



منظمة وقاية النباتات  
التشرق الأدنى  
NEAR EAST PLANT  
PROTECTION  
ORGANIZATION



# EPPO/IOBC/FAO/NEPPO Joint International Symposium on management of *Tuta absoluta* (tomato borer)

**BOOK OF ABSTRACTS**

Agadir, Morocco, November 16-18, 2011

## International Organizing Committee

- *Khaled Alrouechdi, FAO, Rome*
- *Mohamed Besri, convenor of IOBC North Africa Commission, Morocco*
- *Cristina Castane, convenor of the IOBC WG on Greenhouses in the Mediterranean Region, Spain*
- *Mekki Chouibani, Near-East Plant Protection Organization, Morocco*
- *Rosa Gabarra, Council member of IOBC/WPRS, Spain*
- *Kevin Gorman, Rothamsted Research, UK*
- *Michel Guillon, IBMA representative in the IOBC North Africa Commission, France*
- *Ahmed Mazih, member of the IOBC North Africa Commission, Morocco*
- *Ralf Nauen, IRAC chairman, Germany*
- *Emmanouil Roditakis, National Agricultural Research Foundation, Crete, Greece*
- *Vlasta Zlof, EPPO, France*

## Local Organizing Committee

- *Mohamed Besri: Convenor, IOBC North Africa commission-IAV Hassan II, Morocco*
- *Mekki Chouibani: NEPPO-ONSSA, Morocco*
- *Ahmed Mazih: IOBC North Africa Commission-IAV Hassan II, Morocco*
- *Youssef Charhabli: ANIPHOP, Morocco*
- *Lahcen Abaha, ONSSA, Morocco*

## Table of contents

<b>I- PROGRAM.....</b>	<b>6</b>
<b>A- Wednesday, 16<sup>th</sup> November 2011.....</b>	<b>6</b>
1- SESSION 1: DISTRIBUTION, BIO-ECOLOGY AND DAMAGE OF <i>TUTA ABSOLUTA</i> .....	6
2- SESSION 2 A: CURRENT STATUS OF THE TOMATO BORER IN EPPO/NEPPO COUNTRIES	7
3- SESSION 2 B: CURRENT STATUS OF THE TOMATO BORER IN EPPO/NEPPO COUNTRIES	7
4- SESSION 3: CONTROL STRATEGIES: CHEMICAL CONTROL AND MATING DISRUPTION	8
<b>B- Thursday, 17<sup>th</sup> November 2011 .....</b>	<b>8</b>
1- SESSION 4: CONTROL STRATEGIES: BIOLOGICAL CONTROL .....	8
2- SESSION 5 A: CONTROL STRATEGIES: INTEGRATED PEST MANAGEMENT (IPM).....	9
3- SESSION 5B: CONTROL STRATEGIES: INTEGRATED PEST MANAGEMENT .....	9
4- SESSION 6: ROUND TABLE - CONCLUSIONS AND RECOMMENDATIONS OF THE WORKSHOP.....	10
<b>C- Friday 18<sup>th</sup> November – Technical Visit .....</b>	<b>10</b>
<b>D- Saturday 19<sup>th</sup> November: Departure .....</b>	<b>10</b>
 <b>II- ABSTRACTS OF ORAL PRESENTATIONS.....</b>	 <b>16</b>
<b>A- SESSION 1: DISTRIBUTION, BIO-ECOLOGY AND DAMAGE OF <i>TUTA ABSOLUTA</i>.....</b>	<b>16</b>
Biology, distribution and damage of <i>Tuta absoluta</i> , an exotic invasive pest from South America. Giovanna Tropea Garzia, Gaetano Siscaro, Antonio Biondi and Lucia Zappalà .....	16
Spatiotemporal distribution of <i>Tuta absoluta</i> Mey. (Lepidoptera: Gelechiidae) in tomato greenhouses on the coast of Algiers : Hassina Benmessaoud-Boukhalifa et Nora Khellaf .....	17
Population development of <i>Tuta absoluta</i> (Meyrick) (Lepidoptera: Gelechiidae) in UK glasshouses: Andrew G. S. Cuthbertson <sup>1</sup> , James J. Mathers <sup>1</sup> , Lisa F. Blackburn <sup>1</sup> , Anastasia Korycinska <sup>1</sup> , Michelle E. Powell <sup>1</sup> , Weiqi Luo <sup>1</sup> , Rob J. Jacobson <sup>2</sup> , Phil Northing <sup>1</sup> and Raymond J. C. Cannon <sup>1</sup> .....	17
<i>Tuta absoluta</i> in South America: pest status, management & insecticide resistance : Raul Narciso C. Guedes & Marcelo C. Picanço.....	17
<b>B- SESSION 2 A and 2B: CURRENT STATUS OF THE TOMATO BORER IN EPPO/NEPPO COUNTRIES.....</b>	<b>19</b>
IPM Strategy: Case of tomato borer <i>Tuta absoluta</i> in Algeria: Fatiha Benddine.....	19
The status of <i>Tuta absoluta</i> in Egypt: Sobhy A. Temerak.....	20
The current status of <i>Tuta absoluta</i> in Greece and Cyprus: Emmanouil Roditakis <sup>1</sup> and Nicos Seraphides <sup>2</sup> .....	20
First report of <i>Tuta absoluta</i> in Iran and initial control strategies : Valiollah Baniameri.....	21
Stratégie Nationale de lutte contre la mineuse de la tomate <i>Tuta absoluta</i> Meyrick (Lepidoptera : Gelechiidae) au Maroc : K. Ouardi, M. Chouibani, M.A. Rahel, M. El Akel.....	21
The current incidence of tomato borer, <i>Tuta absoluta</i> , in the UK: Kevin Gorman <sup>1</sup> , Madeleine Berger <sup>1</sup> , Khalid Haddi <sup>2</sup> , Chris Bass <sup>1</sup> .....	22
<b>C- SESSION 3: CONTROL STRATEGIES: CHEMICAL CONTROL AND MATING DISRUPTION..</b>	<b>23</b>
General Introduction to the Insecticide Resistance Action Committee: Sybille Lamprecht & Ralf Nauen .....	23
Determination of baseline toxicity of insecticides to <i>Tuta absoluta</i> : Emmanouil Roditakis.....	23

Knockdown resistance (kdr and super kdr) mutations in the voltage-gated sodium channel of tomato borer, <i>Tuta absoluta</i> , associated with pyrethroid resistance: Khalid Haddi <sup>1</sup> , Madeleine Berger <sup>2</sup> , Pablo Bielza <sup>3</sup> , Carmelo Rapisarda <sup>1</sup> , Martin Williamson <sup>2</sup> , Chris Bass <sup>2</sup> , Kevin Gorman <sup>2</sup> .	24
First results from South Europe for <i>Tuta absoluta</i> control using diflubenzuron with adjuvant and with/without <i>Bt kurstaki</i> : G. Chiot, N. Lanza and E. Casagrande	25
Influence of Thunder <sup>®</sup> treatments on <i>Tuta absoluta</i> development: Eitán Martín, Enrique Iñigo, Carlos Solans, David Bernad	25
AA L&K : New alternative to control the population of <i>Tuta absoluta</i> : Mounir Hassani	26
Evaluation of the mating disruption method against the tomato borer, <i>Tuta absoluta</i> (Meyrick), in greenhouse tomato crops in Sardinia (Italy): Arturo Cocco, Salvatore Deliperi and Gavino Delrio	26
Early studies on the control of tomato borer <i>Tuta absoluta</i> with mating disruption technique in Murcia region (Spain): Antonio Monserrat <sup>1</sup> ; Manuel Andreu <sup>1</sup> ; Encarna Martínez <sup>3</sup> ; Mariano Marín <sup>3</sup> ; Jose Luis Gonzalez <sup>3</sup> ; Jose Miguel Martínez <sup>3</sup> ; Raquel García <sup>3</sup> ; Vicente Quinto <sup>3</sup> ; Paolo Sambado <sup>2</sup>	26
<b>D- SESSION 4: CONTROL STRATEGIES: BIOLOGICAL CONTROL</b>	<b>27</b>
Prospects for the biological control of <i>Tuta absoluta</i> in tomato crops of the Mediterranean basin: Rosa Gabarra <sup>1</sup> , Judit Arnó <sup>1</sup> , Alberto Urbaneja <sup>2</sup>	27
Success and extension of biological control strategies for managing <i>Tuta absoluta</i> (Meyrick)(Lep.: Gelechiidae) populations in the Mediterranean area: José E. Belda, Antonio Giménez and F. Javier Calvo	28
Improvement of integrated management against <i>Tuta absoluta</i> by using new egg parasitoids: Hong Do Thi Khanh <sup>*(1)</sup> , Marion Tiradon <sup>(1)</sup> , ETTY Colombel <sup>(1)</sup> , Adrien Bonnet <sup>(1)</sup> , Anaïs Chailleux <sup>(2)</sup> , Nicolas Desneux <sup>(2)</sup> , Elisabeth Tabone <sup>*(1)</sup>	28
Adaptation of indigenous parasitoids to the invasive tomato pest <i>Tuta absoluta</i> in Italy: biology and behaviour of the braconid wasp <i>Bracon nigricans</i> : Lucia Zappalà <sup>1</sup> , Antonio Biondi <sup>1,2</sup> , Gaetano Siscaro <sup>1</sup> , Giovanna Tropea Garzia <sup>1</sup> , Kees van Achterberg <sup>3</sup> , Nicolas Desneux <sup>2</sup>	29
Importance of native polyphagous predators able to prey on <i>Tuta absoluta</i> Meyrick (Lepidoptera: Gelechiidae) on tomato crop: Y. Guenaoui, R. Bensaad and K. Ouezzani	30
Side-effects of lepidoptericides, used against <i>Tuta absoluta</i> , on different biological control agents and pollinators: Guido Sterk	30
<b>E- SESSION 5 A: CONTROL STRATEGIES: INTEGRATED PEST MANAGEMENT (IPM)</b>	<b>31</b>
Efforts of the FAO on the management of the tomato borer <i>Tuta absoluta</i> in the Near East region: Khaled Alrouechdi <sup>1</sup> and Shoki Aldobai <sup>2</sup>	31
History and current IPM strategies for the management of <i>Tuta absoluta</i> in the Mediterranean region: Shakir Al-Zaidi	31
IPM of <i>Tuta absoluta</i> in Israel: Liora Shaltiel Harpaz <sup>1,2</sup> , Shaul Graph <sup>1</sup> , Kedoshim Rika <sup>1</sup> , Lotem Azolay <sup>2</sup> , Tamir Rozenberg <sup>2</sup> , Nachash Yakov <sup>3</sup> , Tamar Alon <sup>4</sup> , Arnon Alush <sup>5</sup> , Shimon Stinberg <sup>5</sup> and Dan Gerling <sup>2</sup>	32
Conception of an integrated pest management program to control the tomato borer <i>Tuta absoluta</i> (Povolny) in industrial tomato crops in Tunisia : Brahim Chermiti and Khaled Abbas	32
Les aspects pratiques de la lutte contre <i>Tuta absoluta</i> : Cas de la région du Souss (Maroc) : Rachid Elaini	33
<b>F- SESSION 5B: CONTROL STRATEGIES: INTEGRATED PEST MANAGEMENT</b>	<b>33</b>
<i>Tuta absoluta</i> : A season-long IPM strategy based on predatory bugs : Rob Jacobson	33
Biological and chemical pest management strategies for the control of <i>Tuta absoluta</i> (Lepidoptera: Gelechiidae) and their effectiveness: Mario V. Balzan and Anna-Camilla Moonen	34
Investigating the potential of genetic control as part of an IPM approach for <i>Tuta absoluta</i> : Neil I Morrison <sup>1</sup> , Adam S Walker <sup>1</sup> , Ian Baxter <sup>2</sup> , Tim Harvey-Samuel <sup>1,3</sup> , Ahmed Hdidi <sup>2</sup> , Luke Alphey <sup>1,3</sup>	34
Integrated control of <i>Tuta absoluta</i> in the Mediterranean region: what we can learn for future pest invasions?: Cristina Castañé	35
<b>III- ABSTRACTS OF POSTERS BY COUNTRY</b>	<b>37</b>
ALGERIA	37
ARGENTINA	43

<b>BRAZIL .....</b>	<b>44</b>
<b>EGYPT.....</b>	<b>45</b>
<b>FRANCE.....</b>	<b>46</b>
<b>GERMANY .....</b>	<b>48</b>
<b>HUNGARY .....</b>	<b>49</b>
<b>INDIA.....</b>	<b>49</b>
<b>IRAN .....</b>	<b>50</b>
<b>IRAQ.....</b>	<b>51</b>
<b>ITALY .....</b>	<b>51</b>
<b>JORDAN.....</b>	<b>54</b>
<b>MAURITANIA.....</b>	<b>55</b>
<b>MONTENEGRO.....</b>	<b>56</b>
<b>MOROCCO.....</b>	<b>57</b>
<b>QATAR.....</b>	<b>59</b>
<b>SAUDI ARABIA .....</b>	<b>59</b>
<b>SPAIN .....</b>	<b>61</b>
<b>SUDAN.....</b>	<b>61</b>
<b>TUNISIA.....</b>	<b>62</b>
<b>TURKEY .....</b>	<b>65</b>
<b>UNITED KINGDOM.....</b>	<b>66</b>

**EPPO/IOBC/FAO/NEPPO Joint International Symposium  
on management of *Tuta absoluta* (tomato borer, Lepidoptera: Gelechiidae)  
in collaboration with the IRAC and IBMA  
Agadir, Morocco, November 16-18, 2011**

**I- PROGRAM**

**Tuesday, 15th November 2011**

**Arrival of participants to the Hotel Beach Club, Agadir**

**16:00 – 19:00 Registration and Posters set up**

Badges, brochures, program, abstracts, preliminary list of participants etc. will be available at the registration desk.

