Z, 11Z)-3,8,11-tetradecatrien-1-yl acetate and (3E, 8Z)-3,8-tetradecadien-1-yl acetate in the proportions of 90:10, respectively (Svatos et al., 1996).

Pheromone lures, traps, and how to use them, were described in the following sections in *Chapter 4, Survey Procedures*: ***Pheromone Lures*** on **page 4-11**, ***Pan Traps*** on **page 4-12**, ***Delta Traps*** on **page 4-14**, ***McPhail Traps*** on **page 4-15**, and ***Bucket Traps*** on **page 4-16**.

Consult with the EDP National Survey Supply Coordinator to find companies that manufacture and market lures, traps, and complete monitoring systems for *Tuta absoluta*.

Refer to ***Table 6-6*** **on page 6-18** for a summary of the estimated level of risk from infestations of *Tuta absoluta* based on male moth captures according to French guidelines (FREDON-Corse, 2009a). Spraying with azadiractin and *Bacillus thuringiensis*, and if necessary indoxacarb, has been suggested for moderate risk (3 to 30 adults per week). Spraying with indoxacarb (young plants) or spinosad (adult plants and in case of a rapid increase of the population) has been suggested for high risk (30+ adults per week) of infestation (van Deventer, 2009).

Table 6-6 Level of Risk Based on Numbers of Captured Adult Male *Tuta absoluta*[1]

Low risk	Less than 10 individuals trapped in 1 month or less than 3 captures in one week Begin mass trapping using 25 to 40 traps/ha
Moderate risk	Between 3 -30 captures in one week Mass trapping (25-40 traps/ha) Treatment every 10 days.
High risk	Over 30 captures in one week Mass trapping (25-40 traps/ha) Treatment every 10 days. Consider stronger measures

1 FREDON-Corse, 2009b.

Monitoring Areas

Monitor for *Tuta absoluta* in the areas that were identified by Russell IPM for being at high risk (Al-Zaidi, 2009). The areas were listed in ***High Risk Areas*** on **page 4-19**.

Mass-Trapping

Mass-trapping involves placing a large number of pheromone baited traps in strategic positions within a crop. Large numbers of adult males are trapped resulting in an imbalance to the sex ratio which impacts the mating pattern of *Tuta absoluta*. Mass trapping can be used to reduce *T. absoluta* populations and is particularly useful in production of greenhouse tomatoes (Russell IPM, 2009b). For mass trapping, pheromone trap density should be 20 to 25 traps/ha inside greenhouses (30 traps/ha for greenhouses destined for plant propagation) and 40 to 50 traps/ha in open fields (Bolkmans, 2009; FREDON-Corse, 2009a).

Pan Traps

Pan traps are easier to maintain, and are less sensitive to dust, compared to Delta, McPhail, and light traps. Pan traps also have a larger trapping capacity than Delta traps. Rectangular plastic trays that hold 6 to 8 liters of water baited with pheromone lures are recommended for mass trapping (InfoAgro, 2009).

Procedure—

1. Gather together the following supplies: pheromone lure, cap, and cage; any locally available rectangular plastic pan that holds 6 to 8 liters of water; wooden stick large enough to fit across the width of the pan; flexible wire; water; any soap.
2. Use the following table to select the appropriate number of traps to install in greenhouses or open fields (Bolkmans, 2009; FREDON Corse, 2009a).

If:	And:	Then install this number of traps per ha
Inside greenhouses	→	20 to 25
Inside greenhouses	Plants will be propagated	30
Open fields	→	40 to 50

Important

Pheromone lures should not be handled without gloves for protection because the oil on fingers can interfere with the pheromone balance of the lure.

3. Wearing gloves, place the pheromone lure inside the cage and secure the cap according to instructions provided by the manufacturer, and set aside.
4. Use a length of wire to attach the wooden stick on top of the pan across its width.
5. Use a length of wire to attach the assembled cage with pheromone lure to the underside of the wooden stick.
6. Fill the pan with soapy water.
7. Replace lures every 4 to 6 weeks.

Figure 6-1 Left: Pheromone Lure, Cage, and Cap Right: Pan Trap with Wooden Stick (Russell IPM Ltd., http://www.russellipm-agriculture.com/ insect.php?insect_id= 125&lang=en)

Figure 6-2 Pheromone Lure Assemby Attached to Underside of the Stick (Russell IPM Ltd., http://www.russellipm-agriculture.com/ insect.php?insect_id= 125&lang=en)

Light Traps

Light traps can also be used to capture adult males and females of *Tuta absoluta* (Bolkmans, 2009; Rodrigues de Oliveira et al., 2008). Light traps have been used to control *T. absoluta* in greenhouse tomato production in Italy as follows: Install traps at a height of 1 meter or less from the ground, at a rate of 1 trap per 500 to 1000 m^2 (Laore Sardegna, 2010). Light traps should be placed near entry doors and used only during sunset and sundown (Bolkmans, 2009). Light traps should **not** be used in vented greenhouses that lack proper screening in the openings (Koppert, 2009).

Russell IPM (2009c) recently developed a light trap for *Tuta absoluta* that is capable of capturing thousands of male insects in addition to a substantial number of females per night. The light trap, named Ferolite-TUA, uses a combination of sex pheromone and a specific light frequency that is highly attractive to *T. absoluta*. The trap has a reported improved effectiveness (over the standard pheromone trap) of 200 to 300 percent.

Biological Control

Biological control is being investigated in most countries where *Tuta absoluta* is present. Refer to ***Table 6-7*** **on page 6-23** for a list of biological control agents that attack *T. absoluta*.

Egg Parasitoids

Trichogramma pretiosum, Trichogramma achaeae, and *Trichogrammatoidea bactrae*, parasitize the eggs of *Tuta absoluta*. In one study, adults of *T. absoluta* were released onto fully developed tomato plants, followed by the release of *Trichogramma pretiosum* 12 hours later. After 24 hours, the level of egg parasitism varied between 1.5 to 28 percent (Faria et al., 2008).

In another study, the optimal number of *Trichogramma pretiosum* needed to control *Tuta absoluta* in commercial tomato plantations was determined to be 16 parasitoids per host egg (Pratissoli et al., 2005). In Argentina, inundative releases of *Trichogrammatoidea bactrae* to control *T. absoluta* in greenhouse grown tomatoes gave good results (Botto et al., 2009; Riquelme et al., 2006).

Trichogramma achaeae has been shown to control *Tuta absoluta* in greenhouses in southeastern Spain (Cabello et al., 2009a). Under laboratory conditions, 100 percent parasitism by *T. achaeae* was reported and of those, 83 percent developed to the blackhead stage. In greenhouse tomatoes there was a 91 percent reduction in damage when 30 *T. achaeae* per plant (75 adults/m^2) were released every 3 to 4 days (Cabello et al., 2009a). *Trichogramma pretiosum* and *T. bactrae* are commercially available in the United States. *Trichogramma acheae* is available in India from Biotech International, Ltd (Bangalore, India).

Larval Parasitoids

Larvae of *Tuta absoluta* spend most of their lifetime inside mines, however, second instars leave their mines during the cooler times of the day making them vulnerable to parasitoids and predation (Torres et al., 2001). Of the larval parasitoids, the braconid *Pseudapanteles dignus* is frequently found parasitizing larvae in South America (Sanchez et al., 2009). Studies have shown that female parasitoids attack hosts daily and do not have a preference among larval instars. Parasitism of *T. absoluta* by *P. dignus* can reach up to 46 percent in late tomato crops (Sanchez et al., 2009). In Argentina, researchers have tested inoculative releases of *P. dignus* in greenhouses before *T. absoluta* reaches high population levels (Botto, 2011).

Colomo and Berta (2006) report collecting a few specimens of a solitary tachinid (Diptera: Tachinidae: Goniinae: Exoristini) larval endoparasitoid from mature (last instar) *Tuta absoluta* larvae on tomato plants in the vicinity of Lules in Tucumán, Argentina in 2003. They claimed that no Tachinidae have ever been reported as parasitizing gelechiid species and that this tachinid is most probably a generalist parasitoid.

Predators

The damsel bug *Nabis pseudoferus* is an effective egg and larval predator of *Tuta absoluta* in Spanish greenhouses (Cabello et al., 2009b). In two semi-field studies, first stage nymphs of *N. pseudoferus* released onto tomato plants (8 to 12 per plant) killed *T. absoluta* eggs, reducing the number of eggs by 92 percent and 96 percent. In addition, adults and last instar nymphs of *N. pseudoferus* were also observed preying on larvae of *T. absoluta*, even when these were inside the mines (Cabello et al., 2009b). *Nabis pseudoferus* is widely distributed in Europe and is commercially available. The recommended dose for outbreaks is 10 to 15 individuals/m^2.

The mirids *Macrolophus pygmaeus* and *Nesidiocoris tenuis* are endemic to Spain and feed on eggs and larvae of *Tuta absoluta*. In one study, adult *M. pygmaeus* and *N. tenuis* consumed 30+ eggs and 2 *T. absoluta* larvae daily (Urbaneja et al., 2009). Although both species were observed feeding on all life stages of *T. absoluta*, they preferred first-instar larvae. *Macrolophus pygmaeus* and *N. tenuis* are available commercially. However, according to a report from the United Kingdom, *Nesidiocoris tenuis* is problematic because it can attack host plants when prey are in short supply. Plant feeding causes brown rings in the vascular tissue and destruction of the plant's growing points (Sanchez et al., 2008; Sixsmith, 2009).

An additional mirid, *Tupiocoris cucurbitaceus,* has been recently evaluated as a potential biological control agent against *Tuta absoluta* and whiteflies in Argentina (López, 2010).

Table 6-7 Biological Control Agents Against *Tuta absoluta*[1]

Action	Taxon	Species
Egg parasitoid	Hymenoptera: Trichogrammatidae	*Trichogramma achaeae* Nagaraja & Nagarkatti, *Trichogrammatoidea bactrae* Nagaraja, *T. fasciatum* (Perkins), *T. pretiosum* Riley, *T. rojasi* Nagaraja & Nagarkatti, *T. nerudai* Pintureau & Gerding
Larval parasitoid	Hymenoptera: Bethylidae	*Parasierola nigrifemur* (Ashmead)
	Hymenoptera: Braconidae	*Agathis sp., Apanteles gelechiidivoris* Marsh, *Apanteles* sp., *Bracon lucileae* Marsh, *Bracon* sp., *Pseudapanteles dignus* (Muesenback), *Earinus* sp., *Origilus* sp.
	Hymenoptera: Eulophidae	*Dineulophus phtorimaeae* De Santis, *Neochrysocharis formosa* (Westwood), *Cirrospilus* sp., *Horismenus* sp.
	Hymenoptera: Ichneumonidae	*Temelucha* sp., *Diadegma* sp.
Egg-larval parasitoid	Hymenoptera: Braconidae	*Chelones* sp.
	Hymenoptera: Encyrtidae	*Copidosoma* sp.
Larval-pupal parasitoid	Hymenoptera: Ichneumonidae	*Campoplex haywardi* Blanchard
Pupal parasitoid	Hymenoptera: Chalcididae	*Conura* sp.
Predator	Hemiptera: Miridae	*Macrolophus pygmaeus* Rambur, *Nesidiocoris tenuis* Reuter, *Tupiocoris cucurbitaceus* Spinola
	Hemiptera: Nabidae	*Nabis pseudoferus ibericus* Remane
	Hemiptera:Pentatomidae	*Podisus nigrispininus* (Dallas)
Larval bacterial		*Bacillus thuringiensis*
Larval fungal		*Beauveria bassiana*
Egg fungal	Clavicipitaceae	*Metarhizium anisopliae*

1 Botto, 1999; Botto et al., 2009; Cabello et al., 2009a; 2009b; Ceriani, 1995; Lopez, 2010; Luna et al., 2007; Polack, 2007.

Microorganisms

Bacillus thuringiensis has been recommended for control of *Tuta absoluta*. More recently, the muscadine fungus *Metarhizium anisopliae* (Metschn.) Sorokin has been studied for control of *T. absoluta* (Pires et al., 2009). Adult females infected with the fungus did not reduce their oviposition or fecundity; however, infection with *M. anisopliae* resulted in 37 percent female mortality. Eggs exposed to *M. anisopliae* were all infected after 72 hours.