17:00-18:30 Meeting of the Organizing Committee (local and international, chairs and co-chairs)

**A- Wednesday, 16<sup>th</sup> November 2011**

**08:00 - 09:00 Registration and Posters set up**

**09:00 - 09:40 Welcome and opening address**

- Officials: Ministry of Agriculture, Regional Council of Agriculture, Mayor of Agadir, President of the region.....
- International Organizing Committee (EPPO, IOBC, NEPPO, FAO on behalf of the organizers)
- House keeping: Local Organizing Committee

**1- SESSION 1: DISTRIBUTION, BIO-ECOLOGY AND DAMAGE OF  
*TUTA ABSOLUTA***

**CHAIR: V. ZLOF (EPPO)**

**CO-CHAIR: B. CHERMITI (Tunisia)**

**09:40-10:05** Biology, distribution and damage of *Tuta absoluta*, an exotic invasive pest from South America **Giovanna Tropea Garzia** (Italy)

**10:05-10:20** Distribution spatiotemporelle de *Tuta absoluta* sous serre de tomates sur le littoral algérois **Hassina Benmessaoud-Boukhalfa** (Algeria)

**10:20-10:35** Population development of *Tuta absoluta* in UK glasshouses **Ray Cannon** (UK)

**10:35-11:00** *Tuta absoluta* in South America: pest status, management & insecticide resistance **Raul Guedes** (Brazil)

**11:00-11:30 COFFEE BREAK – POSTERS**

## **2- SESSION 2 A: CURRENT STATUS OF THE TOMATO BORER IN EPPO/NEPPO COUNTRIES**

**CHAIR: M. CHOUIBANI (Morocco)      CO-CHAIR: L. ZAPPALA (Italy)**

**11:30-11:45 Fatiha Benddine** IPM Strategy: A case of *Tuta absoluta* in **Algeria**

**11:45-12:00 Sobhy Temerak** The status of *Tuta absoluta* in **Egypt**

**12:00-12:15 Yannine Trottin** The current status of *Tuta absoluta* in **France**

**12:15-12:30 Emmanouil Reditakis & Nicos Seraphides** The current status of *Tuta absoluta* in **Greece and Cyprus**

**12:30-12:45 Valiollah Baniameri** First report of *Tuta absoluta* in **Iran** and initial control strategies

**12:45-13:00 Stephano Speranza** The current status of *Tuta absoluta* in **Italy**

**13:00-14:00 LUNCH**

## **3- SESSION 2 B: CURRENT STATUS OF THE TOMATO BORER IN EPPO/NEPPO COUNTRIES**

**CHAIR: R. GABARRA (Spain)      CO-CHAIR: F. DAGLI (Turkey)**

**14:00-14:15 Liora Shaltiel Harpaz** The current status of *Tuta absoluta* in **Israel**

**14:15-14:30 Khadija Ouardi** La stratégie nationale de lutte contre *Tuta absoluta* in **Maroc**

**14:30-14:45 Rosa Gabarra** The current status of *Tuta absoluta* in **Spain**

**14:45-15:00 Bouzid Nasraoui** *Tuta absoluta* in **Tunisia**: three years later?

**15:00-15:15 Sakine Ugurlu** The current status of *Tuta absoluta* in **Turkey** and toxicity of some insecticides

**15:15-15:30 Kevin Gorman** Incidence of tomato borer, *Tuta absoluta*, in the **UK**

**15:30-16:00 COFFEE BREAK – POSTERS**

#### **4- SESSION 3: CONTROL STRATEGIES: CHEMICAL CONTROL AND MATING DISRUPTION**

**CHAIR: K. GORMAN (UK)**

**CO-CHAIR: I. AL-JBOORY (Jordan)**

**16:00-16:30 Sybille Lamprecht** Global introduction to the Insecticide Resistance Action Committee (IRAC)

**16:30-17:00 Emmanouil Roditakis** Determination of baseline toxicity of insecticides to *Tuta absoluta* (Greece)

**17:00-17:15 Khalid Haddi** Mutations in the para-type sodium channel gene confer resistance to pyrethroids in *Tuta absoluta* (UK)

**17:15-17:30 Giancarlo Chiot** First results from South Europe for *Tuta absoluta* control using diflubenzuron with adjuvant and with/without *Bt kurstaki* (Italy)

**17:30-17:45 Eitán Martín** Influence of Thunder<sup>®</sup> treatments on *Tuta absoluta* development (Spain)

**17:45-18:00 Mounir Hassani** AA L&K: New alternative to control the population of *Tuta absoluta* (Switzerland)

**18:00-18:15 Arturo Cocco** Evaluation of the mating disruption method against *Tuta absoluta* in greenhouse tomato crops in Sardinia (Italy)

**18:15-18:30 Paolo Sambado** Early studies on the control of *Tuta absoluta* with mating disruption technique in Murcia region (Spain)

**18:30** End of the first day

**18:30-19:30** Meeting of the Organizing Committee and North Africa Commission: future activities

### **B- Thursday, 17<sup>th</sup> November 2011**

#### **1- SESSION 4: CONTROL STRATEGIES: BIOLOGICAL CONTROL**

**CHAIR: A. MAZIH (Morocco)**

**CO-CHAIR: E. RODITAKIS (Greece)**

**09:00-9:30 Rosa Gabarra** Prospects for the biological control of *Tuta absoluta* in tomato crops of the Mediterranean basin (Spain)

**09:30-09:45 Jose E. Belda** Success and extension of biological control strategies for managing *Tuta absoluta* populations in the Mediterranean area (Spain)

**09:45-10:00 Hong Do** Improvement of integrated management against *Tuta absoluta* by using new egg parasitoids (France)



**10:00-10:15 Lucia Zappalà** Adaptation of indigenous parasitoids to the invasive tomato pest *Tuta absoluta* in Italy: biology and behaviour of the braconid wasp *Bracon nigricans* (Italy)

**10:15-10:30 Yamina Guenaoui** Importance of native polyphagous predators able to prey on *Tuta absoluta* on tomato crops (Algeria)

**10:30-10:45 Guido Sterk** Side-effects of lepidoptericides, used against *Tuta absoluta*, on different biological agents and pollinators (Belgium)

**10:45-11:15 COFFEE BREAK and POSTERS**

## **2- SESSION 5 A: CONTROL STRATEGIES: INTEGRATED PEST MANAGEMENT (IPM)**

**CHAIR: B. NASRAOUI (Tunisia)**

**CO-CHAIR: S. LAMPRECHT (Germany)**

**11:15-11:45 Khaled Alrouechdi** Efforts of the FAO on the management of the tomato borer *Tuta absoluta* in the Near East region

**11:45-12:15 Shakir Al-Zaidi** History and current IPM strategies for the management of *Tuta absoluta* in the Mediterranean region (UK)

**12:15-12:30 Liora Shaltiel-Harpaz** IPM of *Tuta absoluta* in Israel

**12:30-12:45 Brahim Chermiti** Conception of an IPM programme to control *Tuta absoluta* in industrial tomato crops in Tunisia

**12:45-13:00 Rachid Elaini** Les aspects pratiques de la lutte contre *Tuta absoluta* dans la région du Souss, Maroc

**13:00-14:00 LUNCH**

## **3- SESSION 5B: CONTROL STRATEGIES: INTEGRATED PEST MANAGEMENT**

**CHAIR: K. ALROUECHDI (FAO)**

**CO-CHAIR: S. RADONJIC (Montenegro)**

**14:00-14:30 Rob Jacobson** *Tuta absoluta*: A season-long IPM strategy based on predatory bugs (UK)

**14:30-14:45 Mario Balzan** Biological and chemical pest management strategies for the control of *Tuta absoluta* and their effectiveness (Italy)

**14:45-15:00 Neil Morrison** Investigating the potential of genetic control as part of an IPM approach for *Tuta absoluta* (UK)

**15:00-15:30 Cristina Castañé** Integrated control of *Tuta absoluta* in the Mediterranean area, what can we learn for future pest invasions? (Spain)

**15:30-16:15 Poster presentations**

**AUTHORS SHOULD BE IN FRONT OF THEIR POSTERS FOR DISCUSSION  
WITH PARTICIPANTS**

**16:15-16:45 COFFEE BREAK AND POSTERS**

**4- SESSION 6: ROUND TABLE - CONCLUSIONS AND  
RECOMMENDATIONS OF THE WORKSHOP**

**CHAIR: M. BESRI (Morocco)**

**CO-CHAIR: C. CASTAÑÉ (Spain)**

**16:45-18:00** Panel: invited speakers of the sessions dedicated to **Control Strategies**:  
Raul Guedes, Khaled Alrouechdi, Emmanouil Roditakis, Rosa Gabarra,  
Cristina Castañé, Rob Jacobson, Shakir Al-Zaidi

18:00-19:00 Meeting of the Local Organizing Committee

**20:00 Official Dinner**

**C- Friday 18<sup>th</sup> November – Technical Visit**

**Technical visit: A. MAZIH, L. ABAHA, Y. CHARHABAILI**

08:00: Departure from the hotel

09:00: Vegetables nursery: JANA ESSALAM

11:00: IPM in vegetables protected cultivation: Visit of vegetables plastic houses and of the  
Chtouka experimental station

12:00: Biological control: SAOAS insects production unit

13:00 : Lunch

16:00: Packing house: Station SOPROFEL

18:30: Departure to Agadir

19:30: Arrival to the hotel

**D- Saturday 19th November: Departure**

**For the transportation from the hotel to the airport, please register at the secretariat  
(registration desk). Cost per person: 50 DH.**

## LIST OF POSTERS

COUNTRY	AUTHORS	TITLE
ALGERIA	Badaoui Mahdjouba Ikram Berkani Abdallah	The entomopathogenic fungus <i>Beauveria</i> sp. , A promising way to fight against <i>Tuta absoluta</i> Meyrick in Algeria
	Farida Saiah Hamada Menad Naouel Kolai Abdallah Berkani Mahjouba Badaoui	<i>Tuta absoluta</i> Meyrick (Lepidoptera: Gelechiidae): Infestation and parasitism Levels on Tomato under greenhouse conditions in Mostaganem (Western Algeria).
	Salah Oukil Mériem Boukassem Sarah Benabdellah	Etude de l'entomofaune de deux variétés de tomate. Fluctuation temporelle des vols de <i>Tuta absoluta</i> (Lepidoptera: Gelechiidae) dans la Mitidja orientale en zone littorale (wilaya de Boumerdes).
	Mouhouche Fazia Ziri Sihem	Approche de lutte contre <i>Tuta absoluta</i> sur culture de tomate dans le sahel algérois.
	Khadidja Mahdi Bahia Doumandji- Mitiche Lounes Saharaoui Salaheddine Doumandji	Study of the insects associated with the tomato borer <i>Tuta absoluta</i> in Heuraoua (Algeria) [Etude de l'entomofaune associée à la mineuse de la tomate <i>Tuta absoluta</i> à Heuraoua (Algérie)]
	Khadidja Mahdi Bahia Doumandji- Mitiche Lounes Saharaoui Salaheddine Doumandji	Comparaison entre les captures de mâles de <i>Tuta absoluta</i> par les pièges à phéromones type delta et bassines à eau en zone littorale à Heuraoua.
	Abdelhamid Gacemi Yamina Guenaoui	Efficacy of emamectin benzoate on <i>Tuta absoluta</i> Meyrick (Lepidoptera: Gelechiidae) infesting a protected tomato crop [Test d'efficacité d'un bio-insecticide emamectine benzoate contre <i>Tuta absoluta</i> en serre de tomate]
	Bahia Doumandji- Mitiche Chennouf Rekia Doumandji Salaheddine	Trapping of <i>Tuta absoluta</i> Meyrick 1917 (Lepidoptera: Gelechiidae) by three types of pheromone traps and damage assessment in Ouargla (Algerian Sahara) [Captures de <i>Tuta absoluta</i> Meyrick 1917 (Lepidoptera: Gelechiidae) par trois types de pièges à phéromone et estimation des dégâts à Ouargla (Sahara Algérien)]
	Malika Boualem Rahma Hamadi Houcine Alaadine Allaoui	Study of parasitic complex of <i>Tuta absoluta</i> in Mostaganem area.
	Dahliz Abderrahmène Lakhdari Wassima	Essai de lutte biologique contre <i>Tuta absoluta</i> Meyrick (Lepidoptera: Gelechiidae) par l'utilisation de champignons entomopathogènes.
	Zaid Redouane Aroun Mohamed El Fodhil Moumene Khaled	Inventaire des ennemis naturels de <i>Tuta absoluta</i> (Meyrick, 1917) ( <i>Lep: Gelechiidae</i> ) et effet de son parasitoïde <i>Diglyphus isaea</i> ( <i>Hym: Eulophidae</i> ) sur deux variétés de tomate dans les régions de Staouéli et Chéraga
	R. Bensaad Y. Guenaoui	Comparative predation by three predators bugs (Heteroptera: Miridae) on <i>Tuta absoluta</i> Meyrick (Lepidoptera: Gelechiidae) on tomato. [Comparaison de la capacité prédatrice de trois espèces de punaises mirides autochtones vis-à-vis des différents stades de <i>Tuta absoluta</i> Meyrick (Lepidoptera: Gelechiidae) en conditions contrôlées]
	H. Amrouni	Gestion du problème de mineuse de la tomate en Algérie par l'utilisation de piégeage massif.

COUNTRY	AUTHORS	TITLE
	A. Ababsia K. Moumene	Approche de lutte biologique contre <i>Tuta absoluta</i> en Algérie.
	Naouel Kolai Abdallah Cherifa Abdallah Berkani Farida Saiah Mahjouba Badaoui	Observations on the biology of <i>Necremnus</i> sp., new parasitoids of <i>Tuta absoluta</i> in Mostaganem (Algeria).
ARGENTINA	E. Lobos G. Rabinowicz P. Guivisdalsky	Triple T®: Technology for the ethological control of <i>Tuta absoluta</i> Meyrick in tomato crops in Argentina.
BRAZIL	H. V. V. Tomé E. M. G. Cordeiro J. F. Rosado T. M. C. Della Lucia R. N. C. Guedes	Egg exposure to pyriproxyfen in the tomato borer <i>Tuta absoluta</i> : ovicidal activity or behavioural-modulated hatching mortality?
	M. C. Picanço L. Bacci R. B. Queiroz G.A. Silva M. M. M. Miranda G. L. D. Leite F. A. Suinaga N. M. P. Guedes	Social Wasp Predators of <i>Tuta absoluta</i> .
EGYPT	Samy Hussein Mohamed	Use of some eco-biological aspects and statistical analyses in determining the number of generations of <i>Tuta absoluta</i> Povolny on tomato in upper Egypt.
	H.K.M Bekheit A. Impiglia	Tomato borer, <i>Tuta absoluta</i> invasion Egypt.
FRANCE	Yaninne Trottin-Caudal V. Baffert, J.M. Leyre	Experimental studies on <i>Tuta absoluta</i> (Meyrick) in protected tomato crops in France: biological control and integrated crop protection
	Julien Séguret P. Maignet G. Ridray	Efficacité de l'association de deux auxiliaires pour lutter contre <i>Tuta absoluta</i> (Meyrick, 1917) (Lepidoptera : Gelechiidae) sous serres de tomates dans le sud de la France [Efficacy of the combination of two beneficials to control <i>Tuta absoluta</i> (Meyrick, 1917) (Lepidoptera: Gelechiidae) in tomato greenhouses in southern France]
	Anaïs Chailleux Nicolas Desneux Elisabeth Tabone	Potential of European <i>Trichogramma</i> species for biological control of <i>Tuta absoluta</i> in Europe.
	Jean-Marie Ramel Anne-Isabelle Lacordaire Gérard Delvare	<i>Necremnus artynes</i> (Walker, 1839) (Eulophidae), a potential beneficial for the biological control of <i>Tuta absoluta</i> (Meyrick). <i>Necremnus artynes</i> (Walker, 1839) un auxiliaire potential dans la protection biologique contre <i>Tuta absoluta</i> (Meyrick).
GERMANY(	M. Elsharif, M. Haas, S. Lamprecht	Belt® (Flubendiamide), a new tool for effective control of the tomato leaf borer, <i>Tuta absoluta</i>
HUNGARY	Kitti Sipos Béla Péntzes	Daily activity of <i>Tuta absoluta</i> based on automatic sex pheromone trap catches
INDIA	Reddy Sirigireddy Markandeya Gorantla P.R.K. Reddy	A Novel Process for Industrial Production of >98% pure E3,Z8,Z11-14:AC Major Isomer for Effective Mass Trapping of <i>Tuta Absoluta</i> .

COUNTRY	AUTHORS	TITLE
IRAN	Shahram Farrokhi Khosro Zerehgar Hossein Heidari Rasoul Marzban	<i>Tuta absoluta</i> (Lep., Gelechiidae): A serious threat to tomato farming in Iran.
IRAQ	Mohammed A. Ali Alasady Hamid A. Hadwan Rayadh K. Hassan	The optimization of pheromone traps for monitoring and mass attraction of tomato borer <i>Tuta absoluta</i> in greenhouses in Iraq
ITALY	M. Gabriela Luna Norma E. Sánchez Patricia C. Pereyra Eliana Nieves Vivina Savino Stefano Speranza	Biological control of <i>Tuta absoluta</i> in Argentina and in Italy: evaluation of indigenous insects as natural enemies.
	Luciana Tavella Barbara L. Ingegno Chiara Ferracini Paolo Navone Marco Mosti Alberto Alma	Biological control of <i>Tuta absoluta</i> (Meyrick) by native natural enemies in Italy.
	Francesco Savino Andrea Iodice Vittorio Veronelli Fumiaki Mochizuki	IsoLure and IsoTrap a step ahead in the monitoring of <i>Tuta absoluta</i> (Meyrick).
	Antonio Biondi Lucia Zappalà John D. Stark Nicolas Desneux	Potential demographic effects of various bioinsecticides on <i>Bracon nigricans</i> (Hymenoptera: Braconidae) a new parasitoid of <i>Tuta absoluta</i> (Lepidoptera: Gelechiidae)
	Mauro Nannini Fabrizio Atzori Giovanni Murgia Riccardo Pesci Francesco Sanna	Use of predatory mirids for the control of the tomato borer <i>Tuta absoluta</i> (Meyrick) in Sardinian greenhouse tomatoes.
JORDAN	Ashraf Alhawamdeh Marwan Abed el-Wali Jaddou	The impact of Farmer Field School based integrated pest management in controlling <i>Tuta absoluta</i> , a case from Jordan.
MAURITANIA	Sow Moussa Mamadou	Sensibilisation des producteurs de Tomate sur <i>Tuta absoluta</i> 'Attention à la mineuse de la tomate' (TCP/FAO/3104).
	Sow Moussa Mamadou	Utilisation des graines de neem comme insecticide naturel contre quelques ravageurs importants des cultures maraîchères
MONTENEGRO	Snježana Hrnčić <u>Sanja Radonjić</u>	Tomato leaf borer, <i>Tuta absoluta</i> Meyrick (Lepidoptera: Gelechiidae), the current status in Montenegro
MOROCCO	Abdelaziz Nilahyane Abderrahim Hormatallah Nezha Ait Taadaouit Rachid Bouharroud	Larvicidal effect of ethanol extracts of seven Moroccan plants on <i>Tuta absoluta</i> Meyrick (Lepidoptera: Gelechiidae).
	Nezha Ait Taadaouit Mohammed Hsaine Abderrahim Rochdi Abdelaziz Nilahyane Rachid Bouharroud	Effect of methanolic extracts of plant on <i>Tuta absoluta</i> (Lepidoptera: Gelechiidae).
	El Hajja Ben Cheikh Meriem Mouftakir El Mostafa Laftah	Lutte intégrée contre <i>Tuta absoluta</i> .