Beauveria bassiana (strain GHA 1991) was tested alone or in combination with *Bacillus thurengiensis* for control of *Tuta absoluta* in open tomato fields in Ibiza, Spain (Torres Gregorio et al., 2009). Both treatments reduced the number and severity of fruit damage when compared to the control.

Mating Disruption

Michereff-Filho et al. (2000) examined the use of mating disruption for *Tuta absoluta* in small plots of fresh market tomatoes in Brazil. The effectiveness of the technique was assessed through trap captures of males in disrupted plots, mating frequency in mating tables, as well as plant damage. The highest levels of disruption (60 to 90 percent) were recorded in plots treated with 35 to 50 g/ha of sex pheromone. However, no treatment was capable of significantly reducing the percentage of mined leaflets or bored fruits or the frequency of mating as compared to the control plots. The results may be attributed to the composition of the synthetic pheromone, doses used, high pest population density, and mated female migration to the area treated.

More recently, Navarro-Llopis et al. (2010) used mating disruption against *Tuta absoluta* in tomato greenhouses in Spain. Their results showed that *T. absoluta* can be controlled with mating disruption if the treatments are carried out in greenhouses with good isolation which prevents the moth from entering from the outside. Although the method appears effective, final adoption will depend on the price of the pheromone dispenser. Marti-Marti et al. (2010) also suggested that more economical and long-lasting pheromone dispensers need to be available before mating disruption can be considered as a suppression technique for this pest.

A pheromone lure consisting of an amorphous polymer matrix and (3E, 8Z, 11Z)-3,8,11-tetradecatrien-1-yl acetate (*Tuta absoluta* pheromone) is commercially available for mating disruption applications (ISCA, 2010). The polymer matrix allows for the sustained release of the pheromone. The product is applied early in the season, prior to and at the first sign of male flight, as a dollop at the upper one-third of the plant foliage. The dollops cure in 2 to 3 hours to become rainfast and UV resistant.

Environmental Documentation and Monitoring

Obtain all required environmental documentation before beginning. Contact Environmental Services Staff for the most recent documentation. For further information, refer to ***Environmental Compliance*** on **page 7-1**.

7 Environmental Compliance

Tomato Leafminer

Contents

Introduction

Use *Chapter 7 Environmental Compliance* as a guide to environmental regulations pertinent to the tomato leafminer, *Tuta absoluta* (Meyrick).

Overview

Program managers of Federal emergency response or domestic pest control programs must ensure that their programs comply with all Federal Acts and Executive Orders pertaining to the environment, as applicable. Two primary Federal Acts, the National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA), often require the development of significant documentation before program actions may commence.

Program managers should seek guidance and advice as needed from Environmental and Risk Analysis Services (ERAS), a unit of APHIS' Policy and Program Development (PPD) staff. ERAS is available to provide guidance and advice to program managers and prepare drafts of applicable environmental documentation.

In preparing draft NEPA documentation ERAS may also perform and incorporate assessments that pertain to other Acts and Executive Orders described below, as part of the NEPA process. The Environmental Compliance Team (ECT), a part of PPQ's Emergency Domestic Programs (EDP), will assist ERAS in the development of documents, and will implement any environmental monitoring.

Leaders of programs are strongly advised to consult with ERAS and/or ECT early in the development of a program in order to conduct a preliminary review of applicable environmental statutes and to ensure timely compliance. Environmental monitoring of APHIS pest control activities may be required as part of compliance with environmental statutes, as requested by program managers, or as suggested to address concerns with controversial activities. Monitoring may be conducted with regards to worker exposure, pesticide quality assurance and control, off-site chemical deposition, or program efficacy. Different tools and techniques are used depending on the monitoring goals and control techniques used in the program. Staff from ECT will work with the program manager to develop an environmental monitoring plan, conduct training to implement the plan, provide day-to-day guidance on monitoring, and provide an interpretive report of monitoring activities.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires all Federal agencies to examine whether their actions may significantly affect the quality of the human environment. The purpose of NEPA is to inform the decisionmaker prior to taking action, and to inform the public of the decision. Actions that are excluded from this examination, that normally require an Environmental Assessment, and that normally require Environmental Impact Statements, are codified in APHIS' NEPA Implementing Procedures located in 7 CFR 372.5.

The three types of NEPA documentation are Categorical Exclusions, Environmental Assessments, and Environmental Impact Statements.

Categorical Exclusion

Categorical Exclusions (CE) are classes of actions that do not have a significant effect on the quality of the human environment and for which neither an Environmental Assessment (EA) nor an environmental impact statement (EIS) is required. Generally, the means through which adverse environmental impacts may be avoided or minimized have been built into the actions themselves (7 CFR 372.5(c)).

Environmental Assessment

An Environmental Assessment (EA) is a public document that succinctly presents information and analysis for the decisionmaker of the proposed action. An EA can lead to the preparation of an environmental impact statement (EIS), a finding of no significant impact (FONSI), or the abandonment of a proposed action.

Environmental Impact Statement

If a major Federal action may significantly affect the quality of the human environment (adverse or beneficial) or the proposed action may result in public controversy, then prepare an Environmental Impact Statement (EIS).

Endangered Species Act

The Endangered Species Act (ESA) is a statute requiring that programs consider their potential effects on federally-protected species. The ESA requires programs to identify protected species and their habitat in or near program areas, and document how adverse effects to these species will be avoided. The documentation may require review and approval by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service before program activities can begin. Knowingly violating this law can lead to criminal charges against individual staff members and program managers.

Migratory Bird Treaty Act

The statute requires that programs avoid harm to over 800 endemic bird species, eggs, and their nests. In some cases, permits may be available to capture birds, which require coordination with the U.S. Fish and Wildlife Service.

Clean Water Act

The statute requires various permits for work in wetlands and for potential discharges of program chemicals into water. This may require coordination with the Environmental Protection Agency, individual States, and the Army Corps of Engineers. Such permits would be required even if the pesticide label allows for direct application to water.

Tribal Consultation

The Executive Order requires formal government-to-government communication and interaction if a program might have substantial direct effects on any federally-recognized Indian Nation. This process is often incorrectly included as part of the NEPA process, but must be completed prior to general public involvement under NEPA. Staff should be cognizant of the conflict that could arise when proposed Federal actions intersect with Tribal sovereignty. Tribal consultation is designed to identify and avoid such potential conflict.

National Historic Preservation Act

The statute requires programs to consider potential impacts on historic properties (such as buildings and archaeological sites) and requires coordination with local State Historic Preservation Offices. Documentation under this act involves preparing an inventory of the project area for historic properties and determining what effects, if any, the project may have on historic properties. This process may require public involvement and comment prior to the start of program activities.

Coastal Zone Management Act

The statute requires coordination with States where programs may impact Coastal Zone Management Plans. Federal activities that may affect coastal resources are evaluated through a process called Federal consistency. This process allows the public, local governments, Tribes, and State agencies an opportunity to review the Federal action. The Federal consistency process is administered individually by states with Coastal Zone Management Plans.

Environmental Justice

The Executive Order requires consideration of program impacts on minority and economically disadvantaged populations. Compliance is usually achieved within the NEPA documentation for a project. Programs are required to consider if the actions might disproportionally impact minority or economically disadvantaged populations, and if so, how such impact will be avoided.

Protection of Children

The Executive Order requires Federal agencies to identify, assess, and address environmental health risks and safety risks that may disproportionately affect children. If such a risk is identified, then measures must be described and implemented to minimize such risks.

8 Pathways

Tomato Leafminer

Contents

Introduction

Use *Chapter 8 Pathways* as a source of information on the pathways of introduction of the tomato leafminer, *Tuta absoluta* (Meyrick), in the United States.

Overview

The potential entry and establishment of *Tuta absoluta* poses a serious threat to United States agriculture. Several fruits and vegetables as well as ornamental plants in the United States are at risk. This chapter discusses plausible pathways for entry of *T. absoluta* based on its current distribution and on import data for host commodities from infested countries. Pathways for spread within the United States are discussed in light of recent outbreaks in Europe.

Without new restrictions, the likelihood of entry of *T. absoluta* on imported host material from infested countries is high. As such, the USDA–APHIS–PPQ issued Federal Orders in February, May, and December of 2009, April 2010, and March and May of 2011, placing restrictions on admissible tomato fruit from countries where *T. absoluta* is present, and prohibiting the entry of plants for planting belonging to the genera *Solanum*, *Datura*, and *Nicotiana* (USDA, 2011).

Geographical Distribution

Tuta absoluta is native to South America and is present in Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Perú, Uruguay, and Venezuela (EPPO, 2005). It was first reported in Europe at the end of 2006, on tomato crops in Spain. *Tuta absoluta* has spread to neighboring European and Mediterranean countries with alarming speed. The European and Mediterranean Plant Protection Organization (EPPO) Reporting Service has provided the reports of *T. absoluta* in the Euro-Mediterranean region listed in ***Table 8-1*** **on page 8-3**.

In addition, *Tuta absoluta* has been detected in Greece (European Commission, 2009), Lithuania (Ostrauskas and Ivinskis, 2010), Slovenia (Knapic and Marolt 2009), Bahrain, Egypt, Iraq, Jordan, Kuwait, Libya, Panama, Russia, Saudi Arabia, Sudan, and Syria (Russell IPM, 2009a). For further information, refer to the distribution map available from the Centre for Agricultural Bioscience International (CABI).

Because the movement of tomato fruit and plants is not restricted inside the European Union (EU) countries, and the spread of *Tuta absoluta* in the EU is rapid, the United States currently includes all countries of the EU in the list of countries infested with this pest.

Accordingly, the following countries of the world are currently considered infested with *Tuta absoluta*: Albania, Algeria, Argentina, Austria, Bahrain, Belgium, Bolivia, Brazil, Bulgaria, Cayman Islands, Chile, Colombia, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Estonia, Finland, France, Germany, Greece (including Crete), Hungary, Iraq, Ireland, Israel, Italy, Jordan, Kosovo, Kuwait, Latvia, Libya, Lithuania, Luxembourg, Malta, Morocco, Netherlands, Palestinian Authority (West Bank), Panama, Saudi Arabia, Paraguay, Perú, Poland, Portugal (including the Azores), Romania, Russia, Slovakia, Slovenia, Spain (including the Canary Islands), Sweden, Switzerland, Syria, Tunisia, Turkey, United Kingdom (all regions), Uruguay, Venezuela, and Western Sahara (USDA, 2011).