COUNTRY	AUTHORS	TITLE
	Rachid Bouharroud Saadia Lhaloui Fatima Gaboun Abderrahman Ait Lhaj	The costs of the control of <i>Tuta absoluta</i> (Lepidoptera: Gelechiidae) in the Souss valley of Morocco.
QATAR	Emad Hussain Al-Turaihi	Current Status and Future Outlook of Tomato Borer ( <i>Tuta absoluta</i> ) in the State of Qatar
SAUDI ARABIA	Abdul Aziz Sharidi Fahad B. Mohamed Al Saqan; Saud Hajraf Al saadi ; Faisal Nazzal ; Awaji Abul Algith; Naif M. Al Behairi; Ahmed M. Khawaji; Yahia Msheikhi; Hussein Msheikhi; Amar Sihat and Abdelhaq Hanafi	Status of <i>Tuta absoluta</i> in the Kingdom of Saudi Arabia: Efforts of the Ministry of Agriculture in the management of this invasive species
SPAIN	Martín Eitan Enrique Iñigo Carlos Solans David Bernad	Retenol® improves efficacy of control treatments of <i>Tuta absoluta</i> .
SUDAN	Ensaf S.I. Mohamed Khalid Siam	Effect of pheromone traps on mass trapping of tomato borer <i>Tuta absoluta</i> (Lepidoptera: Gelechiidae) in Sudan.
TUNISIA	Dhouibi Mohamed Habib Titouhi Faten Smaan Meriem	Bioassays with two trap models and different sex pheromone capsules of the tomato borer <i>Tuta absoluta</i> Povolny 1994.
	Dhouibi Mohamed Habib Titouhi Faten	Integrated Pest Management against the tomato borer <i>Tuta absoluta</i> Povolny 1994.
	Faten Hamdi	"Updated review of morphological characteristics and new molecular data for an accurate identification of <i>Macrolophus</i> species (Hemiptera: Miridae)".
	Abir Hafsi Khaled Abbes Brahim Chermiti Adel Jemmazi Nasraoui Bouzid	Reaction of the tomato borer <i>Tuta absoluta</i> (Lepidoptera: Gelechiidae) to some bio-insecticides in semi-natural conditions [Réaction de la mineuse de la tomate <i>Tuta absoluta</i> (Lepidoptera: Gelechiidae) à quelques bio-insecticides en conditions semi-naturelles]
	Mohamed Braham Lobna Hajji	Management of the tomato borer, <i>Tuta absoluta</i> with novel insecticides and plant extracts.
	Ahlem Harbi Brahim Chermiti	Evaluation des éléments de base pour la protection de la tomate contre <i>Tuta absoluta</i> (Povolny) sous abri serre en Tunisie [Evaluation of the basic components for the protection of tomato crops against the tomato borer <i>Tuta absoluta</i> (Povolny) under greenhouses in Tunis]
	Khaled Abbes Ahlem Harbi Brahim Chermiti	Comparative study of two protection strategies against <i>Tuta absoluta</i> (Povolny) in late open field tomato crops. [Etude comparative de deux stratégies de protection contre <i>Tuta absoluta</i> (Povolny) sur culture de tomate d'arrière-saison en Tunisie]
TURKEY	Fatih Dağlı Cengiz İkten Elvan Sert Esra Bölücek	Efficacy of 7 different insecticides on a population of <i>Tuta absoluta</i> from Turkey in laboratory bioassays

COUNTRY	AUTHORS	TITLE
	Tülin Kiliç	Current status of tomato borer ( <i>Tuta absoluta</i> (Meyrick) (Lepidoptera: Gelechiidae) in Turkey
UNITED KINGDOM	Madeleine Berger Khalid Haddi Lin Field Martin Williamson Kevin Gorman Chris Bass	Investigating the molecular mechanisms of insecticide resistance in the tomato borer, <i>Tuta absoluta</i> .

## II- ABSTRACTS of ORAL PRESENTATIONS

### A- SESSION 1: DISTRIBUTION, BIO-ECOLOGY AND DAMAGE OF *TUTA ABSOLUTA*

#### **Biology, distribution and damage of *Tuta absoluta*, an exotic invasive pest from South America. Giovanna Tropea Garzia, Gaetano Siscaro, Antonio Biondi and Lucia Zappalà**

*Department of Agri-food and Environmental Systems Management, Agricultural Entomology Section, University of Catania, Via Santa Sofia 100, 95123 Catania, Italy*

*Tuta absoluta* (Meyrick) is an invasive pest of tomato native to South America, where it is responsible for extensive damage. In Europe it was first detected in Spain in 2006 and afterwards it rapidly spread into several countries becoming a key pest due to its behaviour and ecology, to the absence of co-evolved biocontrol agents and to the limited knowledge of its control.

The moth is currently present in Portugal (including Azores), Spain (including Canary Islands), France, Switzerland, Italy, UK, the Netherlands, Germany, Lithuania, Bulgaria, South West Russia, Hungary, Kosovo, Albania, Greece, Cyprus, Turkey, Iraq, Lebanon, Israel, Jordan, the Gaza strip, Morocco, Algeria, Tunisia, Saudi Arabia and Libya. The extraordinary spread of the species can be attributed partly to its dispersal capacity but mainly to the intensive international tomato commercialization. The moth can also feed on other solanaceous species, both cultivated (such as potatoes, eggplant and sweet pepper), and wild (species of the genera *Solanum*, *Datura*, *Nicotiana* and *Lycium*) as well as on some non-solanaceous plants. This capability to use alternative plants as secondary hosts allows the continuous presence of this pest in many habitats, in the absence of tomato crops.

The knowledge of the main biological traits of the pest is the basis on which to develop effective plant protection management strategies. *T. absoluta* is a multivoltine species with an homodynamous behaviour and the length of its life-cycle depends on environmental conditions, particularly temperature. The larvae feed and develop inside tomato leaves, stems and fruits throughout the entire growing cycle. Mature larvae pupate in sheltered sites usually in the soil making control more difficult. The adults have nocturnal habits and in Mediterranean conditions they can be easily detected throughout the year.

Damage is directly related to the reduction of the photosynthetic capacity and of the production levels, both in protected and open-field tomato crops; in addition, economic loss derives from the unmarketability of the infested fruits whose presence makes post-harvest processes (packing, storage and shipment) more expensive. Indirect damage can be also caused by secondary infections of pathogens developing on the infested plant and fruit tissues. Finally, the persistence of the pest inside tomato fruit together with its resistance to low temperatures can strongly interfere with exportation flows to the countries where *T. absoluta* is still not present; this capacity strongly fosters its invasive behaviour.



**Spatiotemporal distribution of *Tuta absoluta* Mey. (Lepidoptera: Gelechiidae) in tomato greenhouses on the coast of Algiers : Hassina Benmessaoud-Boukhalfa et Nora Khellaf**

*Département de zoologie agricole et forestière, Ecole Nationale Supérieure Agronomique (ex INA), Hassen Badi 16200 Alger- Algérie*

In order to develop integrated management against *Tuta absoluta*, a study of the spatiotemporal distribution was conducted on a greenhouse tomato crop of the variety "Agora" on the coast of Algiers. The temporal evolution of imaginal populations revealed the presence of four overlapping generations over a period of six months and an average life cycle of 32 days. The average densities of populations were evaluated: 11.5 eggs, 10.8 for the first stage, 9.4 for the second stage larvae, 7.5 for the third stage and 6.7 for the fourth stage larvae per leaf of tomato estimated.

**Population development of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in UK glasshouses: Andrew G. S. Cuthbertson<sup>1</sup>, James J. Mathers<sup>1</sup>, Lisa F. Blackburn<sup>1</sup>, Anastasia Korycinska<sup>1</sup>, Michelle E. Powell<sup>1</sup>, Weiqi Luo<sup>1</sup>, Rob J. Jacobson<sup>2</sup>, Phil Northing<sup>1</sup> and Raymond J. C. Cannon<sup>1</sup>**

<sup>1</sup> *The Food and Environment Research Agency, Sand Hutton York YO41 1LZ, UK*

<sup>2</sup> *Rob Jacobson Consultancy Ltd, 5 Milnthorpe Garth, Bramham, LS23 6TH, UK*

The tomato borer *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) is a major pest of tomato plants in South America. Since 2006 it has been detected in several European countries where much damage to crops has been reported. It was first recorded in the UK in 2009 where it was subjected to a policy of eradication. In the current work the population development of *T. absoluta* was determined under various UK glasshouse temperatures. The optimum temperature for *Tuta* development ranged from 19 - 23°C. At 19°C, there was 52% survival of *T. absoluta* from egg to adult. As temperature increased (23°C and above) development time of the moth would appear to decrease. Population development ceases between 7 and 10°C. Only 17% of eggs hatched at 10°C but no larvae developed through to adult moths. No eggs hatched when maintained at 7°C. Under laboratory conditions the total lifespan of the moth was longest (72 days) at 13°C and shortest (35 days) at both 23 and 25°C. Development from egg to adult took 58 days at 13°C; 37 days at 19°C and 23 days at 25°C. High mortality of larval stages occurred at all temperatures tested. Under laboratory conditions, first instar larvae were exposed on the leaf surface for approximately 82 minutes before fully tunneling into the leaf. Adult longevity was longest at 10°C with adult moths living for 40 days (when supplied with a food source) and shortest at 19°C where they survived for 16 days. In general, more males than females were produced.

***Tuta absoluta* in South America: pest status, management & insecticide resistance : Raul Narciso C. Guedes & Marcelo C. Picanço**

*Department of Entomology, Federal University of Viçosa, Viçosa, MG 36570-000, Brazil*

**1. Spread of an emerging concern**

If the taxonomic status is any indication of management problems ahead, the tomato borer *Tuta absoluta* and its pest status are very worthy of attention. It was initially described within the genus *Gnorimoschema*, which has been subsequently reviewed and changed to *Scrobipalpula*, *Scrobipalpuloides* and finally *Tuta* (Povolny, 1994). This sequential genus revision which started in the mid-1960`s, took place well after the first recorded report of its occurrence in 1917 in Huancayo, Peru. However, the recognition of its potential problem as a tomato insect pest only started in the 1960`s in Peru, Chile, Colombia and Argentina, and later in the 1970`s in Bolivia, Paraguay and Uruguay (Michereff-Filho & Vilela, 2000). The tomato borer *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) was initially recorded in Brazil only between 1979 and 1980 in the seaside area of the southern state of Paraná, quickly spreading throughout the country during the 1980`s. Curiously, borer greenhouse infestations in Brazil took place only in the mid-1990`s (Michereff-Filho & Vilela, 2000). An immediate consequence of the introduction of *T. absoluta* is illustrated by the sudden increase in insecticide use in Brazilian tomato fields, going from 10-12 applications per cultivation period to over 30, requiring between four and six weekly insecticide applications. Besides the environmental and human safety concerns of such procedures, the tomato production costs more than tripled with the introduction of *T. absoluta* and the pattern of insecticide use required for its control. Crop life analysis carried out in the 1990`s still emphasized the relevance of direct fruit losses in compromising tomato production and the prevalent role of *T. absoluta* as one of the critical factors of fruit loss (Picanço *et al.*, 1998). Even worse – early infestation of *T. absoluta* in tomato fields compromises shoot development, reduces photosynthesis potential and allows the establishment of heavy infestations that will subsequently damage the fruit leading to heavy losses and greatly reducing the efficacy of insecticide spraying against this insect pest species (Guedes *et al.*, 1994; Picanço *et al.*, 2007).

## 2. Management of *Tuta absoluta*

Following up the initial increase in insecticide use against *T. absoluta*, the potential of alternative control methods has been intensively explored. A change in the trellised tomato cultivation system, emphasizing the upright conduction of the tomato plants with pruning over the fourth branch and a smaller plant spacing (0.25 x 1.0 spacing instead of the traditional 0.5 x 1.0 spacing) was suggested earlier because it favoured insecticide coverage of the plant canopy, increasing the control efficacy of *T. absoluta* (Guedes *et al.*, 1994). However, such a recommendation was adopted on a minor scale and other management tactics received more attention, including the development of resistant tomato varieties, the use of pheromone and biological control. The development of resistant tomato varieties has been pursued intensively since the early 1990`s, particularly in Brazil. Sources of *T. absoluta* resistance were readily identified and the leaf density of glandular trichomes was the initial focus of attention (Leite *et al.*, 2001). However, the incorporation of this trait into commercial varieties proved difficult and conflicted with yield parameters, leading to the search for other resistance traits. The current focus of attention is tomato allelochemicals, particularly acylsugars (Maluf *et al.*, 2010), but tomato varieties resistant to the borer *T. absoluta* remain a work in progress. The sex pheromone of *T. absoluta* was identified in the late 1990`s and pheromone blends were subsequently tested aiming their use for field monitoring (Ferrara *et al.*, 2001). However, subsequent trapping studies for decision-making regarding *T. absoluta* control were somewhat limited in scope, thus allowing for lower precision and requiring intensive (and prohibitive) trapping efforts. Therefore, further studies improving on preliminary ones are still necessary to allow for proper sampling and decision-making using pheromone traps of *T. absoluta*. Initial studies of mating disruption of *T. absoluta* did not provide promising results with negligible field reduction of this species population (Michereff *et al.*, 2000). Pheromone traps of the tomato borer are currently available in Brazil from two companies, BIOCONTROLE (Bio Tuta; Indaiatuba, SP) and Isca Tecnologias (ISCALure TUTA; Ijuí, RS).

Biological control has also received attention as a potential tool against *T. absoluta*, particularly in Brazil. The initial focus of attention was predatory stinkbugs (*Podisus nigrispinus* and related species) and subsequently egg parasitoids (*Trichogramma* spp.), in addition to *Bacillus thuringiensis*. The use of predatory stinkbugs was limited to experimental use due to their low density of occurrence in tomato fields, dubious efficacy and higher cost for practical use, added by field parasitism of the

predator and the negative impact on insecticides in the predator population. The use of the egg parasitoid *Trichogramma pretiosum* met with more promising results, particularly in industrial tomato fields with support of the Brazilian Agricultural Research Corporation in the northeast (Anonymous, 1994). Such systems have subsequently been expanded to fields of staked tomato (for *in natura* consumption) and even for greenhouse production aided by the recommendation of *Bacillus thuringiensis* use. However, the still intensive use of insecticide in tomato fields, controversial efficacy of *T. pretiosum* and also some controversial results with *B. thuringiensis* limit the potential usefulness of this recommendation. In addition, life table studies of *T. absoluta* indicate its early larval instars as its critical stages for population regulation, suggesting the potential use of larva parasitoids for its control as a potentially better alternative (Miranda *et al.*, 1998).

### **3. Insecticide resistance and resistance management of *Tuta absoluta***

Despite the intense search for alternative control methods against *T. absoluta*, the conventional approach of insecticide use remains the main tactic employed against this pest species. However, insecticide applications did not always prove as efficient as expected for controlling *T. absoluta*. Insecticide efficacy is usually compromised when the insect population is already well established prior to the tomato reproductive stage (Guedes *et al.*, 1994; Picanço *et al.*, 1995). In addition, intensive insecticide use (and overuse) favours the evolution of insecticide resistance and consequent insecticide control failure (Siqueira *et al.*, 2000; Silva *et al.*, 2011). Few compounds were used earlier against *T. absoluta* in Brazil, but alleged loss of control efficacy and detection of insecticide resistance in populations of this species favoured the registration of a variety of compounds against it. The organophosphate methamidophos, in addition to cartap, abamectin and the pyrethroid permethrin were the insecticides initially available in Brazil against *T. absoluta* until the 1990's (Siqueira *et al.*, 2000). However, reports of organophosphate and pyrethroid resistance from Chile, in addition to the detection of resistance to these four insecticides used initially in Brazil, were followed by an additional report of insecticide resistance in Argentinean populations of *T. absoluta* (Lietti *et al.*, 2005). This scenario and the need for alternative insecticides led to the registration and use of new compounds (Anonymous, 2011). The diversification of insecticide use against *T. absoluta* apparently led to changes in the prevailing patterns of insecticide resistance following the pattern of insecticide use. Intensive use of chitin synthesis inhibitors succeeded the use of abamectin, cartap and permethrin as the preferred insecticide group used against *T. absoluta* in Brazilian tomato fields. As consequence, resistance to chitin synthesis inhibitors reached high levels (> 100-fold) in some regions (Silva *et al.*, 2011). Moderate levels of resistance (up to 27.5-fold) were also observed for indoxacarb, as was low resistance to spinosad (Silva *et al.*, 2011). Local selection favoured by weather conditions and dispersal seems important for resistance evolution and should be considered in designing pest management programmes. In fact, variation for further selection for insecticide resistance does exist in Brazilian populations of *T. absoluta* leading to a high risk of insecticide resistance evolution (Suinaga *et al.*, 2004; Silva *et al.*, 2011). Such a risk seems higher during the dry season and only insecticides not exhibiting control failures should be used in such conditions. In addition, higher diversity of insecticides (out of the cross- and multiple-resistance spectra) should be used in rotation to minimize the risk of evolution of insecticide resistance in populations of *T. absoluta*.

## **B- SESSION 2 A and 2B: CURRENT STATUS OF THE TOMATO BORER IN EPPO/NEPPO COUNTRIES**

### **IPM Strategy: Case of tomato borer *Tuta absoluta* in Algeria: Fatiha Benddine**

*Directorate of Plant Protection and Technical Controls - Ministry of Agriculture and Rural Development- Algiers-Algeria.*

The issues regarding the protection of the human health and the preservation of the environment over several years has resulted in a policy IPM to control pests in Algeria. Thus, the official phytosanitary services of the Ministry of agriculture and Rural Development have implemented IPM programs against *Tuta absoluta*, a new pest introduced in 2008, which has seriously compromised tomato production. The control program involves a set of methods based essentially on the bio-technological control. The results showed the effectiveness of the system set in place that enabled the reduction of populations of tomato borer to economically acceptable levels.

### **The status of *Tuta absoluta* in Egypt: Sobhy A. Temerak**

*Research Entomologist, Plant Protection Department, Faculty of Agriculture, Assiut University, Egypt*

The tomato borer, *Tuta absoluta* (Meyrick) (Gelechiidae: Lepidoptera) invaded Egypt in the nearest Governorate to Libya (Marsa Matruh) in 2009. By 2010 it had reached Giza, coming well established in all Governorates of Egypt and reaching the border and north part of Sudan on June 2011. Overlapping periods of planting tomato within the same year in addition to the climatic conditions, allow pest access to its preferred host, the tomato, all year round and favouring its rapid spread. In Egypt, tomato crops can be planted 4-5 times/ year. This paper presents a list of all tomato pests. The majority of farmers sprayed every 4-5 days/season with a minimum of 8 and maximum of 25 sprays. Insect growth regulator is always added in the tank mix with one POs or PYs or carbamates. Farmers use cheap generic products and/or smuggled ones that do not meet WHO/FAO equivalence and mostly have impurities that exceed the allowed limit. No single or mixed product can satisfy farmers and stop the spraying process. Farmers are in need of a clear management strategy. The following active substances are claimed to be effective against this pest and elongate the interval of spray to be every 7-10 days; spinosad, spinetoram, indoxacarb, thiacloprid, emamectin benzoate, chlorphenpyr, and pyridalyl in addition to the insect growth regulators (IGRS). IGRs applied were lufenuron, methoxyfenozide, chromofenozide and teflubenzuron.

### **The current status of *Tuta absoluta* in Greece and Cyprus: Emmanouil Roditakis<sup>1</sup> and Nicos Seraphides<sup>2</sup>**

<sup>1</sup> *National Agricultural Research Foundation, Plant Protection Institute of Heraklio, Laboratory of Entomology, Heraklio, Crete, Greece*

<sup>2</sup> *Agricultural Research Institute, Nicosia, Cyprus*

The tomato borer *Tuta absoluta* (Lepidoptera: Gelechiidae), was recently identified in Greece and Cyprus, as in most Mediterranean countries. In Greece, the first report of the pest was in July 2009 and in Cyprus, in November 2009. Based on the national survey reports, the pest soon became wide spread and today is considered an established pest in both countries.

Immediately after the identification of the pest, official pest management guidelines were issued, insecticides were officially registered in the national catalogues exclusively for *T. absoluta* control, and public awareness campaigns were organized. Despite these actions, management of the pest was extremely problematic in the first period after invasion. This is attributed to the ignorance of the growers and agronomists, the poor greenhouse structures, and the high pest pressure initially observed possibly due to the absence of adequate natural enemies in the new environment.

Today, management of the pest has been incorporated in IPM schemes and successful control has been achieved in most cases, both in Greece and Cyprus. In greenhouse crops, prevention of the infestation has proven a key component in efficient pest management (i.e. use of insect-proof exclusion nets on the opening, double doors, insect free plant material). In open field crops the importance of Heteropteran predators has also been highlighted, (Perdikis D. *pers. comm.*). Pheromone traps are used mainly for pest monitoring. Mass trapping of males and mating disruption has relatively limited adoption at this stage. Light traps also received little attention. Finally, numerous highly efficient insecticides are available on the market (Roditakis E., this symposium). The environmental profile of these insecticides is currently investigated (Sterk G., this symposium).

### **First report of *Tuta absoluta* in Iran and initial control strategies : Valiollah Baniamერი**

*Iranian Research Institute of Plant Protection (IRIPP), No.1, Tabnakst.Velenjak, Tehran – IRAN.*

In 2010, the tomato growing area in Iran covered about 140 000 ha, mostly located in the south of the country. The Iranian Plant Protection Organization and inspection service (IRIPP) prepared a monitoring program to detect *Tuta absoluta* in 2009 and 2010. A technical guideline was issued and distributed among PPO inspectors. In November 2010, some samples (collected by Javadi-emamzadeh, Uromiyeh PPO) on tomato from Uromiyeh in Azarbaijan province in North West of Iran were identified as *Tuta absoluta* by Alipana from IRIPP. Three months later in January 2011, pheromone traps provided by Koppert Biological Systems were placed in tomato growing areas in Borazjan, Busher province, to intercept and monitor this pest. *T. absoluta* was identified, based on adult morphology and on male genitalia from moths collected in 5 of these traps during January 2011. More pheromone traps installed to cover the entire tomato growing area. As of June 2011, the pest was identified in 20 different locations. This is the first report of *T. absoluta* in Iran. As, *T. absoluta* is a very serious pest of tomato, this is expected to have serious consequences on the next cycle of tomato production starting in autumn and winter in south of Iran. Thus, based on experiences in other countries an IPM program was developed.

### **Stratégie Nationale de lutte contre la mineuse de la tomate *Tuta absoluta* Meyrick (Lepidoptera : Gelichiidae) au Maroc : K. Ouardi, M. Chouibani, M.A. Rahel, M. El Akel**

*Office National de Sécurité Sanitaire des Produits Alimentaires*

Au Maroc, la mineuse de la tomate *Tuta absoluta* a été signalée pour la première fois en avril 2008 dans la région de Nador (Nord-Est du Maroc), puis s'est propagée rapidement dans toutes les régions de production de la tomate. Depuis son signalement, des efforts ont été déployés par la profession et les départements techniques du Ministère de l'Agriculture de la Pêche Maritime (MAPM) pour faire face à ce fléau. Au cours de la campagne 2008-2009, les niveaux d'infestation ont été très variables selon les régions et les types de productions. Rappelons qu'au Maroc, il existe trois types de production de la tomate (Primeurs, saison et tomate industrielle). Les dégâts les plus importants ont été observés en cultures de tomate de plein champ. Suite à cette situation, l'Office National de Sécurité Sanitaire des Produits Alimentaire (ONSA) a entrepris une série de réunions de concertation avec les différents

départements du MAPM et la profession concernée, pour mettre en place une stratégie nationale de lutte contre *Tuta absoluta*. Le plan d'action arrêté se base sur la surveillance, les approches techniques de lutte dans le cadre d'un programme de protection intégrée, la sensibilisation et l'encadrement des agriculteurs, et la production de supports d'information et de vulgarisation. Pour inciter les agriculteurs à adopter une approche de lutte intégrée contre ce ravageur, des subventions ont été mises en place par le MAPM, pour l'acquisition du filet insect proof et des capsules de phéromones à utiliser pour la capture de masse. Aussi, l'ONSSA a autorisé de nouvelles spécialités phytopharmaceutiques pour lutter contre *T. absoluta* en cultures de tomate et de pomme de terre. La mise en œuvre de cette stratégie a contribué au cours de la campagne 2009-2010 dans la maîtrise des dégâts de la mineuse de la tomate. Cette stratégie a fait l'objet d'une évaluation suite à laquelle un plan d'action 2010-2011 a été arrêté. Ce plan d'action s'opère sur les mêmes axes que celui de la campagne 2009-2010 tout en mettant l'accent sur la surveillance du ravageur en cultures de tomates de plein champ, le renforcement du programme de sensibilisation et d'encadrement des agriculteurs et le lancement d'un programme de suivi des résidus de produits phytosanitaires dans les tomates. Au cours de cette campagne, les attaques de la mineuse de la tomate sont toujours maîtrisées.

**The current incidence of tomato borer, *Tuta absoluta*, in the UK: Kevin Gorman<sup>1</sup>, Madeleine Berger<sup>1</sup>, Khalid Haddi<sup>2</sup>, Chris Bass<sup>1</sup>**

<sup>1</sup>Centre for Sustainable Pest and Disease Management, Rothamsted Research, Harpenden, AL5 2JQ, United Kingdom

<sup>2</sup>Dipartimento di Gestione dei Sistemi Agroalimentari e Ambientali - Sezione Entomologia Agraria - Catania - Italy

The UK tomato industry produces around 75 000 metric tonnes of fruit per year, employs approximately 2500 people, and generates a retail value of £175 million. However, this accounts for under 20% of UK tomato consumption and a further 400 000 metric tonnes are imported from a range of mainly European, North African and Middle Eastern countries. Since its establishment and subsequent spread across these regions from 2006, the tomato borer, *Tuta absoluta* Meyrick (*Lepidoptera: Gelechiidae*), has proved to be an intractable pest capable of causing up to 100% yield losses. The earliest report of a UK interception was in a tomato packing facility in March 2009, and in the following July an outbreak of *T. absoluta* established in a UK tomato crop for the first time. Between March 2009 and September 2011 there have been 12 interceptions and 24 outbreaks, and *T. absoluta* is presently considered as the greatest pest threat to UK tomato supplies for many years. Facilitating sustainable and potentially novel management strategies not only relies upon accurate monitoring of pest incidence, geographical distributions, and the efficacy of control tactics, but also on fundamental research relating to the ecology, population dynamics and underlying mechanisms of control failure.

## **C- SESSION 3: CONTROL STRATEGIES: CHEMICAL CONTROL AND MATING DISRUPTION**

### **General Introduction to the Insecticide Resistance Action Committee: Sybille Lamprecht & Ralf Nauen**

#### *IRAC International*

The discovery, development and registration of new insecticides is an increasingly costly and difficult process. Given that effective insecticide resistance management (IRM) depends on the availability of a broad range of insecticides with a variety of modes of action, it is essential to maintain both susceptibility to existing products and to protect new ones from the development of resistance. The Insecticide Resistance Action Committee (IRAC) was formed in 1984 and currently consists of 15 member companies and is a subgroup of CropLife International. IRAC is committed to ensuring the sustained effectiveness of the industry's products. The mission of IRAC is thus to facilitate communication and education on insecticide resistance and to promote the development of resistance management strategies in crop protection and non-agricultural insecticide uses to support sustainable agriculture, improved public health and enhanced professional product use. IRAC has a role in initiating key research and extension projects as well as seeking to improve the measurement and understanding of resistance development. In addition, IRAC International supports IRAC country groups to devise and promote effective local solutions to insecticide resistance problems. All of these initiatives are supported by the advice and guidance on IRAC's website [www.irac-online.org](http://www.irac-online.org).

IRAC maintains and promotes the global classification of modes of insecticide action, and using this information it is possible to construct appropriate IRM strategies using a range of available products. Depending on the insect, it is possible to use insecticides which act at alternative target sites or which are resisted in different ways, thus maintaining the efficacy of the various insecticidal components of a crop protection strategy. The overall aim of this effort is to keep all classes of insecticides and acaricides as viable control options and to protect the long-term viability of insecticide use. In addition, all the major insecticide manufacturers develop resistance management guidance and stewardship for their individual products and where several manufacturers produce compounds in a common mode of action class, it is becoming more common for these manufactures to collaborate to develop agreed, common IRM strategies that provide universal benefits to producers and users.

### **Determination of baseline toxicity of insecticides to *Tuta absoluta* : Emmanouil Roditakis**

*National Agricultural Research Foundation, Plant Protection Institute of Heraklio,  
Laboratory of Entomology, Heraklio, Crete, Greece*

Chemical insecticides are one of the main tools in the management of the tomato borer *Tuta absoluta* (Lepidoptera: Gelechiidae), particularly in greenhouse crops. Currently several insecticides have been officially registered for the control of the pest, however the toxicity of the active substances is unknown. Using a novel "IRAC approved bioassay method", the toxicity of the insecticides was determined on second instar larvae using commercial

formulations of the insecticides indoxacarb, clorantraniliprole, emamectin benzoate, spinosad, metaflumizone, flubendiamide, chlorpyrifos and cypermethrin. Mortality was estimated after 72h of exposure and results were subjected to probit analysis. The lethal concentrations LC<sub>50</sub> and LC<sub>95</sub> were determined. Homogenous responses were observed in most cases producing solid base line toxicity data for the tested insecticides. In the absence of a susceptible *T. absoluta* reference strain, the results were compared to the recommended application rates. The insecticides indoxacarb, clorantraniliprole, emamectin benzoate, spinosad and flubendiamide exhibited high larvicide activity (recommended rates over LC<sub>95</sub>). Chlorpyrifos and metaflumizone exhibited moderate activity (recommended rates under LC<sub>95</sub> but over LC<sub>50</sub>). Cypermethrin exhibited low toxicity levels (recommended rates under LC<sub>50</sub>). These toxicological studies determined the larvicide activity of the registered insecticides, however the overall performance of the products in the field could be affected by additional factors (ovicide or adulticide activity, toxicity to beneficials etc.), suggesting that further studies are required. Nevertheless our results highlighted the importance of the evaluation of plant protection products by independent research organisations, particularly for the control of novel invasive species with unknown responses to the available chemistries.