Table 8-1 European and Mediterranean Plant Protection Organization Reporting Service Reports of *Tuta absoluta* in Euro-Mediterranean Region

Year/Report	Description
2008/001	First report in Spain (EPPO, 2008a)
2008/135	First record in Algeria (EPPO, 2008b)
2008/174	First record in Morocco (EPPO, 2008c)
2009/003	First report in France (EPPO, 2009a)
2009/023	First record in Italy (EPPO, 2009b)
2009/024	Caught in a tomato packing station in the Netherlands (EPPO, 2009c)
2009/042	First report in Tunisia (EPPO, 2009d)
2009/105	Detected again in the Netherlands (EPPO, 2009e)
2009/106	First report from Lazio region, Italy (EPPO, 2009f)
2009/152	First report from the United Kingdom (EPPO, 2009g)
2009/153	Reported from Abruzzo, Liguria and Umbria regions, Italy (EPPO, 2009h)
2009/154	Found on Phaseolus vulgaris in Sicily (EPPO, 2009i)
2009/169	New additions to the EPPO Lists (EPPO, 2009j)
2009/170	First report in Albania (EPPO, 2009k)
2009/171	First report in Portugal (EPPO, 2009l)
2009/172	Found in Puglia and Veneto regions, Italy (EPPO, 2009m)
2009/188	First report in Malta (EPPO, 2009n)
2009/189	First report in Switzerland (EPPO, 2009o)
2009/212	Occurs in Islas Canarias, Spain (EPPO, 2009p)
2009/213	Found in Basilicata, Lombardia and Molise regions, Italy (EPPO, 2009q)
2009/214	New data on quarantine pests and pests of the EPPO Alert List (EPPO, 2009r)
2010/002	First record in Bulgaria (EPPO, 2010a)
2010/003	First record in Cyprus (EPPO, 2010b)
2010/004	First record in Germany (EPPO, 2010c)
2010/005	Found in Piemonte region, Italy (EPPO, 2010d)
2010/026	First record in Israel (EPPO, 2010e)
2010/052	First record in Hungary (EPPO, 2010f)
2010/114	First report in Kosovo (YU) (EPPO, 2010g)
2010/138	First report in Guernsey (EPPO, 2010h)
2010/208	First record in Turkey (EPPO, 2010i)
2011/071	First report in Greece (EPPO, 2011b)
2011/072	First report in Lithuania (EPPO, 2011c)
2011/073	First report in Iraq (EPPO, 2011d)
2011/074	Detected in Trentino-Alto region, Italy (EPPO, 2011e)
2011/075	In the United Kingdom (EPPO, 2011f)
2011/076	Continues to spread around the Mediterranean Basin (EPPO, 2011g)

Commodity Imports

The movement of infested fruit and plants for planting are potential pathways for the entry of *Tuta absoluta* into the United States. *Tuta absoluta* primarily attacks members of the family Solanaceae. *Tuta absoluta* was also recently reported on bean, *Phaseolus vulgaris*, a member of the Fabaceae family. Refer to ***Table 2-3*** **on page 2-8** for a complete list of hosts reported for *Tuta absoluta*.

Refer to ***Table 8-2*** **on page 8-5** for a list of the countries where *Tuta absoluta* is present and which are currently authorized to export host material (with restrictions) to the United States. Currently, plants belonging to the genera *Solanum*, *Datura*, and *Nicotiana* from infested countries are **not** authorized (except seeds) pending the completion of a Pest Risk Analysis.

Tomatoes

The detection of *Tuta absoluta* in tomato (re)packing stations in the Netherlands and the United Kingdom, believed to have arrived on imported Mediterranean tomatoes, emphasizes the risk of moving infested tomato fruit (EPPO, 2009c, 2009g).

USDA–APHIS–PPQ issued a Federal Import Quarantine Order in May, 2011, for tomato fruit from affected countries effective May 5, 2011 (USDA, 2011). It states that tomatoes imported from Algeria, Belgium, Cayman Islands, Cyprus, France, Greece, Israel, Italy, Morocco, Netherlands, Panama, Poland, Portugal (including the Azores), Spain (including the Canary Islands), and United Kingdom (all regions) must meet one of the three import requirements defined in ***Table 8-3*** **on page 8-7**.

Table 8-2 Countries Considered Infested with *Tuta absoluta* Currently Authorized to Export Host Material (with Restrictions) to the United States[1]

Country	Tomato[2] *Solanum lycopersicum*	Eggplant *Solanum melongena*	Potato *Solanum tuberosum*	Pepper *Capsicum annuum*	Sweet cucumber *Solanum muricatum*	Bean[3] *Phaseolus vulgaris*	Cape gooseberry[4] *Physalis peruviana*
Algeria	Green						
Belgium	Any stage			X		NA port[5]	
Cayman Islands	Any stage	X		X		NA port[5,6]	
Chile, all provinces except Arica	Any stage	X		X			
Chile, from Arica Province of Region 15	Any stage, NA ports[5]	X					
Colombia		NA ports[5]				NA ports unless shelled[5]	X
Cyprus	Green	NA ports[5]					
Ecuador					X	NA port[5,6]	
France, Continental France	Green, Pink, Red	NA ports[5]				X	
Greece	Green						
Israel	Green (Pink, Red restricted)	X					
Israel, Arava Valley	Green-house grown, Green only			X			
Italy	Green					X	
Morocco- El Jadida and Safi Province	Green, Pink, Red						
Morocco-Souss-Massa-Draa	Pink						
Netherlands	Green, Pink, Red	X		X		X	
Panama	Green, Pink, Red	X				X	
Poland	Any stage			X			
Portugal, Azores	Green						

Table 8-2 Countries Considered Infested with *Tuta absoluta* Currently Authorized to Export Host Material (with Restrictions) to the United States[1] (continued)

Country	Tomato[2] *Solanum lycopersicum*	Eggplant *Solanum melongena*	Potato *Solanum tuberosum*	Pepper Capsicum annuum	Sweet cucumber *Solanum muricatum*	Bean[3] *Phaseolus vulgaris*	Cape gooseberry[4] *Physalis peruviana*
Portugal, Peninsular Portugal	Green						
Spain, from the Canary Islands	Green						
Spain, from the Specified Provinces and Municipalities	Green, Pink, Red			X			
Spain, Peninsular and Balearic Islands	Green	X				X	
United Kingdom, regions of England, Orkney Island, Scotland, and Wales	Any stage NA ports[5]						
United Kingdom, Channel Islands	Any stage						
Venezuela						NA ports[5]	
Western Sahara	Green, Pink						

1 USDA-APHIS Fruits and Vegetables Import Restrictions (FAVIR) Online Database queried 11/10/10.

2 Tomato fruit or cluster of fruit.

3 Bean pod or shelled.

4 Cape gooseberry fruit with or without calyx.

5 Importation into North Atlantic ports only.

6 Importation into South Atlantic and Gulf ports with methyl bromide fumigation.

Table 8-3 Import Requirements for *Tuta absoluta* on Tomato Fruit

If:	Then:	And:
Pest-free area	Tomato fruit must be imported as commercial consignments only	Each consignment of tomatoes must be accompanied by a Phytosanitary Certificate of inspection issued by the National Plant Protection Organization of the country of origin bearing the following Additional Declaration: "Tomato fruit in this consignment originate from a pest-free area that meets the requirements of 7 CFR 319.56-5, and are free of *Tuta absoluta*."
Countries with growers practicing APHIS-approved systems approach[1]	Tomato fruit must be imported as commercial consignments only	Each consignment of tomatoes must be accompanied by a Phytosanitary Certificate of inspection issued by the National Plant Protection Organization of the country of origin bearing the following Additional Declaration (AD): "Tomato fruit in this consignment have been produced in accordance with an APHIS approved systems approach, and have been visually inspected and are free of *Tuta absoluta*."
Treatment	Tomato fruit must be imported as commercial consignments only	As provided in 7 CFR 305, methyl bromide treatment schedule T101-c-3-1, is an approved treatment for green, red, or pink tomatoes produced in areas infested with *T. absoluta*. This treatment can only be applied in a preclearance program. Of the countries known to be infested with *Tuta absoluta*, only Chile has an established preclearance program. Any country desiring establishment of a preclearance program should contact APHIS–PPQ.
Other than above	→	Entry is prohibited.

1 See Federal Import Quarantine Order DA-2011-12 May 5, 2011.

The tomato shipping season for green, pink, or red, tomatoes from Spain (Specified Provinces and Municipalities), Morocco (El Jadida, Safi Provence, and Souss-Massa-Draa,) and Western Sahara is restricted to between December 1 and April 30, inclusive.

The tomato shipping season for green tomatoes from Spain (Peninsular Spain and the Balearic Islands) is restricted to between September 15 and May 31. Chile may export tomatoes at any stage of ripeness to the United States despite the presence of *Tuta absoluta*, provided that tomato fruit are either fumigated with methyl bromide in an established preclearance program according to 7 CFR 319.56-28(d) (1) or grown in accordance with the systems approach outlined in 319.5628(d) (2). Shipments of admissible tomatoes from Algeria, Belgium, Cyprus, France, Greece, Israel, Italy, Morocco, Netherlands, Poland, Portugal (including the Azores), Spain (including the Canary Islands), and United Kingdom must also be grown in accordance with the systems approach outlined in 319.5628(d) (2).

Tomato imports are a pathway for the entry of *Tuta absoluta* into the United States. Larvae of *T. absoluta* attack leaves, buds, stems, flowers, calyces and tomato fruit (Vargas, 1970). As an internal feeder, there is a chance that an early infestation could go undetected in tomato consignments at U.S. ports of entry. In addition, the fruit calyx when attached to the developing fruit, usually exhibits greater larval damage than the fruit (FERA, 2009a). This information suggests that vine or truss tomatoes are a higher risk pathway for entry of *T. absoluta* than tomatoes without stems and calyces.

Larvae, pupae, and adults of *Tuta absoluta* could also survive in tomato packing materials. According to a report from the United Kingdom, the most severe problem facing UK growers is the arrival of infested crates at clean tomato growing sites (Sixsmith, 2010). As such, it is reasonable to consider that reused and infested crates and boxes, if used to pack produce for export to the United States, might be a pathway for *T. absoluta*.

Tomato imports arrive in the United States packed in boxes that are used to transport the produce to its final destination. If larvae, pupae or adults are imported in tomato packing materials, adults might be able to fly away when tomatoes are unpacked. Larvae and pupae could complete their development and escape from infested boxes or crates, particularly if they are discarded outdoors. If consumers purchase and discover an infested tomato fruit, they are more likely to discard the damaged fruit in an indoor trash bin rather than outdoors. However, backyard composting might be a minor pathway to consider.

Use ***Table 8-4* on page 8-9** to review the import statistics for tomatoes for the calendar years 2004 to 2009. The Netherlands, Spain, and Israel, are the largest exporters of tomatoes to the United States that have confirmed infestations of *T. absoluta*. Colombia and Bulgaria are currently **not** authorized to export tomatoes to the United States.

Table 8-4 Import Statistics[1] for Fresh or Chilled Tomatoes Imported From January to December 1, 2004 to 2009

Country	Tomatoes, Fresh or Chilled (Tonnes)					
	2004	2005	2006	2007	2008	2009
Mexico	778,713	801,362	844,359	949,695	987,685	1,046,868
Canada	133,652	141,634	135,176	111,697	119,376	130,310
Netherlands[2]	11,572	6,212	6,172	5,147	3,445	5,370
Dominican Republic	807	857	2,422	2,650	2,853	2,862
Spain[2]	2,451	275	2,141	480	1,035	92
Guatemala	0	0	4	252	1,155	2,762
Israel[2]	2,916	349	565	241	221	194
Belgium-Luxembourg[2]	1,400	865	1,240	555	199	367
Costa Rica	11	56	36	214	84	779
Chile[2]	231	55	0	0	21	0
New Zealand	4	0	0	9	11	52
Colombia	0	0	0	9	8	3
Poland[2]	13	22	10	19	6	0
Morocco[2]	0	0	0	0	<1	0
Bulgaria	0	0	<1	0	0	0
Italy[2]	0	1	284	0	0	0
Ukraine	0	2	0	0	0	0
Leeward-Windward Islands	1	0	0	0	0	0
Grand Total	**931,771**	**951,690**	**992,408**	**1,070,966**	**1,116,098**	**1,189,601**

1 Department of Commerce, U.S. Census Bureau, Foreign Trade Statistics. Queried 02/26/10.

2 Countries considered infested with *Tuta absoluta* but with U.S. import restrictions in place.

Potato

Tomato leafminers attack the leaves of potato (EPPO, 2005) but there are recent (Russell IPM, 2009b; Maiche, 2009) as well as historical (Pastrana, 1967) reports of damage to potato tubers. At present, no countries with *Tuta absoluta* are authorized to export potatoes to the United States, so this is not a pathway for entry of this pest.

Eggplant

Estay (2000) reported that *Tuta absoluta* attacks the leaves of eggplant. In Italy, eggplant is the second preferred host of *T. absoluta* after tomato. It has infested protected tomato and eggplant crops in a number of regions (Ministero delle Politiche Agricole Ailmentari e Forestali, 2009). Recent reports of outbreaks of *T. absoluta* on eggplant have not specified if larvae attack the stem, calyx and/or fruit in addition to leaves. Irrespective of the plant part affected, eggplant could be a pathway for entry of *T. absoluta* into the United States. Several South American and European countries with *T. absoluta* are currently authorized to export eggplant to the United States. Refer to the USDA–APHIS Fruits and Vegetables Import Requirements (FAVIR) online database (APHIS, 2010a) for further information.

Pepper and Bean

Tuta absoluta was reported on greenhouse peppers and beans in Sicily, Italy (EPPO, 2009i; Ministero delle Politiche Agricole Alimentari e Forestali, 2009) but there was no mention of the plant part affected. These commodities could be a pathway for entry of *Tuta absoluta* into the United States. A number of South American and European countries with *T. absoluta* are currently authorized to export these commodities to the United States. Refer to the USDA–APHIS Fruits and Vegetables Import Requirements (FAVIR) online database (APHIS, 2010a) for further information. Australia considers pepper (*Capsicum annuum*) as a pathway for the entry of *T. absoluta*, requiring consignments to be accompanied by a phytosanitary certificate stating that “fruit in this consignment has been sourced from a place of production which is free of *T. absoluta*” or “fruit in this consignment has been subjected to a treatment effective against *T. absoluta*” (WTO, 2009).

Cape Gooseberry

In Italy, Cape gooseberry (*Physalis peruviana*), is reported as a host of *Tuta absoluta*. It is not clear which plant part is affected by the pest (Garzia, 2009b). Cape gooseberry is a cherry-sized orange-fleshed fruit related to tomatillo (*Physalis philadelphica*, syn: *P. ixocarpa*).

At present, Colombia is authorized to export Cape gooseberry to the United States on condition of cold treatment (T107-a). Fruit are authorized arrival at ports of entry located north of the 39° latitude and east of the 104° longitude (with approved cold treatment facilities). The PPQ 280 database (queried 01/27/10), shows no inspection of fruit of *Physalis peruviana* from Colombia performed at U.S. ports (APHIS, 2010b).

Plants for Planting

Pursuant to the May 2011 Federal Order, plants for planting of the genera *Datura* spp., *Nicotiana* spp., and *Solanum* spp. (including *Lycopersicon* spp.) are **not** authorized entry pending a pest risk analysis from Albania, Algeria, Argentina, Austria, Bahrain, Belgium, Bolivia, Brazil, Bulgaria, Cayman Islands, Chile, Colombia, Cyprus, Czeck Republic, Denmark, Ecuador, Estonia, Egypt, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Jordan, Kosovo, Kuwait, Latvia, Libya, Lithuania, Luxembourg, Malta, Morocco, Netherlands, Palestinian Authority (West Bank), Panama, Paraguay, Perú, Poland, Portugal (including the Azores), Romania, Russia, Saudi Arabia, Slovakia, Slovenia, Spain (including the Canary Islands), Sweden, Switzerland, Syria, Tunisia, Turkey, United Kingdom (all regions), Uruguay, Venezuela, and Western Sahara (USDA, 2011). Plants for planting of the genera *Capsicum* and *Phaseolus* are also prohibited from all countries except Canada (Nursery Stock Restrictions Manual, queried 02/08/10). As such, the likelihood of entry of *Tuta absoluta* on imported plants for planting from these genera is low.

Physalis peruviana (Cape gooseberry) is **not** listed in the PPQ *Nursery Stock Restrictions Manual*, although *Physalis philadelphica* and *P. pubescens* (seed) are listed (PPQ, 2009a). The PPQ 280 database (APHIS, 2010b) indicates that material for propagation of the genus *Physalis* has arrived at U.S. ports. Between 2000 and 2010, 86 shipments of *Physalis* were recorded. Of these shipments, 7,850 plant units of *Physalis* from Colombia and 278 plant units from the United Kingdom arrived at the Miami, FL plant inspection station, and 9,190 plant units from the Netherlands arrived at the Newark, NJ seaport.

Because there is only one report of *Physalis peruviana* (Cape gooseberry) reported as a host of *Tuta absoluta* (Garzia, 2009b), we are uncertain if movement of *Physalis* propagative material is a pathway for entry of this pest. However, because these are consignments of plants for planting, the risk for pest introduction is high if infested plants are planted outdoors where other host material may be present. In particular, *T. absoluta* can pupate inside leaf mines (Uchoa-Fernandes et al., 1995; Viggiani et al., 2009) so there is a risk of introducing pupae in this commodity.

Cut Flowers and Greenery

Capsicum and *Physalis* spp. are listed in the PPQ *Cut Flowers and Greenery Import Manual* as regulated material (PPQ, 2009b). Other hosts of *Tuta absoluta* (*Solanum*, *Datura*, and *Nicotiana*) are **not** listed so they are prohibited from entering the United States under this category. *Capsicum* and *Physalis* fruits are regulated to prevent entry of the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), and thus require an import permit in addition to inspection. Stems, leaves, or inflorescences, of *Capsicum* and *Physalis* only require inspection.

The PPQ 280 database indicates that cut flowers or greenery of *Capsicum* and *Physalis* have arrived at U.S. ports (APHIS, 2010b). Between 2000 and 2010, 256 shipments of *Capsicum* arrived at U.S. ports with 133 of those shipments originating from the Netherlands. During the same time period, 56 shipments of *Physalis* arrived at U.S. ports with 30 consignments originating from the Netherlands. Importation of cut flowers and greenery may be a pathway for entry of *Tuta absoluta*, particularly through the movement of infested shipping boxes or containers.

It is not known whether *Tuta absoluta* can complete its development on *Capsicum*. Laboratory studies on *Physalis angulata* L. (cutleaf groundcherry) indicate that development cannot be completed on this species (Fernandez and Montagne, 1990b). Cut greenery, being perishable, might not support full development of *T. absoluta* if present as eggs or young larvae since development requires on average 23.8 days from egg to adult at 27°C. Refer to ***Developmental Rates and Day Degrees*** on **page 2-10** for further information.

There is the risk for introduction, however, if infested cut flowers or greenery are used or discarded outdoors where other host material may be present.

Import Destinations

Tomato

Refer to ***Table 8-5*** **on page 8-13** for a summary of tomatoes arriving for the years 2006 to 2009 in U.S. ports of entry from the following countries where *Tuta absoluta* is present: Chile, Colombia, Italy, Morocco, the Netherlands, and Spain.

Some of the States where ports are located are major tomato-producers where abundant host material would be available for survival of *Tuta absoluta*. In addition, solanaceous weed hosts are naturalized throughout most of the United States.

California is the leading producer of tomatoes, accounting for one-third of the fresh-market crop and 96 percent of processing tomatoes (ERS, 2009). Until 2008, Florida was the largest producer of fresh-market tomatoes.

In 2008, 572 tonnes of tomatoes from the Netherlands arrived at the Los Angeles, CA district ports, and 170 tonnes at the Miami, FL district ports. During the same year, 14 tonnes of tomatoes were shipped from Spain to the Los Angeles, CA district ports.

While California and Florida are the top tomato-producing states, fresh-market tomatoes are produced in every State in the United States, with commercial-scale production reported in about 20 States (ERS, 2009). After Florida and California, Ohio, Virginia, Georgia, Tennessee, North Carolina, New Jersey, New York and South Carolina complete the list of top tomato growing states (NASS, 2009).

Table 8-5 Shipping Weight of Fresh or Chilled Tomatoes Arriving in the United States from Countries with *Tuta absoluta*[1]

Country	Port	Tomatoes, Fresh or Chilled (tonnes)							
		2006		2007		2008		2009	
		Vessel	Air	Vessel	Air	Vessel	Air	Vessel	Air
Chile	Chicago IL								
	Los Angeles CA						6		
	Miami FL						15		
	New York City NY						2		
Colombia	New York City NY			9		9			
Italy	New York City NY	309							
Morocco	New York City NY						0.4		
Netherlands	Baltimore MD								
	Boston MA		1,281		760		330		712
	Buffalo NY								
	Chicago IL		922		1,063		398		956
	Cleveland OH								
	Columbia-Snake WA				0.4				
	Dallas/Fort Worth TX		8		16		98		59
	Detroit MI		40		16				143
	Great Falls MT				2				
	Houston TX		71		63				
	Los Angeles CA		976		856		570		347
	Miami FL		319		198		172		124
	Minneapolis MN								
	New York City NY	281	2,267	170	2,088	14	1,877	227	2,885
	Philadelphia PA		2						
	San Francisco CA		121		21		8		
	Savannah GA		0.7				1		
	Seattle WA		8		15		5		
	Tampa FL		1						
	Washington DC		312		246		144		712
	Boston MA		416		9		111		

Table 8-5 Shipping Weight of Fresh or Chilled Tomatoes Arriving in the United States from Countries with *Tuta absoluta*[1] *(continued)*

Country	Port	Tomatoes, Fresh or Chilled (tonnes)							
		2006		2007		2008		2009	
		Vessel	Air	Vessel	Air	Vessel	Air	Vessel	Air
Spain	Chicago IL		291		89		252		58
	Detroit MI		17						
	Los Angeles CA						14		
	Miami FL		121						
	New York City NY	167	1,276		400		639		41
	Philadelphia PA		25		8		6		
	San Francisco CA		4		8				
	Savannah GA		5						
	Seattle WA						2		
	Washington DC		12				50		

1 Department of Commerce, U.S. Census Bureau, Foreign Trade Statistics. Queried 02/26/10.

Since 1984, there have been no interceptions of *Tuta absoluta* or synonyms of *T. absoluta* (*Phthorimaea absoluta*, *Gnorimoschema absoluta*, *Scrobipalpula absoluta*, *Scrobipalpuloides absoluta*) documented in PestID (queried 02/12/10). The genus *Tuta* is not listed in the PestID database but the genera *Phthorimaea*, *Gnorimoschema*, and *Scrobipalpula* are reportable, as is the family Gelechiidae (PestID, 2010).

There are no documented interceptions for the genus *Scrobipalpula* in PestID but there have been interceptions for unspecified *Phthorimaea*, *Gnorimosochema*, and Gelechiidae species on tomato, potato, eggplant, and pepper. The lack of interceptions of *Tuta absoluta* could be due to the fact that the United States has successfully regulated tomato, potato, eggplant, and pepper from South American countries where *T. absoluta* originates. Only recently has *T. absoluta* expanded into Europe and neighboring Mediterranean countries.

There have been 24 interceptions of unspecified Gelechiidae species associated with tomato fruit since 1984, which includes one unspecified *Phthorimaea*, one unspecified *Gnorimoschema*, and five unspecified *Keiferia* species. Twenty of the interceptions were for immature stages found inside tomato fruit. Most interceptions were from South America (71 percent) from maritime stores. There were seven interceptions from permit or general cargo originating from the Dominican Republic, Costa Rica, Venezuela or Mexico.

Refer to ***Table 8-6*** **on page 8-15** for a summary of the pest interception data for unspecified Gelechiidae for 1984 until present for tomato (queried as *Lycoper-*

sicum esculentum), potato (*Solanum tuberosum*), eggplant (*Solanum melongena*), and pepper (*Capsicum annuum*) (PestID, 2010).

Table 8-6 Interceptions of Unspecified Gelechiidae Species on Tomato, Potato, Eggplant, and Pepper[1, 2]

Commodity	Gelechiid	With Larva Inside Fruit or Tuber	Predominant Pathway	Predominant Origin	Permit Cargo
Tomato	24[3]	20 (83)	Maritime stores (71)	South America (75)	7 (29)
Potato	91[4]	83 (91)	Baggage (95)	South America (89)	0
Eggplant	61[5]	47 (77)	Baggage (61)	Sub Saharan Africa (44)	22 (36)
Pepper	13	7 (54)	Baggage (85)	South America (38) and Central America (46)	2 (15)

1 Pest ID Database (02/12/2010). Interception data: 1984 to present.

2 Numbers in parenthesis represent percentage of interceptions.

3 Includes 1 unspecified *Phthorimaea*, 1 unspecified *Gnorimoschema*, and 5 unspecified *Keiferia* species.

4 Includes 4 unspecified *Phthorimaea* and 5 unspecified *Gnorimoschema* species.

5 Includes 2 unspecified *Anarsia* species.

Smuggling

Smuggling of infested agricultural commodities might be a pathway for *Tuta absoluta*. Even though interception data in ***Table 8-6* on page 8-15** is for unspecified Gelechiidae, it suggests that members of this family (and species belonging to some of the synonyms of *Tuta*, *Phthorimaea* and *Gnorimoschema*) are able to follow the fruit/tuber pathway into the United States.