**Knockdown resistance (kdr and super kdr) mutations in the voltage-gated sodium channel of tomato borer, *Tuta absoluta*, associated with pyrethroid resistance: Khalid Haddi<sup>1</sup>, Madeleine Berger<sup>2</sup>, Pablo Bielza<sup>3</sup>, Carmelo Rapisarda<sup>1</sup>, Martin Williamson<sup>2</sup>, Chris Bass<sup>2</sup>, Kevin Gorman<sup>2</sup>.**

<sup>1</sup> *Dipartimento di Gestione dei Sistemi Agroalimentari e Ambientali, Sezione Entomologia Agraria, Catania, Italy*

<sup>2</sup> *Centre for Sustainable Pest and Disease Management, Rothamsted Research, Harpenden, AL5 2JQ, United Kingdom*

<sup>3</sup> *Departamento de Produccion Vegetal, Universidad Politecnica de Cartagena, Spain*

*Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) is a primary pest of tomato plants and is native to South America. Since the first documented European case in 2006, it has spread throughout the Mediterranean basin and North Africa. Larval stages cause direct feeding damage and reductions to both yield and fruit quality. Chemical insecticides have been the main control tools used against *T. absoluta*, but decreasing efficacy has been attributed to the development of insecticide resistance. During this study, leaf-dip bioassays were used to quantify responses of five field strains of *T. absoluta* to insecticides belonging to different chemical classes. The results showed significant variation in susceptibilities to pyrethroids. Pyrethroids are a major class of neurotoxic insecticides and acaricides used extensively over the last four decades. One important mechanism of resistance to pyrethroids, termed knockdown resistance (*kdr*), has been shown to arise through alterations (point mutations) in the *para*-type sodium channel protein leading to reduced sensitivity of the insect nervous system to these compounds. Cloning and sequencing of domains II, III, and IV of the *T. absoluta* sodium channel gene revealed the presence of several *kdr* mutations previously reported to confer reduced sensitivity in other arthropod species. Diagnostic tools that allow detection in individual larvae and adults were developed and used to screen field samples of diverse geographical origin and assess their distribution in global *T. absoluta* populations.



## **First results from South Europe for *Tuta absoluta* control using diflubenzuron with adjuvant and with/without *Bt kurstaki*: G. Chiot, N. Lanza and E. Casagrande**

*Chemtura AgroSolutions, Italy*

Considering the high number of generations developed by the tomato borer in tomato under protected cultivation and the risk of quickly decreasing efficacy of agrochemicals if not properly alternated, it is very important to carefully evaluate all the actives / combinations belonging to different chemical families and modes of action in order to have a long term sustainable control of the pest. Over the last two years trials have been conducted in Italy and Spain to evaluate the level of efficacy of diflubenzuron (dfb) (chitin inhibitor) for the control of *Tuta absoluta* (Meyrick) on greenhouse tomato. Different adjuvants and rates were tested during the first year in comparison with dfb used alone. In 2011 the combination with two different *Bacillus thuringiensis kurstaki* (*Btk*) was also tested compared to the most effective products already on the market. The results clearly show that the addition of an adjuvant significantly improves dfb performance. Furthermore, since on this pest dfb is presumably acting mainly as an ovicide, in case of overlapping of pest growth stages and/or very early and virulent attack, the combination with *Btk* is giving an important increase in *Tuta* control on both leaf and tomato fruit. Finally first observations were also made on the very positive interaction between dfb and *Btk* on another pest (*Heliothis armigera*) found on tomato in one of our trials on *Tuta*.

## **Influence of Thunder<sup>®</sup> treatments on *Tuta absoluta* development: Eitán Martín, Enrique Iñigo, Carlos Solans, David Bernad**

*DAYMSA (Desarrollo Agrícola y Minero, S.A.) Camino de Enmedio, 120 50013 Zaragoza Spain*

*Tuta absoluta* (Meyrick) is considered a key tomato pest. Both yield and fruit quality can be significantly reduced by the direct damage of *T. absoluta* and secondary pathogens that may enter through the wounds made by the insect. The influence of Thunder<sup>®</sup> on *T. absoluta* was studied. Thunder<sup>®</sup> is a product in Daymsa's phytoprotectants range, based on plant extracts and certified for its use on Organic Agriculture, according to EC Regulation n° 834/2007.

A field trial was conducted in a tomato greenhouse on "Daniela" cultivar, in Níjar (Almería, Spain). Two foliar applications were made at 7 days interval. Two dosages of Thunder<sup>®</sup> (3 and 5 cc/L) were evaluated, with a spray volume of 800 L/ha. The number of mines and affected foliar surface were assessed on T1+0, T1+7=T2+0, T2+7 and T2+14 days. The trial design was set up as a randomized block in 4 replicates per treatment. Each replicate was composed of 48 plants.

The trial results show Thunder<sup>®</sup> efficacy at the two dosages, significantly delaying the *T. absoluta* development, until the end of the evaluation, fourteen days after the second application. Treatments started at the beginning of infestation and the pest pressure at the end of trial was very high. In all assessment dates there were statistical differences between treated with Thunder<sup>®</sup> and control plants in foliar surface damaged and number of mined leaves. No phytotoxicity symptoms were observed. The trial confirmed the performance of Thunder<sup>®</sup> as an effective tool for control of the development of *T. absoluta* and an adequate complement to the use of plant protection products.

## **AA L&K : New alternative to control the population of *Tuta absoluta*: Mounir Hassani**

*Atlas Agro AG, Switzerland*

*Tuta absoluta* is considered a major tomato pest, and can generate losses of up to 80-100 % on this crop. In the past different method to control this pest has been used. The use of pheromones for monitoring and mass trapping and the insecticide are very important. Atlas Agro has developed a new method called AA L&K which combines two technologies in one: first the attraction of male insects by a pheromone, and then the elimination of the insect with a very low dose of an insecticide. The pheromone is released gradually to attract adult males that will approach the lure. The elimination of these males by the insecticide removes them from the reproductive cycle, reducing the insect population. This method can be a good alternative of the use of high dose of insecticide and high number of pheromone traps. The mode of action, advantages and results of trials will be shown and discussed.

## **Evaluation of the mating disruption method against the tomato borer, *Tuta absoluta* (Meyrick), in greenhouse tomato crops in Sardinia (Italy): Arturo Cocco, Salvatore Deliperi and Gavino Delrio**

*Department of Plant Protection, University of Sassari, via De Nicola 1, 07100 Sassari, Italy*

The tomato borer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), was first recorded in Sardinia (Italy) in late 2008, spreading rapidly to all tomato-growing areas. The control of this pest is complicated by its biotic potential and resistance to a number of insecticides. With the aim to control *T. absoluta* infestations using more environmentally friendly control methods, we tested the effectiveness of the mating disruption technique against the tomato borer. Trials were carried out in Southwestern Sardinia in 2010-2011 in plastic greenhouses equipped with insect-proof nets using twist-tie pheromone dispensers (70 mg of active substance) produced by ShinEtsu (Japan). Male captures, damage on leaves and proportion of infested fruits were compared among untreated greenhouses or those protected with 500 and 1000 synthetic sex pheromone dispensers/ha. All the parameters monitored were significantly lower in plots with 1000 dispensers/ha than in control greenhouses, showing the effectiveness of this control strategy. In the plots 1000 dispensers/ha, male catches were reduced by 96%, damage on leaves reduced by 77% and the percentage of infested fruits reduced by 81% compared with untreated greenhouses. Pheromone dispensers at the density of 500/ha were not effective in reducing the damage on tomato leaves and fruits. Our results show that the mating disruption method may represent an effective control tool to reduce tomato borer infestations.

## **Early studies on the control of tomato borer *Tuta absoluta* with mating disruption technique in Murcia region (Spain): Antonio Monserrat<sup>1</sup>; Manuel Andreu<sup>1</sup>; Encarna Martínez<sup>3</sup>; Mariano Marín<sup>3</sup>; Jose Luis Gonzalez<sup>3</sup>; Jose Miguel Martínez<sup>3</sup>; Raquel García<sup>3</sup>; Vicente Quinto<sup>3</sup>; Paolo Sambado<sup>2</sup>**

<sup>1</sup>*Consejería de Agricultura y Agua, Servicio de Sanidad Vegetal, Murcia, Spain*

<sup>2</sup>*CBC Iberia, Barcelona,* <sup>3</sup>*TRAGSA*

A series of experiments have been made to evaluate mating disruption technique in the management of *Tuta absoluta* in protected tomato plantations for fresh consumption. This work was carried out in commercial plantations, covering about 8 ha distributed in 12

glasshouses on 8 farms. It includes different dates, size of plots and types of structures. In all the trials, mating disruption was complemented with other pest management strategies to control *T. absoluta*, including physical isolation of the greenhouses, release of beneficials or insecticide treatments whenever necessary. Greenhouses applying current pest management strategy were used as control plots. The effectiveness of the mating disruption technique was evaluated by comparing the number of males caught in Delta traps baited with commercial pheromone lure and virgin females, by checking the evolution of the infestation and the crop damage, as well as by the number of treatments needed to maintain larvae population below economic injury level. Mating disruption technique with Shin-Etsu dispensers showed excellent results in pest control in all trials conducted, except for a small plot that was not well sealed with anti-insect nets. These excellent results were obtained both in plastic greenhouses and in mesh greenhouses. All ‘mating disruption plots’ achieved complete traps shutdown for several months, increase of population was delayed and additional insecticides applications were reduced to achieve good pest control. This technique proved to be easy to use and compatible with other pest management systems (release of beneficials, low impact insecticides) and could be a valuable tool in IPM for tomato for fresh consumption grown under structures offering physical protection.

#### **D- SESSION 4: CONTROL STRATEGIES: BIOLOGICAL CONTROL**

##### **Prospects for the biological control of *Tuta absoluta* in tomato crops of the Mediterranean basin: Rosa Gabarra<sup>1</sup>, Judit Arnó<sup>1</sup>, Alberto Urbaneja<sup>2</sup>**

<sup>1</sup>Entomology. IRTA. Ctra. de Cabrils km 2, 08348 Cabrils, Barcelona, Spain

<sup>2</sup>Unidad Asociada de Entomología IVIA-CIB CSIC, Centro de Protección Vegetal y Biotecnología, Instituto Valenciano de Investigaciones Agrarias (IVIA), Carretera Moncada-Náquera km 4,5. 46113 Moncada, Valencia, Spain

Since its detection in the Mediterranean basin and other European countries, the South American tomato borer, *Tuta absoluta* (Meyrick), has become a serious threat to tomato crops. In newly infested areas the pest was especially problematic the first year after the invasion. Nevertheless, after two to three years, the incidence of *T. absoluta* became less severe. There are several factors that could explain this reduction such as an increase in farmers’ and producers’ knowledge of pest behavior and biology and the correct application of integrated pest control strategies. Also, the impact of opportunistic native natural enemies is probably one of the key factors in this reduction. In the Mediterranean basin, several native natural enemies have been observed parasitizing or preying on *T. absoluta*: at least 11 species of parasitoids, belonging to the families Eulophidae, Braconidae, Ichneumonidae and Trichogrammatidae and 9 predatory species, belonging to the families Miridae, Anthocoridae, Nabidae, Vespidae and Phytoseiidae. Predators are currently the most widely used natural enemies in the Mediterranean basin. Also, *Bacillus thuringiensis*-based formulations have shown high efficacy in controlling *T. absoluta* in the field and have been successfully used in IPM-strategies. Herein we summarize the available information on Mediterranean indigenous natural enemies, we report the current pest management approaches used in this area against *T. absoluta* and we discuss future scenarios for biological control of the pest.

## **Success and extension of biological control strategies for managing *Tuta absoluta* (Meyrick)(Lep.: Gelechiidae) populations in the Mediterranean area: José E. Belda, Antonio Giménez and F. Javier Calvo**

*Koppert España S.L., Calle Cobre 22, 04745 La Mojonera, Almería, SPAIN*  
[jbelda@koppert.es](mailto:jbelda@koppert.es).

*Tuta absoluta* (Meyrick) (Lep.: Gelechiidae) has become a major pest in tomato crops in the Mediterranean area, both in greenhouses and open field. Moreover, the tobacco whitefly *Bemisia tabaci* (Genn.) (Hem: Aleyrodidae), a vector of TYLC, is also a key pest in tomato and it must be therefore well controlled. Several natural enemies have been shown to be potential biological control agents against these pests, but the mirid bug, *Nesidiocoris tenuis* Reuter (Hem.: Miridae) have been proven to be effective controlling *T. absoluta* and *B. tabaci* either alone or together. Traditionally, *N. tenuis* was released some weeks after transplanting and it took several weeks until the predator reached a sufficiently high population density to keep the pests under control. Therefore, plants were not well protected against the whitefly and *T. absoluta* during this period. Recently, a new approach for *N.tenuis*, which consists on the release of the predator adults on the crop before transplanting at the plant propagator facilities, has been implemented by Koppert Biological Systems in Spain in tomato crops. With this method the predator is present in sufficient numbers from the beginning of the cropping season and the crop is therefore protected from the pests attacks. This approach increases effectiveness against both *T. absoluta* and whitefly in respect to the current above-mentioned standard method and has permitted to increase adoption of biological control-based IPM in greenhouses grown tomato in Almeria from less than 20% to more than 50% of the total surface in only one year. This would likely have the same effect in other production areas in Spain and around the world including open field and processed tomatoes. In fact, this method is already being successfully implemented in other Mediterranean countries such as Morocco, Turkey and Italy. Nowadays, *Necremnus artynes* (Walker) (Hym: Eulophidae), an indigenous larval parasitoid of *T.absoluta* from the Mediterranean area is being evaluated as a supplementary biocontrol agent to *N. tenuis*.

### **Improvement of integrated management against *Tuta absoluta* by using new egg parasitoids: Hong Do Thi Khanh<sup>(1)</sup>, Marion Tiradon<sup>(1)</sup>, Etty Colombel<sup>(1)</sup>, Adrien Bonnet<sup>(1)</sup>, Anaïs Chailleux<sup>(2)</sup>, Nicolas Desneux<sup>(2)</sup>, Elisabeth Tabone<sup>(1)</sup>**

(1) INRA Centre PACA, Unité Expérimentale de Lutte Biologique (UELB), 400 route des CHAPPES, 06903 Sophia Antipolis, France. Tel. + 33 492 386 426 / 503. Fax. + 33 492 386 401

[tabone@sophia.inra.fr](mailto:tabone@sophia.inra.fr), [hong.do@sophia.inra.fr](mailto:hong.do@sophia.inra.fr)

(2) INRA Centre PACA, Unité de Recherches Intégrées en Horticulture (URIH), 400 route des CHAPPES, 06903 Sophia Antipolis, France.

The tomato borer, *Tuta absoluta*, is an invasive pest causing important loss on tomato production in many countries. Newly introduced in France on tomato crops (2008), the number of infested zones has quickly increased. Many alternative methods of protection exist in France and are used in IPM, mostly for biological control (predator: *Macrolophus*

*pygmaeus*, egg parasitoid: *Trichogramma achaeae*). However, while limiting the damage, they are quite expensive. So, it is important and urgent to find a new efficient biological solution which is less expensive and safe for the environment. With a funding from the French Ministry of Agriculture (CASDAR), we are looking for a new beneficial oophagous parasitoid. Initially oophagous parasitoids from our collection at INRA PACA were used to compare parasitoid performance against *T. absoluta*. Experiments were performed on tomato leaves at  $25 \pm 1^\circ\text{C}$ , RH  $75 \pm 5\%$  and 16L: 8hD in order to evaluate emergence rate, fecundity and longevity of parasitoid females. First results of *Trichogramma* strains efficiency in the lab will be presented and compared to *T. achaeae*. We hope to find a more efficient species, which can be stored at low temperature and which is adapted to the harsh conditions of tomato crops. The development of this new strategy will be integrated into the IPM method currently available on tomato crops. For this, coordinated actions mobilizing research organisations, development institutes, and private companies, were established.