Predominant areas of origin for smuggled fruit in baggage in ***Table 8-6* on page 8-15** are South America, Central America and Sub Saharan Africa. Only recently has the geographical range of *Tuta absoluta* expanded into Europe and neighboring Mediterranean and Middle Eastern countries. Perhaps future queries of Pest ID will indicate interceptions of Gelechiidae in smuggled solanaceous fruits and tubers from these countries.

Establishment and Spread

Once introduced to a new area, *Tuta absoluta* has the potential to spread naturally through adult flight or over longer distances through human assisted means. This section discusses pathways for spread within the United States in light of recent outbreaks of *T. absoluta* in Europe.

Importantly, infestations in Europe have not been confined to warm regions where *T. absoluta* is expected to survive outdoors. Greenhouse production and tomato packing houses have been hit hard across Europe. As discussed herein, protected environments are capable of supporting *T. absoluta* in regions that would otherwise be considered too cold for establishment.

Since its introduction into Europe in 2006, *Tuta absoluta* has continued to spread through the European and Mediterranean regions. In France, the pest is now found in the Languedoc-Roussillon and Rhone-Alps regions in addition to areas in Corse and Provence-Alpes-Cote-d'Azur (EPPO, 2009r). In Italy, the first detection occurred in 2008 in the regions of Sardinia, Calabria, Campania and Sicily (EPPO, 2009b), but as of January 2010, *T. absoluta* has been confirmed in ten additional areas (Abruzzo, Basilicata, Lazio, Liguria, Lombardia, Molise, Piemonte, Puglia, Umbria, and Veneto) (EPPO, 2010d).

The northward geographical expansion of *T. absoluta* in Europe is most alarming. For example, three adults were captured at a tomato packing facility in the Netherlands in January 2009 (these were thought to have arrived on imported tomatoes from Spain). The National Plant Protection Organization of the Netherlands considered the finding incidental because of the small number of insects and because it seemed unlikely that *T. absoluta* could spread from the packing station to nearby glasshouses during the winter (EPPO, 2009c). However, in May 2009 *T. absoluta* was again detected in the Netherlands (EPPO, 2009e), this time in greenhouse production, suggesting that the pest was able to spread in areas with cooler climate, even during winter. By July 2009, *T. absoluta* was intercepted 56 times at 13 packing stations and 61 times at 24 greenhouses in the neighborhood of infected packing stations in the Netherlands (Potting et al., 2009).

More recently, *Tuta absoluta* has spread to Germany where it was detected at a central market, a packing station, and at four tomato production sites (EPPO, 2010c). Adults of *T. absoluta* have also been detected in tomato greenhouses and vegetable warehouses in Lithuania (Ostrauskas and Ivinskis, 2010).

Natural Spread

Adults of *Tuta absoluta* have well-developed wings, but their flight capacity is unknown. Male moths are reported to disperse for mating purposes (between 7:00 and 11:00 am) (Miranda-Ibarra, 1999). However, natural spread is expected particularly if host plants are available and climactic conditions are favorable.

Margarey et al. (2008) suggested that *Tuta absoluta* can establish in hardiness zones (HZ) 9 (Corse, France), 10 (Uruguay), 11 (San Paulo, Brazil), 12 (Bahia, Brazil), and 13 (Ceara, Brazil). As such, locations in the United States where *T. absoluta* could establish include parts of California, Florida, Texas, Arizona, Louisiana and coastal regions of Alabama, Georgia, and Mississippi (HZ 9 and 10). Refer to ***Figure 2-1*** **on page 2-6** for a risk map of the establishment potential of *Tuta absoluta* in the conterminous United States based on climatic suitability.

Suitable solanaceous host plants exist in most parts of the United States so establishment and spread is possible into warmer regions if appropriate pest management is not in place. In addition to crop plants (tomato, potato, eggplant), solanaceous weeds in the United States (black nightshade, silver nightshade, jimson-weed, tree tobacco, and thorn apple) could serve as host reservoirs for this pest.

There is only one report of bean (*Phaseolus vulgaris*) and pepper (*Capsicum annuum*) being attacked by *Tuta absoluta* in Italy (EPPO, 2009i; Ministero delle Politiche Agricole Alimentari e Forestali, 2009); it is not known yet if these crops serve as host reservoirs for *T. absoluta*. Laboratory studies by Galarza (1984) indicated that tobacco (*Nicotiana tabacum*) cannot support the development of *T. absoluta* under laboratory conditions. According to the study, insect development was interrupted at the first and second instars when reared on *Nicotiana tabacum*. A more recent study (Cardozo et al., 1994) reported that *T. absoluta* is able to complete development on *Nicotiana tabacum*, and can use *Solanum elaeagnifolium* as an altertnate host plant.

Spread to Greenhouse Production, Packing Stations, Other

If present in areas where it can survive outdoors, *Tuta absoluta* can enter greenhouses, produce packing stations, or tomato processing plants through natural spread (adult flight) particularly if structures are not well-protected with insect netting and double-entry doors. Close proximity of either host crops or solanaceous weeds to greenhouses and other structures increases the likelihood that *T. absoluta* will find its way into these environments.

Close proximity between packing stations and production sites has allowed *Tuta absoluta* to spread to numerous growing sites in the UK. As of January 2010, 21 packing sites and 11 growing areas have reported outbreaks of *T.*

absoluta (Sixsmith, 2010). As observed in Europe, once *T. absoluta* is introduced into greenhouse production or produce packing stations, it can become established in regions otherwise considered too cold for survival.

Human-Assisted Spread

Human-assisted spread of *Tuta absoluta* can be helped in a number of ways. Simply failing to secure greenhouses, produce packing sites, or tomato processing plants, with insect screening or double-entry doors can assist in the spread of the moth. In addition, eggs, larvae, pupae, and adult moths, can be introduced to these environments on clothing or contaminated pots, carts, or greenhouse tools. Therefore, it is important to thoroughly inspect and clean these items before entering enclosed tomato production areas, produce packing areas, or tomato processing plants. Refer to ***Cultural Control*** on **page 6-3** for additional information.

If already present in tomato production sites, human-assisted spread of *Tuta absoluta* to packing centers, processing plants, or wholesale vegetable markets can occur through the movement of infested tomato fruit. Furthermore, tomato containers used for shipping and the shipping vehicles themselves are pathways for spread. As described in ***Cultural Control*** on **page 6-3**, it is important that crates and vehicles be inspected and cleaned before shipping tomatoes to other sites. Infested packing and shipping containers have been the biggest problem facing growers in the UK. This problem can be mitigated by using non-returnable tomato packing boxes and by assembling and storing new (clean) boxes in areas away from infested crates (Sixsmith, 2010).

If *Tuta absoluta* were introduced into the plants-for-planting pathway in the United States, dispersal could be rapid since millions of tomato transplants are produced and shipped around the country each year. For example, the Florida containerized vegetable transplant industry produced 519 million tomato transplants in 1990 (Vavrina and Summerhill, 1992). These transplants were distributed to 34 States and 2 countries. Eggplant transplants can also serve as a pathway. For example, in Italy (Campania), *T. absoluta* was found on tomato and eggplant seedlings in March of 2009 (Ministero delle Politiche Agricole Ailmentari e Forestali, 2009).

Movement of *Tuta absoluta* on ornamental Solanaceae in the nursery trade is also possible since plants belonging to the genera *Capsicum*, *Datura*, *Nicotiana*, and *Solanum* are sold as ornamentals. Examples of these are: *Capsicum annuum* (ornamental pepper), *Datura inoxia* (syn.: *Datura metel*) (angel's trumpet), *Nicotiana alata* (flowering tobacco), and *Solanum pseudo-capsicum* (Jerusalem cherry).

Finally, end-consumers might also serve as a pathway for the spread of *Tuta absoluta*, although we have no data on how many consumers discard fruits or vegetables outdoors (in compost bins or piles).

Higher risk areas from which *Tuta absoluta* can spread were summarized in ***Table 4-4*** **on page 4-20**. The list has been modified to include all host plants of *T. absoluta*.

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A

Tomato Leafminer

Forms

Contents

PPQ 391 Specimens For Determination

This report is authorized by law (7 U.S.C. 147a). While you are not required to respond your cooperation is needed to make an accurate record of plant pest conditions. *See reverse for additional OMB information.*

FORM APPROVED
OMB NO. 0579-0010

U.S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE

SPECIMENS FOR DETERMINATION

Instructions: Type or print information requested. Press hard and print legibly when handwritten. Item 1 - assign number for each collection beginning with year, followed by collector's initials and collector's number. Example (collector, John J. Dingle): 83-JJD-001.
Pest Data Section – Complete Items 14, 15 and 16 or 19 or 20 and 21 as applicable. Complete Items 17 and 18 if a trap was used.

FOR IIBIII USE
LOT NO.
PRIORITY

1. COLLECTION NUMBER
2. DATE — MO / DA / YR
3. SUBMITTING AGENCY — ☐ State Cooperator ☐ PPQ ☐ Other ____

SENDER AND ORIGIN
4. NAME OF SENDER
6. ADDRESS OF SENDER
ZIP

INTERCEPTION SITE
5. TYPE OF PROPERTY *(Farm, Feedmill, Nursery, etc.)*
7. NAME AND ADDRESS OF PROPERTY OR OWNER
COUNTRY/ COUNTY

PURPOSE
8. REASON FOR IDENTIFICATION *("x" ALL Applicable Items)*
- A. ☐ Biological Control (Target Pest Name)
- B. ☐ Damaging Crops/Plants
- C. ☐ Suspected Pest of Regulatory Concern *(Explain in* REMARKS*)*
- D. ☐ Stored Product Pest
- E. ☐ Livestock, Domestic Animal Pest
- F. ☐ Possible Immigrant *(Explain in* REMARKS*)*
- G. ☐ Survey *(Explain in* REMARKS*)*
- H. ☐ Other *(Explain in* REMARKS*)*

9. IF PROMPT OR URGENT IDENTIFICATION IS REQUESTED, PLEASE PROVIDE A BRIEF EXPLANATION UNDER "REMARKS".

HOST DATA
10. HOST INFORMATION
NAME OF HOST *(Scientific name when possible)*

11. QUANTITY OF HOST
NUMBER OF ACRES/PLANTS
PLANTS AFFECTED *(Insert figure and indicate* ☐ Number ☐ Percent*):*

12. PLANT DISTRIBUTION
- ☐ LIMITED
- ☐ SCATTERED
- ☐ WIDESPREAD

13. PLANT PARTS AFFECTED
- ☐ Leaves, Upper Surface
- ☐ Leaves, Lower Surface
- ☐ Petiole
- ☐ Stem
- ☐ Trunk/Bark
- ☐ Branches
- ☐ Growing Tips
- ☐ Roots
- ☐ Bulbs, Tubers, Corms
- ☐ Buds
- ☐ Flowers
- ☐ Fruits or Nuts
- ☐ Seeds

PEST DATA
14. PEST DISTRIBUTION
- ☐ FEW
- ☐ COMMON
- ☐ ABUNDANT
- ☐ EXTREME

15. ☐ INSECTS ☐ NEMATODES ☐ MOLLUSKS

NUMBER SUBMITTED	LARVAE	PUPAE	ADULTS	CAST SKINS	EGGS	NYMPHS	JUVS.	CYSTS
ALIVE								
DEAD								

16. SAMPLING METHOD
17. TYPE OF TRAP AND LURE
18. TRAP NUMBER

19. PLANT PATHOLOGY – PLANT SYMPTOMS *("X" one and describe symptoms)*
☐ ISOLATED ☐ GENERAL

20. WEED DENSITY
☐ FEW ☐ SPOTTY ☐ GENERAL

21. WEED GROWTH STAGE
☐ SEEDLING ☐ VEGETATIVE ☐ FLOWERING/FRUITING ☐ MATURE

22. REMARKS

23. TENTATIVE DETERMINATION

24. DETERMINATION AND NOTES *(Not for Field Use)*

SIGNATURE
DATE

FOR IIBIII USE
DATE RECEIVED
NO.
LABEL
SORTED
PREPARED
DATE ACCEPTED
RR

PPQ FORM 391 *Previous editions are obsolete.*
(AUG 02)

This is a 6-Part form. Copies must be disseminated as follows:
- ☐ PART 1 – PPQ
- ☐ PART 2 – RETURN TO SUBMITTER AFTER IDENTIFICATION
- ☐ PART 3 – IIBIII OR FINAL IDENTIFIER
- ☐ PART 4 – INTERMEDIATE IDENTIFIER
- ☐ PART 5 – INTERMEDIATE IDENTIFIER
- ☐ PART 6 – RETAINED BY SUBMITTER

Figure A-1 Example of PPQ 391 Specimens For Determination, side 1

OMB Information
According to the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number. The valid OMB control number for this information collection is 0579-0010. The time required to complete this information collection is estimated to average .25 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Instructions
Use PPQ Form 391, Specimens for Determination, for domestic collections (warehouse inspections, local and individual collecting, special survey programs, export certification).