**Adaptation of indigenous parasitoids to the invasive tomato pest *Tuta absoluta* in Italy: biology and behaviour of the braconid wasp *Bracon nigricans*: Lucia Zappalà<sup>1</sup>, Antonio Biondi<sup>1,2</sup>, Gaetano Siscaro<sup>1</sup>, Giovanna Tropea Garzia<sup>1</sup>, Kees van Achterberg<sup>3</sup>, Nicolas Desneux<sup>2</sup>**

<sup>1</sup>Department of Agri-food and Environmental Systems Management, University of Catania, Via S. Sofia 100 - 95123 Catania, Italy; lzappala@unict.it

<sup>2</sup>French National Institute for Agricultural Research (INRA), UR 880, 400 Route des Chappes, 06903 Sophia-Antipolis, France

<sup>3</sup>Netherlands Centre for Biodiversity Naturalis, Leiden The Netherlands

A survey of indigenous natural enemies attacking *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) was conducted since its first detection in Italy (late 2008), both by collecting *T. absoluta*-infested materials (cultivated and wild host plants) and by using sentinel tomato plants (pre-infested by *T. absoluta* in the laboratory) in various sites with diverse ecological features. Plants were exposed in the field for one week, and were observed in order to collect parasitized *T. absoluta* instars which were kept in the laboratory until adult emergence. Subsequently some parasitoid species were reared in order to study their biological and behavioural traits on *T. absoluta*. Fourteen hymenoptera species were recovered, among these the most common ones were an ichneumonid, two braconid species and three eulophids (Zappalà *et al.*, submitted). Three species were reproduced in the laboratory on *T. absoluta* as host. The braconid *Bracon nigricans* Szepligeti was successfully reared for more than fifty generations with no apparent adverse effects on the parasitoid biological performances. The subsequent works were focused on this species aiming to evaluate under laboratory conditions: potential host stage preference, daily fertility, development life tables, longevity and fertility at various host densities and diet regimes. The braconid proved to be a gregarious, idiobiont, arrhenotokous ectoparasitoid of *T. absoluta* mature larvae (4<sup>th</sup> instar preferred). The survival of the young instars is negatively correlated with the gregariousness rate. Adults fed with a sugar-protein artificial diet lived longer and produced more progeny than those provided only *T. absoluta* host larvae. The parasitoid progeny was correlated to host densities, and the parasitism rate was higher at lower host densities. Because females should mate multiple times to be able to produce female progeny through their life span, sex-ratio mostly depended of male longevity (i.e. availability of males). Both females and males were reproductively active soon after emergence. Parasitoid females showed intense stinging activity before effectively starting to lay eggs on hosts. During this pre-oviposition activity, parasitoid females inject fluids, presumably venom, for paralyzing hosts and also assessing

host suitability for offspring development (based on host size and/or host haemolymphatic kairomone recognition). Furthermore, host feeding behaviour was observed. The proportion of hosts that were permanently parasitized was stable in all the trials. Semi-field and field studies will be conducted in order to evaluate the efficacy of this braconid parasitoid as biological control agent of *T. absoluta* on tomato in Europe.

#### References

Zappalà *et al.*, 2011. Survey on indigenous parasitoids of the invasive exotic pest *Tuta absoluta* (Meyrick) in Southern Italy. Submitted.

### **Importance of native polyphagous predators able to prey on *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) on tomato crop: Y. Guenaoui, R. Bensaad and K. Ouezzani**

*Department of Agronomy, University of Mostaganem, Mostaganem, 27000, Algeria*

The tomato borer *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) became the major pest of the tomato crop in Algeria since 2008, causing heavy economic damage. Chemical control has been the main method of controlling it. The occurrence of possible resistant strains of this pest to used insecticides and many problems such as toxicity to workers, presence of toxic compounds on fruits, elimination of natural enemies, has encouraged integrated pest management to a large extent. Biological control is one of the main methods through the conservation of natural enemies. The knowledge of the potentially active natural enemies of *T. absoluta* in tomato crops is the first step of the implementation of integrated pest management to control it. The aim of this study is to search for indigenous predators to evaluate their potential role in the control of *T. absoluta*. Three species belonging to the Miridae family were found in association with *T. absoluta* near Mostaganem and identified as *Macrolophus caliginosus*, *Nesidiocoris tenuis* and *Dicyphus tamanii*. For the first time, experiments were conducted in the northwestern Algeria, to evaluate the suitability of *T. absoluta* as prey for the three native predators. Both species can prey on eggs and the four larval stages of the pest with a significant difference between species. First results, based on laboratory tests and field observations reporting the capacity of the three predatory mirids are useful to perfect knowledge on their mode of predation, prey capture and on their interactions with imported geographical strains released in some greenhouses tomato crops. The realistic advantages encouraging the use of native natural enemies are discussed.

### **Side-effects of lepidoptericides, used against *Tuta absoluta*, on different biological control agents and pollinators: Guido Sterk**

*IPM Impact. Gierkensstraat 21 3511 Hasselt Belgium*

Semi-field trials were conducted to determine the ovicidal and larvicidal activity of several old and new active substances on *Tuta absoluta*. At the same time, these plant protection products were tested for toxicity and residual activity on beneficial predators and parasitoids that are frequently introduced in tomatoes, e.g. *Macrolophus caliginosus*, *Nesidiocoris tenuis*, *Encarsia formosa*, *Eretmocerus eremicus*, *Diglyphus isaea* and *Phytoseiulus persimilis*. In addition the direct and indirect effects of these plant protection products on the important pollinator *Bombus terrestris* were tested under worst-case laboratory conditions, using different routes of application like topical treatment, feeding through pollen and drinking

through sugarwater. Several compounds turned out to be compatible with the use of these beneficial organisms.

## **E- SESSION 5 A: CONTROL STRATEGIES: INTEGRATED PEST MANAGEMENT (IPM)**

### **Efforts of the FAO on the management of the tomato borer *Tuta absoluta* in the Near East region: Khaled Alrouechdi<sup>1</sup> and Shoki Aldobai<sup>2</sup>**

<sup>1</sup>FAO-HQ, Italy, <sup>2</sup>FAO-RNE, Egypt

Within the framework of its regular and operational programmes and with the technical assistance of international consultants, the FAO has developed an efficient strategy of detection, surveillance and control of the tomato borer *Tuta absoluta* including the necessary phytosanitary measures. In the meantime, several sessions of awareness and extension for both technicians and farmers have been organized, in particular within the framework of the Farmer' Field Schools (FFS) approach. These activities were carried out in various countries, especially in North Africa, the Middle East and the Arab Gulf. A regional Technical Cooperation Programme (TCP) project document is being finalized, covering the management of *T. absoluta* in the Middle East countries. This project covers mainly:

1. national and regional training sessions on: biology, damage, surveillance and control of the pest (IPM strategy);
2. necessary phytosanitary measures on national and regional levels;
3. collaboration on national regional and international levels;
4. qualified international and national consultants as well as material for the planned activities;
5. participating countries: Egypt, Iran, Iraq, Jordan, Lebanon, Syria and Yemen.

### **History and current IPM strategies for the management of *Tuta absoluta* in the Mediterranean region: Shakir Al-Zaidi**

*Russell IPM Ltd, 68 Third Avenue, Deeside Industrial park, Flintshire, CH5 3RQ, UK.*

The arrival of the *Tuta absoluta* to the Mediterranean region in 2006 and its spread over the past five years have highlighted serious weaknesses in national and regional strategies to manage the spread of highly mobile pests. It also provided an opportunity to develop and adopt IPM management programs. The arrival of the pest in the Near East countries has opened a new chapter in the spread of this pest well into the heart of Asia, a new environment with varied climatic profiles, rich variations of host plants and diverse farming practices.

**IPM of *Tuta absoluta* in Israel: Liora Shaltiel Harpaz<sup>1,2</sup>, Shaul Graph<sup>1</sup>, Kedoshim Rika<sup>1</sup>, Lotem Azolay<sup>2</sup>, Tamir Rozenberg<sup>2</sup>, Nachash Yakov<sup>3</sup>, Tamar Alon<sup>4</sup>, Arnon Alush<sup>5</sup>, Shimon Stinberg<sup>5</sup> and Dan Gerling<sup>5</sup>**

<sup>1-</sup> Plant protection unit, Northern R&D, Migal, P.O.Box 831, Kiryat Shmona 11016, Israel.

<sup>2-</sup> Tel- Hai academic collage- Israel

<sup>3-</sup> Eden Research Station- Israel

<sup>4-</sup> Ministry of agriculture- Israel

<sup>5-</sup> BioBee.- Israel

<sup>6-</sup> Tel Aviv University- Israel

The moth *Tuta absoluta* Povolny is a key tomato pest originating from South America. In 2006 it was detected in Spain and has spread rapidly across the Mediterranean region, Europe and Asia. TA appeared in Israel in December 2009, and within months was present throughout the country. Since its initial discovery this pest has caused extensive damage to tomato crops in all the countries it invaded, despite frequent pesticide application. However, despite the high abundance of *T. absoluta* in Israel throughout the year, for the last 2 years, we have not observed significant damage in open-field processing tomatoes. Since the beginning of the *T. absoluta* invasion the Israel Ministry of Agriculture, along with researchers and extension service personnel, has instructed growers to minimize pesticide usage in order to enhance the activity of local natural enemies. The study included a survey of the natural enemies attacking *T. absoluta*, namely, identification, determination of relative abundances and evaluation of their efficacy in laboratory and field experiments. A wide range of natural enemies of *T. absoluta* were found in commercial fields, including predators and parasitic wasps. Most of the parasitoids were from the Braconidea family, and the Chalcidoidea super family. The total parasitism rate in the field reached 26%. The Mirid *Nesidiocoris tenuis* was the most abundant predator found in all the commercial fields monitored. Its density was 0.5-2.3 bugs/plant and was negatively correlated to pesticide use ( $R^2=0.72$ ). In an experimentally pesticide-free field the density of *N. tenuis* rose to an average of 18 bugs/plant and total control of *T. absoluta* was achieved. In laboratory experiments *N. tenuis* predation rate rose with *T. absoluta* density (type III functional response) and one female consumed  $220\pm 32$  eggs and larva per week. At this stage it seems that the local natural enemy fauna has adapted to *T. absoluta* and preserving natural enemies in an IPM regime can keep the pest population in Israel under the economic threshold for processing tomato fields.

**Conception of an integrated pest management program to control the tomato borer *Tuta absoluta* (Povolny) in industrial tomato crops in Tunisia : Brahim Chermi and Khaled Abbas**

*High Agronomic Institute of Chott-Mariem, University of Sousse, Tunisia.*

An experimental trial on integrated pest management against *Tuta absoluta* based on mass trapping with 30 traps/ha was conducted in 5 ha open field tomato crop. During this trial the efficiency of three brands of sex pheromone dispensers commercialized in Tunisia was tested with a split plot experimental plan. Mass trapping was combined with the evaluation of the biological efficiency of three treatment calendars with three widely used insecticides in the country; two of them are of biological origin while the third is well known to be safe for beneficials.



## **Les aspects pratiques de la lutte contre *Tuta absoluta* : Cas de la région du Souss (Maroc) : Rachid Elaini**

*IPM Department Manager, Omnium Agricole du Souss, Agadir, Maroc*

La région du Souss (Sud-Ouest du Maroc), considérée comme zone des primeurs par excellence, a connu une évolution très rapide des superficies conduites en lutte intégrée, surtout durant les cinq dernières années. Ainsi, ces superficies sont passées de 80 ha (60 ha de tomate et 20 ha de poivron) en 2005 à plus de 3700 ha en 2010. Depuis l'introduction de la mineuse de la tomate, *Tuta absoluta* Meyrick (Lepidoptera : Gelichiidae) au Maroc, plusieurs programmes ont été essayés pour contrôler ce ravageur. En plus de la lutte chimique, la lutte biologique par *Nesiodiocris tenuis* Reuter (Hemiptera : Miridae) est l'une des principales composantes de ces programmes. Aujourd'hui, après trois ans d'expérience de lutte contre *Tuta absoluta*, des résultats très satisfaisants sont concrétisés. En effet, ce ravageur n'est plus considéré comme le premier ravageur qui menace la culture de la tomate dans la région du Souss. Elle a cédé la place à la mouche blanche du tabac *Bemisia tabaci* Gennadius (Homoptera : Aleyrodidae), vecteur du virus responsable de la maladie des feuilles jaunes en cuillère de la tomate TYLCV (*Tomato Yellow Leaf Curl Virus*).

## **F- SESSION 5B: CONTROL STRATEGIES: INTEGRATED PEST MANAGEMENT**

### ***Tuta absoluta*: A season-long IPM strategy based on predatory bugs : Rob Jacobson**

*RJC Ltd, 5 Milnthorpe Garth, Bramham, West Yorkshire, LS23 6TH, UK.  
Web: [robjacobsonconsultancy.co.uk](http://robjacobsonconsultancy.co.uk)*

The development of this IPM strategy was commissioned by the British Tomato Growers' Association via the Horticultural Development Company specifically for organic tomato crops in the UK. However, the practical studies are being done in both organic and conventional tomato crops in the UK and in Portugal. The IPM programme is based on the predatory bugs *Macrolophus caliginosus* in the UK and *M. pygmaeus* and *Nesiodiocris tenuis* in Portugal. It is hoped that in the near future, these predators will be supplemented by the larval parasitoid, *Necremnus artynes*. The growing season in the UK is divided into four distinct periods. The first period is from planting in December until early-mid spring which is the key period for establishing *M. caliginosus*. The predators are released immediately after planting at rates varying from 0.5-2.0m<sup>2</sup>. However, they are slow to establish and usually do not produce useful populations for biocontrol for at least four months. Other methods are employed throughout this period to slow down *T. absoluta* population growth. These include exclusion, defoliation, sticky floor treatments and mass trapping with pheromone and/or UV light traps. Regular treatments with *Bacillus thuringiensis* may also make a contribution although the cost-benefit has been questioned. It is hoped that mating disruption will soon become an additional option for this period. The second period is from mid to late spring. Despite the measures taken during the first period to delay *T. absoluta* population growth, it seems inevitable that a second line of defence (SLoD) treatment will be required before the predatory bugs start to have a significant impact. The aim here is to apply a product that is quick to act and compatible with all the biocontrol agents being used in the greater IPM

programme. Chemical options for organic crops are currently limited to spinosad as a high volume spray but other IPM compatible products are becoming available for conventional crops. The entomopathogenic nematode, *Steinernema feltiae*, provides a useful alternative and this technique is being further refined to optimise efficacy. The third period is from early summer through to early autumn. The predatory bugs should now be numerous and should suppress the *T. absoluta* population growth by feeding on eggs and larvae. However, careful monitoring is required to determine whether it becomes necessary to apply additional SLoD treatments. The fourth period is from early to late autumn when the main objective is to reduce the number of pests that survive to infest the following crop. For conventional crops, it is possible to broaden the range of chemical pesticides used during this period to include those which are less compatible with biocontrol agents as their role has been completed for the season.

### **Biological and chemical pest management strategies for the control of *Tuta absoluta* (Lepidoptera: Gelechiidae) and their effectiveness: Mario V. Balzan and Anna-Camilla Moonen**

*Institute of Life Sciences, Scuola Superiore Sant'Anna, Via S. Cecilia, 3, Pisa, 56127, Italy*

With several large-scale open field cultivations dedicated to processing tomatoes each year, this crop remains particularly important for several regions in Italy. Since its introduction, the tomato borer *Tuta absoluta* has become widespread and an important pest throughout the region. Yet, while several studies on the ecology and management of *T. absoluta* have been conducted within controlled environments, limited information is currently available on the importance of this pest in open field cultivations, which may translate into ineffective management strategies. Within this study we have monitored adult populations of *T. absoluta* in organic cultivations of processing tomatoes in Pisa (Tuscany) using pheromone lures. Moreover, in two separate trials in Grosseto (Tuscany) we have recorded data relating to direct yield loss from larval feeding in eight conventionally managed fields, and carried out surveys in four organically managed fields from Grosseto that investigated the presence of *T. absoluta* by measuring direct fruit damage and the number of galleries made by larval stages in a standardised number of leaves. Trials measuring yield loss arising from *T. absoluta* fruit damage in conventionally managed farms were conducted over a period of two years with four fields per year, whilst data relating to organic cultivation of processing tomatoes was obtained from field trials carried out between June-August, 2011. Results from conventional fields for 2010 and 2011 suggest relatively high crop damage for tomatoes transplanted later in the season and harvested towards the end of August to early September. Similarly, larval galleries in leaves of organically managed cultivations of processing tomato was higher in tomatoes transplanted later in the season, but yield loss from this pest seems to be particularly limited for the surveyed organically managed fields. These results are supported by adult monitoring which suggests a concurrent exponential increase in population size. Finally, biological and chemical pest management strategies for the control of *T. absoluta* adopted by farmers within the region are reviewed and discussed with reference to their effectiveness based on pest damage and yield loss data.