BLOCK	INSTRUCTIONS
1	1. Assign a number for each collection beginning the year, followed by the collector's initials and collector's number **EXAMPLE** In 2001, Brian K. Long collected his first specimen for determination of the year. His first collection number is 01-BLK-001 2. Enter the collection number
2	Enter date
3	Check block to indicate Agency submitting specimens for identification
4	Enter name of sender
5	Enter type of property specimen obtained from (farm, nursery, feedmill, etc.)
6	Enter address
7	Enter name and address of property owner
8A-8L	Check all appropriate blocks
9	Leave Blank
10	Enter scientific name of host, if possible
11	Enter quantity of host and plants affected
12	Check block to indicate distribution of plant
13	Check appropriate blocks to indicate plant parts affected
14	Check block to indicate pest distribution
15	• Check appropriate block to indicate type of specimen • Enter number specimens submitted under appropriate column
16	Enter sampling method
17	Enter type of trap and lure
18	Enter trap number
19	Enter X in block to indicate isolated or general plant symptoms
20	Enter X in appropriate block for weed density
21	Enter X in appropriate block for weed growth stage
22	Provide a brief explanation if Prompt or URGENT identification is requested
23	Enter a tentative determination if you made one
24	Leave blank

Distribution of PPQ Form 391
Distribute PPQ Form 391 as follows:
1. Send Original along with the sample to your Area Identifier.
2. Retain and file a copy for your records.

Figure A-2 Example Of PPQ 391 Specimens For Determination, side 2

Purpose

Submit PPQ Form 391, Specimens for Determination, along with specimens sent for positive or negative identification.

Instructions

Follow the instructions in ***Table A-1* on page A-5**. Inspectors must provide all relevant collection information with samples. This information should be communicated within a State and with the regional office program contact. If a sample tracking database is available at the time of the detection, please enter collection information in the system as soon as possible.

Address	Fillable PPQ Form 391 http://www.aphis.usda.gov/library/forms/pdf/PPQ_Form_391.pdf

Distribution

Distribute PPQ Form 391 as follows:

1. Send the original along with the sample to your area identifier.
2. Retain and file a copy for your records.

Table A-1 Instructions for Completing PPQ Form 391, Specimens for Determination

Block		Instructions
1	COLLECTION NUMBER	1. ASSIGN a collection number for each collection as follows: 2-letter State code–5-digit sample number (Survey Identification Number in Parentheses) Example: PA-1234 (04202010001) 2. CONTINUE consecutive numbering for each subsequent collection 3. ENTER the collection number
2	DATE	ENTER the date of the collection
3	SUBMITTING AGENCY	PLACE an X in the PPQ block
4	NAME OF SENDER	ENTER the sender's or collector's name
5	TYPE OF PROPERTY	ENTER the type of property where the specimen was collected (farm, feed mill, nursery, etc.)
6	ADDRESS OF SENDER	ENTER the sender's or collector's address
7	NAME AND ADDRESS OF PROPERTY OR OWNER	ENTER the name and address of the property where the specimen was collected
8A-8H	REASONS FOR IDENTIFICATION	PLACE an X in the correct block
9	IF PROMPT OR URGENT IDENTIFICATION IS REQUESTED, PLEASE PROVIDE A BRIEF EXPLANATION UNDER "REMARKS"	LEAVE blank; ENTER remarks in *Block 22*
10	HOST INFORMATION NAME OF HOST	If known, ENTER the scientific name of the host
11	QUANTITY OF HOST	If applicable, ENTER the number of acres planted with the host
12	PLANT DISTRIBUTION	PLACE an X in the applicable box
13	PLANT PARTS AFFECTED	PLACE an X in the applicable box
14	PEST DISTRIBUTION FEW/COMMON/ ABUNDANT/EXTREME	PLACE an X in the appropriate block
15	INSECTS/NEMATODES/ MOLLUSKS	PLACE an X in the applicable box to indicate type of specimen
	NUMBER SUBMITTED	ENTER the number of specimens submitted as ALIVE or DEAD under the appropriate stage
16	SAMPLING METHOD	ENTER the type of sample
17	TYPE OF TRAP AND LURE	ENTER the type of sample
18	TRAP NUMBER	ENTER the sample numbers
19	PLANT PATHOLOGY-PLANT SYMPTOMS	If applicable, check the appropriate box; otherwise LEAVE blank
20	WEED DENSITY	If applicable, check the appropriate box; otherwise LEAVE blank

Table A-1 Instructions for Completing PPQ Form 391, Specimens for Determination (continued)

Block		Instructions
21	WEED GROWTH STAGE	If applicable, check the appropriate box; otherwise LEAVE blank
22	REMARKS	ENTER the name of the office or diagnostic laboratory forwarding the sample; include a contact name, email address, phone number of the contact; also include the date forwarded to the State diagnostic laboratory or USDA–APHIS–NIS
23	TENTATIVE DETERMINATION	ENTER the preliminary diagnosis
24	DETERMINATION AND NOTES (**Not** for Field Use)	LEAVE blank; will be completed by the official identifier

PPQ 523 Emergency Action Notification

According to the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number. The valid OMB control number for this information is 0579-0102. The time required to complete this information collection is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

FORM APPROVED - OMB NO. 0579-0102

U.S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE

EMERGENCY ACTION NOTIFICATION

SERIAL NO.

1. PPQ LOCATION

2. DATE ISSUED

3. NAME AND QUANTITY OF ARTICLE(S)

4. LOCATION OF ARTICLES

5. DESTINATION OF ARTICLES

6. SHIPPER

7. NAME OF CARRIER

8. SHIPMENT ID NO.(S)

9. OWNER/CONSIGNEE OF ARTICLES

Name:

Address:

PHONE NO. | FAX NO.

SS NO. | TAX ID NO.

10. PORT OF LADING

11. DATE OF ARRIVAL

12. ID OF PEST(S), NOXIOUS WEEDS, OR ARTICLE(S)

12a. PEST ID NO.

12b. DATE INTERCEPTED

13. COUNTRY OF ORIGIN

14. GROWER NO.

15. FOREIGN CERTIFICATE NO.

15a. PLACE ISSUED

15b. DATE

Under Sections 411, 412, and 414 of the Plant Protection Act (7 USC 7711, 7712, and 7714) and Sections 10404 through 10407 of the Animal Health Protection Act (7 USC 8303 through 8306), you are hereby notified, as owner or agent of the owner of said carrier, premises, and/or articles, to apply remedial measures for the pest(s), noxious weeds, and or article(s) specified in Item 12, in a manner satisfactory to and under the supervision of an Agriculture Officer. Remedial measures shall be in accordance with the action specified in Item 16 and shall be completed within the time specified in Item 17.

AFTER RECEIPT OF THIS NOTIFICATION, ARTICLES AND/OR CARRIERS HEREIN DESIGNATED MUST NOT BE MOVED EXCEPT AS DIRECTED BY AN AGRICULTURE OFFICER. THE LOCAL OFFICER MAY BE CONTACTED AT:

16. ACTION REQUIRED

☐ TREATMENT:

☐ RE-EXPORTATION:

☐ DESTRUCTION:

☐ OTHER:

Should the owner or owner's agent fail to comply with this order within the time specified below, USDA is authorized to recover from the owner or agent cost of any care, handling, application of remedial measures, disposal, or other action incurred in connection with the remedial action, destruction, or removal.

17. AFTER RECEIPT OF THIS NOTIFICATION COMPLETE SPECIFIED ACTION WITHIN (Specify No. Hours or No. Days):

18. SIGNATURE OF OFFICER:

ACKNOWLEDGMENT OF RECEIPT OF EMERGENCY ACTION NOTIFICATION

I hereby acknowledge receipt of the foregoing notification.

SIGNATURE AND TITLE: | DATE AND TIME:

19. REVOCATION OF NOTIFICATION

ACTION TAKEN:

SIGNATURE OF OFFICER: | DATE:

PPQ FORM 523 (JULY 2002) Previous editions are obsolete.

Figure A-3 Example of PPQ 523 Emergency Action Notification

Purpose

Issue a PPQ 523, Emergency Action Notification (EAN), to hold all host plant material at facilities that have the suspected plant material directly or indirectly connected to positive confirmations. Once an investigation determines the plant material is not infested, or testing determines there is no risk, the material may be released and the release documented on the EAN.

The EAN may also be issued to hold plant material in fields pending positive identification of suspect samples. When a decision to destroy plants is made, or in the case of submitted samples, once positive confirmation is received, the same EAN which placed plants on hold also is used to document any actions taken, such as destruction and disinfection. Additional action may be warranted in the case of other fields or greenhouses testing positive for red palm weevil.

Instructions

If plant lots or shipments are held as separate units, issue separate EANs for each unit of suspected plant material and associated material held. EANs are issued under the authority of the Plant Protection Act of 2000 (statute 7 USC 7701-7758). States are advised to issue their own hold orders parallel to the EAN to ensure that plant material cannot move intrastate.

When using EANs to hold articles, it is most important that the EAN language clearly specify actions to be taken. An EAN issued for positive testing and positive-associated plant material must clearly state that the material must be disposed of, or destroyed, and areas disinfected. Include language that these actions will take place at the owner's expense and will be supervised by a regulatory official. If the EAN is used to issue a hold order for further investigations and testing of potentially infested material, then document on the same EAN, any disposal, destruction, and disinfection orders resulting from investigations or testing.

Follow the instructions in ***Table A-2* on page A-9** when completing PPQ 523 for the this pest. Find additional instructions for completing, using, and distributing the form in the PPQ *Manual for Agricultural Clearance*.

Address	PPQ *Manual for Agricultural Clearance* http://www.aphis.usda.gov/import_export/plants/manuals/ online_manuals.shtml

Table A-2 Instructions for Completing PPQ Form 523, Emergency Action Notification

Block		Instructions
1	COLLECTION NUMBER	ENTER the name and location of the nearest PPQ office
2	DATE	ENTER the date of the collection
3	PPQ LOCATION	ENTER the host scientific name and cultivar
4	LOCATION OF ARTICLES	ENTER the location of the article (premise location, pier, dock, container yard, hold space, etc.)
6	SHIPPER	ENTER the plant material source if known
7	NAME OF CARRIER	LEAVE blank unless that information is known
8	SHIPMENT ID NO.	LEAVE blank unless that information is known
12	ID OF PEST	To place plant material on a property on “Hold”, enter “suspect PEST NAME”; the authority under which actions are taken is The Plant Protection Act of 2000, Statute 7 USC 7701-7758
16	ACTION REQUIRED	ENTER the action required

B

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Field Screening Aid for *Tuta absoluta*

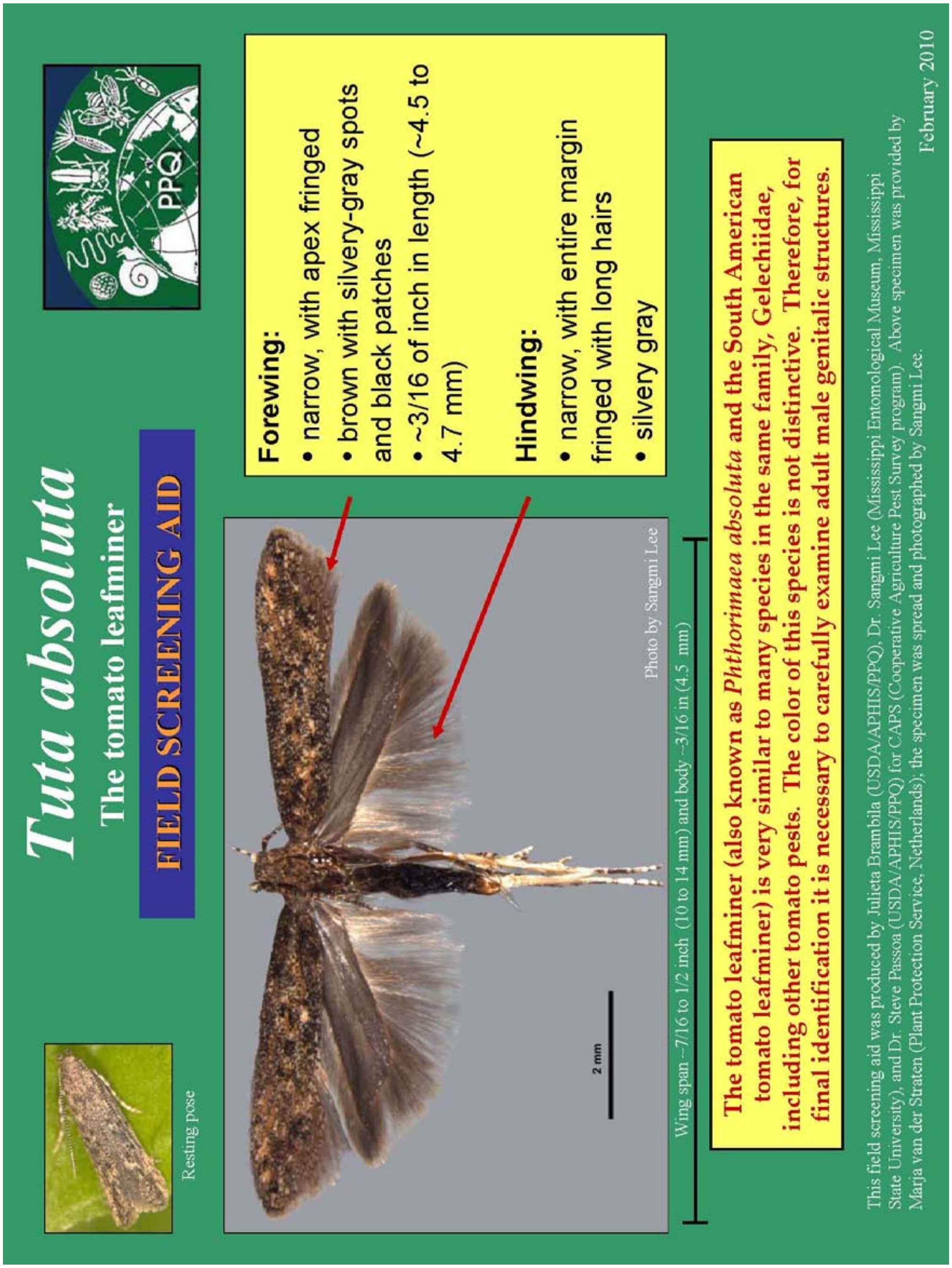

Figure B-1 Field Screening Aid for *Tuta absoluta* (Brambila et al., 2010)

C

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Diagnostic Aid for *Tuta absoluta*

Figure C-1 Diagnostic Aid for *Tuta absoluta* (Brambila et al., 2010)

D

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Diagnostic Aid for *Phthorimaea operculella*

Figure D-1 Field Screening Aid for *Phthorimaea operculella* (Brambila et al., 2010)

E

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Field Screening Aid for *Keiferia lycopersicella*

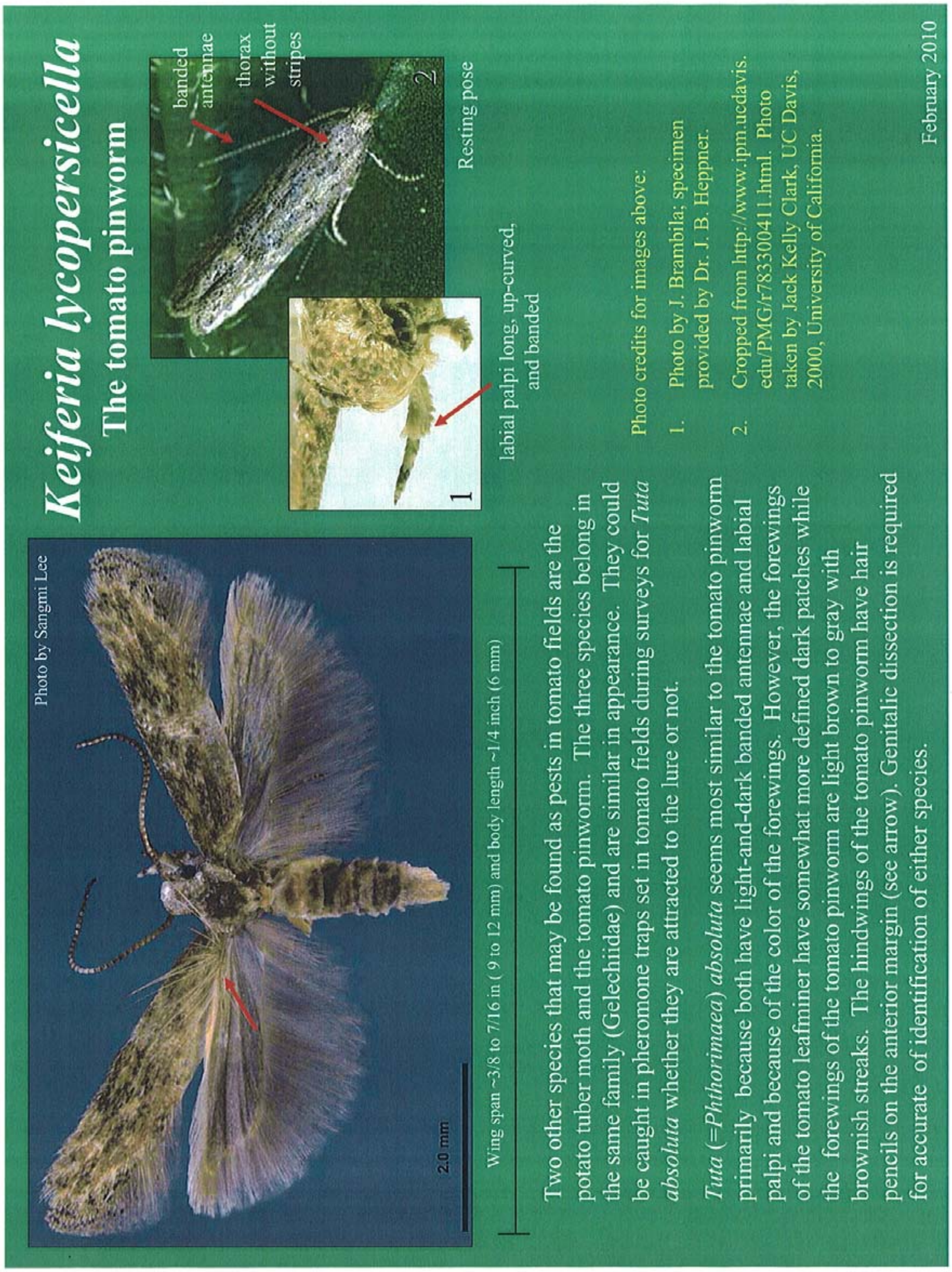

Figure E-1 Field Field Screening Aid for *Keiferia lycopersicella* (Brambila et al., 2010)

F

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How to Submit Insect Specimens

Insects and Mites

Taxonomic support for insect surveys requires that samples be competently and consistently sorted, stored, screened in most cases, and submitted to the identifier. The following are submission requirements for insects.

1. Sorting Trap Samples

   Trapping initiative is most commonly associated with a pest survey program, such as Wood Boring and Bark Beetles (WBBB), see Bark Beetle Submission Protocol from the PPQ Eastern Region CAPS program for detailed procedures. As such, it is important to sort out the debris and non-target insect orders from the trap material. The taxonomic level of sorting will depend on the expertise available on hand and can be confirmed with the identifier.

2. Screening Trap Samples

   Consult the screening aids on the CAPS website for screening aids for particular groups. The use of these aids should be coupled with training from identifiers and/or experienced screeners before their use. These can be found at: http://pest.ceris.purdue.edu/caps/screening.php

3. Storing Samples

   Where appropriate, samples can be stored indefinitely in alcohol, however samples of dried insects such as those in sticky traps may decompose over time if not kept in a cool location such as a refrigerator or freezer. If insect samples have decomposed, do not submit them for identification.

4. Packaging and Shipping

   Ensure specimens are dead prior to shipping. This can be accomplished by placing them in a vial of alcohol or place the dry specimens in the freezer for at least 1day. The following are a few tips on sorting, packaging and shipping liquids, sticky traps and dry samples.

Liquids

Factors such as arthropod group, their life-stage and the means they were collected determine the way the specimens are handled, preserved and shipped to the identifier. In general mites, insect larvae, soft-bodied and hard-bodied adult insects can be transferred to vials of 75-90% Ethanol (ETOH), or an equivalent such as isopropyl alcohol. At times, Lingren funnel trap samples may have rainwater in them. To prevent later decay, drain off all the liquid and replace with alcohol. Vials used to ship samples should contain samples from a single trap and a printed or hand-written label with the associated collection number that is also found in the top right corner of form 391. Please make sure to use a writing utensil that isn't alcohol soluble, such as a micron pen or a pencil. It is very important not to mix samples from multiple traps in a single vial so as to preserve the locality association data. Vials can be returned to field personnel upon request.

If sending specimens in alcohol is an issue with the mail or freight forwarder, the majority of liquid can be decanted off from the vial and then sealed tightly in the container just prior to shipping. Notify the identifier that the vials will need to have alcohol added back to them as soon as they are received. During the brief time of shipping, the specimens should not dry out if the vial is properly sealed.

Sticky Trap Samples

Adult Lepidoptera, because of their fragile appendages, scales on wings, etc. require special handling and shipping techniques. Lepidoptera specimens in traps should not be manipulated or removed for preliminary screening unless expertise is available. Traps can be folded, with stickum-glue on the inside, but only without the sticky surfaces touching, and secured loosely with a rubber band for shipping. Inserting a few styrofoam peanuts on trap surfaces without insects will cushion and prevent the two sticky surfaces from sticking during shipment to taxonomists. Also DO NOT simply fold traps flat or cover traps with transparent wrap (or other material), as this will guarantee specimens will be seriously damaged or pulled apart – making identification difficult or impossible.

An alternative to this method is to cut out the area of the trap with the suspect pest and pin it securely to the foam bottom of a tray with a lid. Make sure there is some room around the specimen for pinning and future manipulation. For larger numbers of traps, placing several foam peanuts between sticky surfaces (arranged around suspect specimens) can prevent sticky surfaces from making contact when packing multiple folded-traps for shipment. DO NOT simply fold traps flat or cover traps with transparent wrap (or other material), as this will guarantee specimens will be seriously damaged or pulled apart – making identification difficult or impossible.

Dry Specimens

Some collecting methods produce dry material that is very fragile. Dry samples can be shipped in vials or glassine envelopes, such as the ones that can be purchased here: http://www.bioquip.com/Search/default.asp. As with the alcohol samples, make sure the collection label is associated with the sample at all times. This method is usually used for larger insects and its downside is the higher chance of breakage during shipping. Additionally, dry samples are often covered in debris and sometimes difficult to identify.