**Investigating the potential of genetic control as part of an IPM approach for *Tuta absoluta*: Neil I Morrison<sup>1</sup>, Adam S Walker<sup>1</sup>, Ian Baxter<sup>2</sup>, Tim Harvey-Samuel<sup>1,3</sup>, Ahmed Hdidi<sup>2</sup>, Luke Alphey<sup>1,3</sup>**

<sup>1</sup>*Oxitec Ltd, 71 Milton Park, Oxford, Oxon, UK OX14 4RX*

<sup>2</sup>*Certis BCP, Newbury House, Court Lodge Farm, Hinxhill, Ashford, Kent TN25 5NR*

<sup>3</sup>*Department of Zoology, University of Oxford, South Parks Road, Oxford OX1 3PS, UK*

Since its arrival in Europe and the Mediterranean basin in 2006, the tomato borer (*Tuta absoluta*), tomato growers have struggled to maintain adequate control of this pest, due in part to growing pesticide resistance. In Morocco, for example, outdoor tomato production has been decimated by this insect. Low-residue produce is increasingly demanded by consumers, and an effective chemical-free control method, to add to current IPM options, would be highly attractive. This presentation describes the initial stages of development of a new control method for *T. absoluta*, called RIDL. This technique works by the same principle as the sterile insect technique (SIT): sustained mass-release of sterile insects to mate with wild counterparts and thereby cause population reduction of the pest. RIDL offers improvements over some aspects of SIT. Firstly, there is no requirement for sterilization by irradiation, which can have a negative impact on the insects' performance and increases costs. RIDL insects are also genetically marked, for reliable monitoring of wild and released moths. In addition, the insects cannot persist in the wild as they rely on an artificial dietary additive, which is only made available to them in the production facility. RIDL is described and the work with *T. absoluta* and other pest insects outlined.

## **Integrated control of *Tuta absoluta* in the Mediterranean region: what we can learn for future pest invasions?: Cristina Castañé**

*IRTA, Ctra. Cabrils Km 2, 08348-Cabrils, (Barcelona), Spain*

The trade of agricultural products around the world is the cause of most of the new pest invasions that occur in our crops. Quarantine services and eradication programs can limit the establishment of some species; however other pests escape and spread. The frequency of new invasions is increasing, as is the amount of agricultural trade. The analysis of control strategies that have been used in our region for managing invasive pest can help us to better address future invasions. In the last three decades the main invasive species of vegetable crops in the Mediterranean region were the leafminer *Liriomyza trifolii*, thrips *Frankliniella occidentalis* and the whitefly *Bemisia tabaci*. Nowadays these pests are integrated in our agro-ecosystems and they have been successfully controlled with IPM programs based on the use of local or regional natural enemies. The same trend has also been shown for the control of *Tuta absoluta*. After looking for solutions in the countries of origin, and by applying IPM programs based on the conservation of native beneficial fauna and adapted to local/regional crop cycles, the control of the pest is progressing. More pests are likely to become a problem, since the trade of agricultural products will not decrease. Their control with insecticides is not the sole solution for several reasons: the appearance of resistant populations, the limited pesticides availability due to restrictive EU regulations, and the 'zero residues' tolerance for food products by consumers. To search the solution in the pest place of origin and 'import it' presents difficulties and risks. The import of exotic natural enemies is highly restricted due to the risk of affecting non-target species. Also, many countries have strict regulations concerning the exportation of their 'living heritage,' resulting in the impossibility of exporting beneficial arthropods associated with the new pest. Therefore, the best strategy is to have IPM programs well established and applied in the territory that could respond to the unbalances produced in the ecosystem by the new pest. These programs have to be focused on the conservation of local beneficial fauna and complemented with other practices such as crop rotation, pest monitoring,

or the use of compatible selective pesticides. Local fauna, when not disturbed by insecticides, have a quick adaptation response to the new pest. First, generalist predators incorporate the new pest into their prey spectrum. With more time, parasitoids also incorporate the new pest as a host. These programs need to be developed for each territory since they have to be adapted to the local agricultural practices.

### III- ABSTRACTS of POSTERS by COUNTRY

#### ALGERIA

##### **The entomopathogenic fungus *Beauveria* sp., a promising way to fight against *Tuta absoluta* Meyrick in Algeria**

**Badaoui Mahdjouba Ikram and Berkani Abdallah**

*Laboratory of Plant Protection, Faculty of Exact Sciences and Sciences of Nature and of Life, University Abdelhamid Ibn Badis, BP 300, Mostaganem, Algeria 27000*

The tomato borer, *Tuta absoluta* Meyrick 1917 (Lepidoptera: Gelechiidae), is considered to be one of the most devastating pests affecting tomato crops in Algeria. If no control measures are taken, the pest can cause up to 80–100% yield losses. To control the tomato borer, farmers tend to use chemical insecticides, which may cause adverse environmental effects. For this reason, there is great interest to find efficient, economical control alternatives that allow sustainable production. For pest management, biological control is a promising alternative. In this study an autochthon strain, *Beauveria* sp., isolated from the cockchafer *Geotrogus deserticola* Blanch (Coleoptera; Scarabaeidae), was investigated. The susceptibility of *T. absoluta* larvae to the entomopathogenic fungi *Beauveria* sp. was examined under laboratory conditions. Three doses were used: D1=  $4.75 \times 10^7$  spores/mL, D2 =  $4.75 \times 10^6$  spores/mL and D3 =  $4.75 \times 10^5$  spores/mL. Controls were treated with distilled water. At high dose, all individuals treated died (100 %) in the third day, whereas at low doses the mortality rate reached 87 % in fourth day. For witness, more than 80 % of larvae have evolved into pupal stage as result of low mortality. Results obtained are consistent with those observed by other researchers and demonstrate the effectiveness of this strain in the native laboratory conditions.

##### ***Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae): Infestation and parasitism Levels on Tomato under greenhouse conditions in Mostaganem (Western Algeria)**

**Farida Saiah, Hamada Menad, Naouel Kolai, Abdallah Berkani and Mahjouba Badaoui**

*Laboratory of Plant Protection, University of Abdel Hamid Ibn Badis, BP300 Mostaganem 27000. Algeria*

*Tuta absoluta* (Lepidoptera: Gelechiidae) is an important tomato pest native to South America which appeared in west of Algeria at the end of 2008. Under greenhouse conditions, a high attack rate of 100 % was found and low parasitism level (07%). This shows that *T. absoluta* continues to cause significant damage when there is total absence of chemical treatment and the presence of a relatively few natural enemies. It is time to establish an efficient integrated control programme against this pest.

##### **Etude de l'entomofaune de deux variétés de tomate. Fluctuation temporelle des vols de *Tuta absoluta* (Lepidoptera : Gelechiidae) dans la Mitidja orientale en zone littorale (Algérie)**

**Salah Oukil<sup>1</sup>, Mériem Boukassem<sup>2</sup> et Sarah Benabdellah<sup>2</sup>**

*1 INRAA Division Protection des Cultures CRP Mahdi Boualem BP 37 Baraki 16210 Alger, Algérie*

*2. U.S T H.B. Faculté des Sciences Biologiques. Alger, Algérie*

Cette étude a été réalisée dans la wilaya de Boumerdes (Mitidja orientale, Nord de l'Algérie). L'étude quantitative et qualitative de l'entomofaune a permis d'inventorier 9 et 8 ordres respectivement pour les variétés de tomate Daoucen et Agora. Les Diptères, les Hyménoptères, les Homoptères et les Coléoptères prédominent dans l'une et l'autre variété quant au piégeage à l'aide de bassines jaunes, alors que par le piégeage à l'aide de pots Barber, ce sont les Coléoptères et les Hémiptères qui ont été plus particulièrement capturés. Quel que soit le piégeage utilisé l'entomofaune est plus importante chez la variété Agora. (Bassines jaunes : Agora 58,31% et Daoucen 41,69% ; Pots Barber : Agora 56,36% et Daoucen 43,64%). Il ressort également que les fluctuations temporelles de *Tuta absoluta* lorsqu'on utilise les pièges à phéromones sexuelles sont plus importantes dans la variété Agora (29,09%) qui paraît beaucoup plus attractive que la variété Daoucen (23,19%). Par ailleurs, les premières attaques larvaires sur feuilles ont lieu à partir de la mi-avril.

### **Approche de lutte contre *Tuta absoluta* sur culture de tomate dans le sahel algérois (Algérie)**

**Mouhouche Fazia<sup>1</sup> et Ziri Sihem<sup>2</sup>**

*<sup>1</sup>Département de Zoologie agricole -Laboratoire de Phytopharmacie Ecole Nationale Supérieure Agronomique El-Harrach (ENSA ex INA)*

*<sup>2</sup>Doctorante département de Zoologie agricole Ecole Nationale Supérieure Agronomique El-Harrach (ENSA ex INA)*

En Algérie, au cours de ces quatre dernières années (2008-2011), la culture de tomate sous serre et de plein champ ont subi des dégâts suite à l'introduction d'un nouveau et redoutable ravageur *Tuta absoluta*. Des essais sont effectués dans le but de contribuer à l'élaboration d'une lutte intégrée associant les effets des méthodes culturales, biotechnologiques (à l'aide du piégeage) et chimiques basées sur un choix judicieux d'insecticides caractérisés par des familles chimiques et des modes d'actions différents dans le but de gérer le phénomène de résistance. Les résultats obtenus montrent que malgré les conditions climatiques favorables au développement de *T. absoluta*, le taux d'infestation par *T. absoluta* enregistré sur la culture de tomate d'arrière-saison dans la parcelle traitée est 12,2% alors que celui relevé dans la parcelle témoin est de 85,7%.

### **Study of the insects associated with the tomato borer *Tuta absoluta* in Heuraoua (Algeria)**

**Khadidja Mahdi<sup>1</sup>, Bahia Doumandji-Mitiche<sup>2</sup>; Salah Oukil<sup>1</sup>; Lounes Saharaoui et Salaheddine Doumandji<sup>2</sup>**

*<sup>1</sup> Institut National de la Recherche Agronomique Algérie*

*<sup>2</sup> Ecole Nationale Supérieure Agronomique Algérie*

Two sampling methods are used to study the insect fauna associated with *Tuta absoluta* in the vegetable growing area of Heuraoua (Northern Algeria) in January-May 2009: these are the

methods of Barber pots and plates yellow. The inventory by the method of Barber pots placed Insecta shows the dominance of greenhouse gases and Out of more than 89%. Total wealth in cash pots captured through traps is too high (199 species). Of these 64 species are considered as potential predators and parasites such as Braconidae, the Eulopidae, as species of Ichneumonidae parasites, and predators like *Nesidiocoris tenuis* and Macrolophus. In yellow plates, 3,908 individuals distributed among 298 species were captured in the resort of vegetable crops in Heuraoua. Among the classes of arthropods, insects are the most represented with more than 96.0%. The total number of species recorded is 265 species. Among them are some 113 species as predatory and parasitic Hymenoptera which are the most abundant with Chalcidae, the Ichneumonidae and Brachonidae.

## **Comparaison entre les captures de mâles de *Tuta absoluta* par les pièges à phéromones type delta et les bassines à eau en zone littorale à Heuraoua (Algérie)**

**Khadidja Mahdi<sup>1</sup>, Bahia Doumandji-Mitiche<sup>2</sup>, Lounes Saharaoui et Salaheddine Doumandji<sup>2</sup>**

<sup>1</sup> *Institut National de la Recherche Agronomique Algérie*

<sup>2</sup> *Ecole Nationale Supérieure Agronomique Algérie*

Les pièges à phéromones sont un outil précieux pour l'étude des fluctuations des générations des ravageurs. Les niveaux de captures de mâles de la mineuse de la tomate *Tuta absoluta* par les pièges à phéromones type delta diffèrent entre les pièges à phéromones placés dans les serres ou en dehors de celles-ci. Au total 5 pics sont observés durant les 5 mois de l'expérimentation. 82,45 % des mâles sont capturés dans les pièges à phéromone munis de bassines à eau contre seulement 17,55 % par les pièges Delta. Ceci confirme l'efficacité des bassines sur le terrain.

## **Efficacy of emamectin benzoate on *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) infesting a protected tomato crop**

**Abdelhamid Gacemi and Yamina Guenaoui**

*Department of Agronomy, University of Mostaganem, Algeria*

*Tuta absoluta* Meyrick, (Lepidoptera: Gelechiidae), is the most important pest of tomato crops since its first detection in 2008 in Algeria. Increasing problems in control of *Tuta absoluta* in tomato crops necessitate development of an integrated control program through a combination of preventive methods with cultural practices, biological control and chemical control in order to keep the population density as low as possible. In the vicinity of Mostaganem, the density of *T. absoluta* increase dramatically and many growers had 50 to 100% damage to their fruit production. As a result of this outbreak, chemical control is implicated by use selective pesticides newly homologated in Algeria against *T. absoluta* in an integrated strategy. This study is conducted in order to evaluate the efficacy of emamectin benzoate. This foliar insecticide with a specific mode of action on several pests of Lepidoptera group is a derivative of the natural avermectin family produced by fermentation of a soil microorganism *Streptomyces avermitilis*. A field trial was conducted in tomato greenhouse (in 2009/ 2010). Three foliar applications were made at 7 days interval. The results showed a good activity on

*Tuta absoluta* larvae while having a good compatibility with its main native natural enemies. The efficacy after the last foliar application of emamectin benzoate reached 87 %.

## **Trapping of *Tuta absoluta* Meyrick 1917 (Lepidoptera: Gelechiidae) by three types of pheromone traps and damage assessment in Ouargla (Algerian Sahara)**

**Doumandji-Mitiche Bahia<sup>1</sup>, Chennouf Rekia<sup>2</sup> et Doumandji Salaheddine<sup>1</sup>**

<sup>1</sup> *Ecole Nationale Supérieure Agronomique El Harrach Alger*

<sup>2</sup> *Université de Ouargla (Algérie)*

Our work is a contribution to the study of bio-ecological tomato borer in Ouargla including pheromone trapping and damage assessment. The number of individuals of *Tuta absoluta* captured by three types of pheromone traps (Delta, MC. Phail and water) was recorded for a month from January 22 to February 21, 2010 in a greenhouse. The numbers are obtained from 455 adults caught in the trap Mc Phail, 527 in the trap Delta and reached 10500 adults with water trap with pheromone. The rate of infestation of tomato borers on leaves and fruits was calculated on two tomato varieties, Zahra and Nedjma in three greenhouses. Zahra leaf infestation rates are respectively in the three greenhouses 2.22%, 9.34% and 6.02% in November 2009 to reach 100% in February 2010. Infestations of the populations of *T. absoluta* on the fruit of the tomato variety Zahra is 8.33%, 41.9% and 15.4% in January to 100% in February. On the leaves of the variety Nedjma, the rate is 3.62%, 6.8% and 11.9% respectively in the three greenhouses in November and reached a maximum rate of 100% in February. On the fruit of this variety it is 0.22%, 29.8% and 17.24% in January and reached 100% in February in the three greenhouses.

## **Study of parasitic complex of *Tuta absoluta* in Mostaganem area (Algeria)**

**Malika Boualem, Rahma Hamadi and Houcine Alaadine Allaoui**

*Université Abdelhamid Ibn Badis, Faculté des Sciences exactes et sciences de la nature et de la vie, Département d'Agronomie, Laboratoire de Protection des végétaux, BP 188-CP Mostaganem, Algeria*

The appearance of the invasive pest *Tuta absoluta* Meyrick in 2008 in Algeria, on the tomato fields has pushed the implication of the agricultural and scientific research work, to aim the control against this pest by various methods, including the using of appropriate biological means. Our work has focused on the study of *Tuta absoluta* biology and its natural predator *Nesidiocoris tenuis*, and the inventory of its parasite complex in Mostaganem area. For the life cycle study of *T. absoluta*, ten couples were placed separately in ventilated boxes of fresh tomato leaf. The study has concerned fifty eggs of *T. absoluta* freshly laid. The eggs are placed in separate Petri dishes airy, fresh tomato leaf on nutrient Agar agar. As for the tomato borer, the study of *Nesidiocoris tenuis* biology has concerned fifty eggs. The study of the life cycle and longevity of both species was carried out in laboratory natural conditions, under an average temperature of  $26 \pm 1.6$  °C and  $23.4 \pm 2$  °C, relative humidity of  $87 \pm 6.4\%$  and  $75 \pm 3\%$ , and photoperiod of 16/8. Observations are made twice daily, morning and evening. The inventory of parasitic complex required a weekly sampling of 50 tomato leaves infested with *T. absoluta*. The results of *T. absoluta* biology have revealed a development cycle of  $21.1 \pm 0.4$  and  $29.4 \pm 2$  days and longevity of  $12.5 \pm 3.6$  and  $12.1 \pm 2.5$  days, respectively at



26 ± 1.6 °C and 23.4 ± 2 °C. The life cycle of the predatory bug *N. tenuis* showed a development cycle of 17.1 ± 0.5 days at 26 ± 1.6 °C, longevity of 16 ± 1.6 days for individuals fed to the *T. absoluta* larvae and 9 ± 2.2 days for those not fed. In addition, the inventory has allowed us to detect the presence of three species of predators pledged to *T. absoluta*: *Nesidiocoris tenuis* Reuter, *Macrolophus caliginosus* Wagner and *Dicyphus errans* Wolff; and three species of parasitic wasps: *Necremnus* sp., and two species of Ichneumonidae.