Be sure that the samples are adequately packed for shipment to ensure safe transit to the identifier. If a soft envelope is used, it should be wrapped in shipping bubble sheets; if a rigid cardboard box is used, pack it in such a way that the samples are restricted from moving in the container. Please include the accompanying documentation and notify the identifier prior to shipping. Remember to inform the identifier that samples are on the way, giving the approximate number and to include your contact information.

Documentation

Each trap sample/vial should have accompanying documentation along with it in the form of a completed PPQ form 391, Specimens for Determination. The form is fillable electronically and can be found here:

http://cals-cf.calsnet.arizona.edu/azpdn/labs/submission/PPQ_Form_391.pdf

It is good practice to keep a partially filled electronic copy of this form on your computer with your address and other information filled out in the interest of saving time. Indicate the name of the person making any tentative identification prior to sending to an identifier. Please make sure all fields that apply are filled out and the bottom field (block 24: Determination and Notes) is left blank to be completed by the identifier. Include the trap type, lure used, and trap number on the form. Also, include the phone number and/or e-mail address of the submitter. Other documentation in the form of notes, images, etc. can be sent along with this if it useful to the determination. It is important that there be a way to cross-reference the sample/vial with the accompanying form. This can be done with a label with the “Collection Number” in the vial or written on the envelope, etc.

G

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Taxonomic Support for Surveys

Background

The National Identification Services (NIS) coordinates the identification of plant pests in support of USDA's regulatory programs. Accurate and timely identifications provide the foundation for quarantine action decisions and are essential in the effort to safeguard the nation's agricultural and natural resources.

NIS employs and collaborates with scientists who specialize in various plant pest groups, including weeds, insects, mites, mollusks and plant diseases. These scientists are stationed at a variety of institutions around the country, including federal research laboratories, plant inspection stations, land-grant universities, and natural history museums. Additionally, the NIS Molecular Diagnostics Laboratory is responsible for providing biochemical testing services in support of the agency's pest monitoring programs.

On June 13, 2007, the PPQ Deputy Administrator issued PPQ Policy No. PPQ-DA-2007-02 which established the role of PPQ NIS as the point of contact for all domestically- detected, introduced plant pest confirmations and communications. A Domestic Diagnostics Coordinator (DDS) position was established to administer the policy and coordinate domestic diagnostic needs for NIS. This position was filled in October of 2007 by Joel Floyd (USDA, APHIS, PPQ-PSPI,NIS 4700 River Rd., Unit 52, Riverdale, MD 20737, phone (301) 734-4396, fax (301) 734-5276, e-mail: joel.p.floyd@aphis.usda.gov).

Taxonomic Support and Survey Activity

Taxonomic support for pest surveillance is basic to conducting quality surveys. A misidentification or incorrectly screened target pest can mean a missed opportunity for early detection when control strategies would be more viable and cost effective. The importance of good sorting, screening, and identifications in our domestic survey activity cannot be overemphasized.

Fortunately most states have, or have access to, good taxonomic support within their states. Taxonomic support should be accounted for in cooperative agreements as another cost of conducting surveys. Taxonomists and laboratories within the state often may require supplies, develop training materials, or need to hire technicians to meet the needs of screening and identification. Moreover, when considering whether to survey for a particular pest a given year, it is advisable to consider the challenges of taxonomic support as a factor in choosing that as a survey target in the first place.

Sorting and Screening

For survey activity, samples that are properly sorted and screened prior to being examined by an identifier will result in quicker turn around times for identification.

Sorting

is the first level of activity that assures samples submitted are of the correct target group of pests being surveyed, i.e., after removal of debris, ensure that the correct order, or in some cases family, of insects is submitted; or for plant disease survey samples, select those that are symptomatic if appropriate. There should be a minimum level of sorting expected of surveyors depending on the target group, training, experience, or demonstrated ability.

Screening

is a higher level of discrimination of samples such that the suspect target pests are separated from the known non-target, or native species of similar taxa. For example, only the suspect target species or those that appear similar to the target species are forwarded to an identifier for confirmation. There can be first level screening and second level depending on the difficulty and complexity of the group. Again, the degree of screening appropriate is dependent on the target group, training, experience, and demonstrated ability of the screener.

Check individual survey protocols to determine if samples should be sorted, screened or sent entire (raw) before submitting for identification. If not specified in the protocol, assume that samples should be sorted at some level.

Resources for Sorting, Screening, and Identification

Sorting, screening, and identification resources and aids useful to CAPS and PPQ surveys are best developed by taxonomists who are knowledgeable of the taxa that includes the target pests and the established or native organisms in the same group that are likely to be in samples and can be confused with the target. Many times these aids can be regionally based. They can be in the form of dichotomous keys, picture guides, or reference collections. NIS encourages the development of these resources, and when aids are complete, post them in the CAPS Web site so others can benefit. If local screening aids are developed, please notify Joel Floyd, the Domestic Diagnostics Coordinator, as to their availability. Please see the following for some screening aids currently available: http://pest.ceris.purdue.edu/caps/screening.php

Other Entities for Taxonomic Assistance in Surveys

When taxonomic support within a state is not adequate for a particular survey, in some cases other entities may assist including PPQ identifiers, universities and state departments of agriculture in other states, and independent institutions. Check with the PPQ regional CAPS coordinators about the availability of taxonomic assistance.

Universities and State Departments of Agriculture:

Depending on the taxonomic group, there are a few cases where these two entities are interested in receiving samples from other states. Arrangements for payment, if required for these taxonomic services, can be made through cooperative agreements. The National Plant Diagnostic Network (NPDN) also has five hubs that can provide service identifications of plant diseases in their respective regions.

Independent Institutions

The Eastern Region PPQ office has set up multi-state arrangements for Carnegie Museum of Natural History to identify insects from trap samples. They prefer to receive unscreened material and work on a fee basis per sample.

PPQ Port Identifiers

There are over 70 identifiers in PPQ that are stationed at ports of entry who primarily identify pests encountered in international commerce including conveyances, imported cargo, passenger baggage, and propagative material. In some cases, these identifiers process survey samples generated in PPQ conducted surveys, and occasionally from CAPS surveys. They can also enter into our Pest ID database the PPQ form 391 for suspect CAPS target or other suspect new pests, prior to being forwarded for confirmation by an NIS recognized authority.

PPQ Domestic Identifiers

PPQ also has a limited number of domestic identifiers (three entomologists and two plant pathologists) normally stationed at universities who are primarily responsible for survey samples. Domestic identifiers can be used to handle unscreened, or partially screened samples, with prior arrangement through the PPQ regional survey coordinator. They can also as an intermediary alternative to sending an unknown suspect to, for example, the ARS Systematic Entomology Lab (SEL), depending on their specialty and area of coverage. They can also enter into our Pest ID database the PPQ form 391 for suspect CAPS target or other suspect new pests, prior to being forwarded for confirmation by an NIS recognized authority.

PPQ Domestic Identifiers
Bobby Brown
Domestic Entomology Identifier
Specialty: forest pests (coleopteran, hymenoptera)
Area of coverage: primarily Eastern Region

USDA, APHIS, PPQ
901 W. State Street
Smith Hall, Purdue University
Lafayette, IN 47907-2089
Phone: 765-496-9673
Fax: 765-494-0420
e-mail: robert.c.brown@aphis.usda.gov

Julieta Brambila
Domestic Entomology Identifier
Specialty: adult Lepidoptera, Hemiptera
Area of Coverage: primarily Eastern Region
USDA APHIS PPQ
P.O. Box 147100
Gainesville, FL 32614-7100
Office phone: 352- 372-3505 ext. 438, 182
Fax: 352-334-1729
e-mail: julieta.bramila@aphis.usda.gov

Kira Zhaurova
Domestic Entomology Identifier
Specialty: to be determine
Area of Coverage: primarily Western Region
USDA, APHIS, PPQ
Minnie Belle Heep 216D
2475 TAMU
College Station, TX 77843
Phone: 979-450-5492
e-mail: kira.zhaurova@aphis.usda.gov

Grace O'Keefe
Domestic Plant Pathology Identifier
Specialty: Molecular diagnostics (citrus greening, P. ramorum, bacteriology, cyst nematode screening)
Area of Coverage: primarily Eastern Region
USDA, APHIS, PPQ
105 Buckhout Lab
Penn State University
University Park, PA 16802

Lab: 814 - 865 - 9896
Cell: 814 – 450- 7186
Fax: 814 - 863 – 8265
e-mail: grace.okeefe@aphis.usda.gov

Craig A. Webb, Ph.D.
Domestic Plant Pathology Identifier
Specialty: Molecular diagnostics (citrus greening, P. ramorum, cyst nematode screening)
Area of Coverage: primarily Western Region
USDA, APHIS, PPQ
Department of Plant Pathology
Kansas State University
4024 Throckmorton Plant Sciences
Manhattan, KS 66506-5502
Cell (785) 633-9117
Office (785) 532-1349
Fax: 785-532-5692
e-mail: craig.a.webb@aphis.usda.gov

Final Confirmations

If identifiers or laboratories at the state, university, or institution level suspect they have detected a CAPS target, a plant pest new to the United States, or a quarantine pest of limited distribution in a new state, the specimens should be forwarded to an NIS recognized taxonomic authority for final confirmation. State cooperator and university taxonomists can go through a PPQ area identifier or the appropriate domestic identifier that covers their area to get the specimen in the PPQ system (for those identifiers, see table G-1-1 in the Agriculture Clearance Manual, Appendix G link below). They will then send it to the NIS recognized authority for that taxonomic group.

State level taxonomists, who are reasonably sure they have a new United States. record, CAPS target, or new federal quarantine pest, can send the specimen directly to the NIS recognized authority, but must notify their State Survey Coordinator (SSC), PPQ Pest Survey Specialist (PSS), State Plant Health Director (SPHD), and State Plant Regulatory Official (SPRO).

Before forwarding these suspect specimens to identifiers or for confirmation by the NIS recognized authority, please complete a PPQ form 391 with the tentative determination. Also fax a copy of the completed PPQ Form 391 to “Attention: Domestic Diagnostics Coordinator” at 301-734-5276, or send a PDF file in an e-mail to mailto:nis.urgents@aphis.usda.govwith the overnight carrier tracking number.

The addresses of NIS recognized authorities of where suspect specimens are to be sent can be found in The Agriculture Clearance Manual, Appendix G, tables G-1-4 and G-1-5: http://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/mac_pdf/g_app_identifiers.pdf

Only use Table G-1-4, the "Urgent" listings, for suspected new United States records, or state record of a significant pest, and Table G-1-5, the "Prompt" listings, for all others.

When the specimen is being forwarded to a specialist for NIS confirmation, use an overnight carrier, insure it is properly and securely packaged, and include the hard copy of the PPQ form 391 marked "Urgent" if it is a suspect new pest, or "Prompt" as above.

Please contact Joel Floyd, the Domestic Diagnostics Coordinator if you have questions about a particular sample routing, at phone number: 301-734-5276, or e-mail: joel.p.floyd@aphis.usda.gov

Digital Images for Confirmation of Domestic Detections

For the above confirmations, do not send digital images for confirmation. Send specimens in these instances. For entry into NAPIS, digital imaging confirmations can be used for new county records for widespread pests by state taxonomists or identifiers if they approve it first. They always have the prerogative to request the specimens be sent.

Communications of Results

If no suspect CAPS target, program pests, or new detections are found, communication of these identification results can be made by domestic identifiers or taxonomists at other institutions directly back to the submitter. They can be in spread sheet form, on hard copy PPQ form 391's, or other informal means with the species found, or "no CAPS target or new suspect pest species found". Good record keeping by the intermediate taxonomists performing these identifications is essential.

All confirmations received from NIS recognized authorities, positive or negative, are communicated by NIS to the PPQ Emergency and Domestic Programs (EDP) staff in PPQ headquarters. EDP then notifies the appropriate PPQ program managers and the SPHD and SPRO simultaneously. One of these contacts should forward the results to the originating laboratory, diagnostician, or identifier.

Data Entry

Cooperative Agricultural Pest Survey (CAPS)

For survey data entered into NAPIS, new country and state records should be confirmed by an NIS recognized authority, while for others that are more widespread, use the identifications from PPQ identifiers or state taxonomists.

Index

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X
Y
Z