## **Essai de lutte biologique contre *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) par l'utilisation de champignons entomopathogènes**

**Dahliz Abderrahmène et Lakhdari Wassima**

INRAA, Station de Sidi Mahdi, Tougourt, Algérie

Les insectes ravageurs constituent une des contraintes de la réussite de la culture de la tomate. Parmi ces déprédateurs, la mineuse de la tomate (*Tuta absoluta*) qui vient juste de pénétrer en Algérie (2008) constitue le premier défi pour les agriculteurs comme pour les scientifiques. En effet, cet insecte est introduit sans son cortège d'ennemis naturels susceptible de réduire ses dégâts. Cette espèce a également montré sa capacité de développer des formes de résistance à de nombreuses matières actives insecticides. Afin de contribuer à l'élaboration d'une stratégie de lutte contre *T. absoluta*, nous avons fait l'inventaire de ses agents entomopathogènes. Deux champignons ont été identifiés parmi d'autres extériorisés sur les adultes. Il s'agit d'*Aspergillus flavus* et de *Metarhizium* sp. Des essais ont été menés au laboratoire pour connaître l'efficacité de ces antagonistes. Des taux de mortalité de 42% et 56% ont été enregistrés pour ces deux champignons respectivement.

## **Inventaire des ennemis naturels de *Tuta absoluta* (Meyrick, 1917) (Lepidoptera : Gelechiidae) et effet de son parasitoïde *Diglyphus isaea* (Hymenoptera : Eulophidae) sur deux variétés de tomate dans les régions de Staouéli et Chéraga (Algérie)**

**Redouane Zaid<sup>1</sup>, Mohamed El Fodhil Aroun<sup>1</sup> et Khaled Moumene<sup>2</sup>**

<sup>1</sup> Département des Sciences Agronomiques Faculté des Sciences Agro-Vétérinaires -Université Saad Dahleb de Blida -ALGERIE

<sup>2</sup> Institut National de la Protection des Végétaux – Hacén Badi El Harrach-ALGER

Quelques aspects écobiologiques de *Tuta absoluta* et l'impact de ses ennemis naturels ont été étudiés. Les résultats montrent qu'il existe de nombreux ennemis naturels de ce ravageur de la tomate dont les plus importants sont représentés par un champignon parasite, *Verticillium* sp, deux prédateurs *Nesidiocoris tenuis* (Heteroptera : Miridae) et *Orius* sp. (Heteroptera : Anthocoridae) ainsi qu'un parasitoïde *Diglyphus isaea* (Hymenoptera : Eulophidae). L'échantillonnage mené au niveau de la région de Staouéli et Chéraga (Nord de l'Algérie) sur une culture de la tomate montre que les risques d'attaque et d'infestation, ainsi que la distribution des différents états biologiques du ravageur et du parasitoïde *D. isaea* varient en fonction des variétés, des périodes et des étages foliaires. Le taux de parasitisme par *D. isaea* peut atteindre 45%.

## **Comparative predation by three predators bugs (Heteroptera:Miridae) on**

## ***Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) on tomato**

**R. Bensaad and Y. Guenaoui**

*Department of Agronomy, University of Mostaganem, Mostaganem 27000, Algeria.*

*Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) has been first reported in Mostaganem (northwestern Algeria) in 2008. Heavy economic damage occurs in every growing season. In order to reduce chemical treatments, others methods of controlling the pest are been developing. Biological control is one of the main methods used. The aim of this study is to evaluate the efficacy of three indigenous predatory mirids found preying on *T. absoluta* infesting different host plants in the growing area in the vicinity of Mostaganem. Three species have been identified as *Macrolophus caliginosus*, *Nesidiocoris tenuis* and *Dicyphus tamanii* and described. We have evaluated their capacity to feed on *T. absoluta* eggs and both larval instars in a no choice experiment. Both species prey actively on eggs. There is no significant difference between both species when fed on the first and second larval instars. On older larvae *N. tenuis* is more active with significant difference between both predators. Field observations showed the suitability of *T. absoluta* as prey for the predatory mirids and their capacity to reduce populations in untreated tomato crops.

## **Gestion du problème de mineuse de la tomate en Algérie par l'utilisation de piégeage massif**

**H. Amrouni**

*Chef de service et coordinatrice du programme de lutte contre *Tuta absoluta* en Algérie*

*Ministère de l'Agriculture et du Développement Rural*

*Institut National de la Protection des Végétaux*

Depuis l'apparition de la mineuse *Tuta absoluta* en Algérie en mai 2008 et après l'échec de la lutte chimique qui était le seul recours des agriculteurs, le Ministère de l'Agriculture et de Développement Rural par le biais de l'Institut National de la Protection des Végétaux a élaboré une stratégie de lutte qui est basée sur le piégeage massif. En effet, après plusieurs essais sur terrain utilisant plusieurs types de pièges et de phéromones sous des conditions diverses, une stratégie nationale de lutte contre *T. absoluta* a été adoptée. Elle repose sur l'utilisation des pièges à eau, à raison de 20 à 50 pièges/hectare tant au niveau des serres qu'en plein champ. Les niveaux d'infestation ont considérablement baissé notamment pour les cultures de tomate sous serre, passant de 100% en 2008 à 14% en 2011. Aussi, à partir de la campagne 2009/2010, le problème de la mineuse est maîtrisé grâce au piégeage sexuel et la sensibilisation des agriculteurs sur la nécessité de conjuguer différents moyens de lutte dans le cadre d'une stratégie de lutte intégrée.

## **Approche de lutte biologique contre *Tuta absoluta* en Algérie**

**A. Ababsia<sup>1</sup> et K. Moumene<sup>2</sup>**

*Ministère de l'Agriculture et du Développement Rural*

<sup>1</sup>chef de service d'Entomologie de l'INPV, Algérie <sup>2</sup>Directeur Général de l'INPV, Institut National de la Protection des Végétaux Algérie

La mineuse de la tomate *Tuta absoluta* Meyrick (Lepidoptera : Gelechiidae) a été identifiée pour la première fois en Algérie au cours de l'été 2008 dans la région ouest du pays. Depuis, plusieurs études sur la bioécologie et l'inventaire de la faune auxiliaire autochtone ont été menées à travers le territoire national. En 2010, un projet de coopération avec la FAO a permis l'introduction, l'élevage et la production de *Nesidiocoris tenuis* (Hemiptera : Miridae) qui a été relâché dans quelques sites pilotes de la culture de la tomate, dans le cadre de la lutte intégrée (IPM), particulièrement à Mostaganem (région ouest). Après une période de 6 mois de suivi, les résultats font état de l'efficacité de *N. tenuis* : les infestations par *T. absoluta* ne dépassaient pas 9% (de mines sur feuilles). Le taux de prédation était alors de 15% du total des œufs et larves L1 de *T. absoluta* observés sur les feuilles. Par ailleurs, cette action a permis de vulgariser la lutte biologique auprès des maraîchers, de réduire le nombre des applications des pesticides et de vulgariser l'utilisation de biopesticides.

### **Observations on the biology of *Necremnus artynes* ; New parasitoids of *Tuta absoluta* in Mostaganem (Algeria)**

**Naouel Kolai, Abdallah Cherifa, Abdallah Berkani , Farida Saiah and Mahjouba Badaoui**  
*Laboratory of Plant Protection, University of Abdel Hamid Ibn Badis, BP300 Mostaganem 27000.Algeria*

A survey has been carried out in spring 2011 in Mostaganem (western Algeria) to look for *Tuta absoluta* natural enemies on tomato greenhouse crops. It has been noted for the first time the presence of *Necremnus artynes*, an eulophidae native from Mediterranean habitat which acts as ectophagus parasitoid of first and second of *T. absoluta* larvae. In laboratory semi-controlled conditions, *N. artynes* showed  $3.9 \pm 1.37$  days (N=15; T= 3±1) as mean ±SE developmental time from egg to larvae when pupation is completed in  $7.13 \pm 1.88$  days. This parasitoid might constitute an efficient natural enemy for the regulation of phytophagous population.

## **ARGENTINA**

### **Triple T®: Technology for the ethological control of *Tuta absoluta* Meyrick in tomato crops in Argentina**

**Lobos, E., G. Rabinowicz and P. Guivisdalsky**

*WayneAgro, division of Wayne Chemical S.R.L.. Arias 1671 4ª (C1429DWA) Ciudad Autónoma de Buenos Aires – Argentina. [info@wayneagro.com](mailto:info@wayneagro.com)*

*Tuta absoluta* has been present in most production sites of tomato in Argentina for over 50 years. Already established in most regions with tomato in greenhouses or open fields, it requires frequent applications of insecticides to control its damage. Recently, problems with this control technique have arisen, due to resistance indicators, environmental issues, workers intoxications and final consumer rejections. WayneAgro, the agronomic division of Wayne Chemical S.R.L., developed the Triple T® (Tuta Trap Technology) in 2008, which added to a suitable IPM (integrated pest management) for the tomato crop control of *Tuta absoluta*. The pest is effectively controlled through correct distribution of traps with pheromones, placed few weeks before the seeding or transplanting, and during the entire crop cycle. The

pheromone attracts continuously the males that fly among the plants and end up captured in the traps, taking them out of the adult population without any chance to copulate; consequently, the females do not oviposit and, therefore, harmful larvae do not develop on the leaves, sprouts, flowers or fruits. Experiences conducted in several provinces in Argentina, allowed WayneAgro to develop the Triple T® technology, protecting the production and reducing the number of applications of pesticides. It is important to emphasize that Triple T® does not leave residues on/in the produce, it does not represent any danger to the workers, it does not require specific protection gear for the growers, it does not contaminate the environment, increases the natural control of outbreaks, reduces the amount of water used for the application of pesticides, and does not generate resistance issues. This technology, new for this market, it has been installed in 30 ha of greenhouses at a pre-commercial level, and soon will be fully available for sustainable production systems, either organic or conventional sites.

## BRAZIL

### **Egg exposure to pyriproxyfen in the tomato borer *Tuta absoluta*: ovicidal activity or behavioural-modulated hatching mortality?**

<sup>1</sup>H.V.V. Tomé, <sup>1</sup>E.M.G. Cordeiro, <sup>1</sup>J.F. Rosado, <sup>2</sup>T.M.C. Della Lucia, <sup>1</sup>R.N.C. Guedes

<sup>1</sup>Department of Entomology and

<sup>2</sup>Department of Animal Biology of the Federal University of Viçosa (UFV), 36570-000, Viçosa, MG, Brazil

Insecticide susceptibility varies with the insect life stage and although the egg stage is sometimes perceived as the most vulnerable, it is a difficult target for insecticide application and little studied as such. Egg susceptibility to insecticides is generally considered important for insect growth regulators and insect pests of reduced mobility like leafminers and borers because of their placement on the host plant part targeted by the insecticidal application. The egg exposure to the juvenile hormone mimic pyriproxyfen was studied here in the tomato borer *Tuta absoluta* (Lepidoptera: Gelechiidae), a key tomato insect pest, aiming to assess if mortality is achieved due to insecticide ovicidal activity or due to behavioural impairment of the larvae preventing egg hatching. Survival analysis of treated tomato leaves and/or eggs indicated the importance of egg exposure to pyriproxyfen leading to significant decrease in survival with a nearly 50% reduction in survival time, which peaked at the 1<sup>st</sup> instar. Ovicidal activity of pyriproxyfen in the tomato borer was negligible, but image recording and behaviour analysis indicated behavioural impairment of larva activity compromising hatching and leaf mining by early instar larvae leading to high mortality at this stage (ca. 50%). The likely causes and management implications of such findings are discussed.

### **Social Wasp Predators of *Tuta absoluta***

M. C. Picanço<sup>1</sup>, L. Bacci<sup>2</sup>, R. B. Queiroz<sup>1</sup>, G. A. Silva<sup>3</sup>, M. M. M. Miranda<sup>1</sup>, G. L. D. Leite<sup>4</sup>, F. A. Suinaga<sup>5</sup>, N. M. P. Guedes<sup>1</sup>

<sup>1</sup>Department of Entomology and <sup>3</sup>Department of Plant Science, Federal University of Viçosa,

<sup>2</sup>Federal University of Sergipe,

<sup>4</sup>Federal University of Minas Gerais,

<sup>5</sup>EMBRAPA (Hortaliças)

The social Vespidae are important agents for biological control in agroecosystems and natural ecosystems. *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) is the most important tomato pest in South America. This insect was introduced into Europe and the Mediterranean region of Africa, where it has caused great damage. Despite the importance of Vespidae, little is known about their activity as predators of pest insects. Thus, this study aimed to determine the importance of social Vespidae as predators of *Tuta absoluta*, to study the influence of climatic elements on their foraging activity, to establish techniques for sampling, and to study their predatory behavior. The main predators of *T. absoluta* larvae were the social Vespidae, which preyed mainly 3<sup>rd</sup> and 4<sup>th</sup> instar caterpillars. The social Vespidae predators of *T. absoluta* larvae were: *Brachygastra lecheguana*, *Protopolybia exigua*, *Polybia ignobilis*, *Polybia scutellaris*, *Protonectarina sylveirae*, *Polybia fastidiosuscula* na *Synoeca cyanea*. *Polybia scutellaris* and *P. sylveirae* were the most abundant ones. The social Vespidae showed predation activity from 2 to 11 hours after sunrise. Predation of *T. absoluta* by Vespidae involved the plant-locating behavior, locating of mines in the leaves, identification of mines with caterpillars, opening of mines, caterpillars capture, their transportation, and body cleansing.

## EGYPT

### **Use of some eco-biological aspects and statistical analyses in determining the number of generations of *Tuta absoluta* on tomato in Upper Egypt**

**Samy Hussein Mohamed**

*Plant Protection Dep., Fac. of Agric. Assiut Univ., Assiut, Egypt*

*Tuta absoluta* is a devastating pest of tomato. It originates from South America. Recently *Tuta absoluta* considered to be the serious pest to tomato production in Mediterranean region especially in Egypt. The effect of three constant temperatures on the development of *Tuta absoluta* on tomato leaves were determined and used to calculate the threshold of development and the thermal unit of this insect pest. The averages of monthly temperature at Assiut were also determined and used to calculate the effective temperature in Assiut area. By these eco-biological aspects and statistical analyses the number of *Tuta absoluta* generations was determined. Results indicated that the duration period of the life span of *Tuta absoluta* reared on tomato leaves under the three constant temperatures of 14, 20, and 27° C were 76.1, 36.2 and 22.5 days, respectively. Results revealed also that the calculated threshold for the development was found to be 8.53 C and the total thermal units required for development of one generation were found to be 415.68 day-degree. The mean effective temperature for one year in the Assiut area was calculated from the average monthly temperature prevailing in Assiut governorate and it was 5687.66 day-degree. The number of generations of *Tuta absoluta*, which could develop on tomato leaves under Assiut conditions, can be determined by dividing the mean effective temperature for one year at Assiut area on the total thermal units required for development one generation of the pest and it was found to be 13.6 generations per year.

## ***Tuta absoluta* (tomato borer) outbreak and control measures in Egypt**

**Bekheit, H.K.M**

*Plant Protection Research Institute, ARC, Egypt*

**Impiglia, A.**

*Food and Agriculture Organization (FAO) of the United Nations, Syria*

In Egypt, *Tuta absoluta* was found in July 2009 at Nubaria, El-Behera Governorate; its similarity with potato tuber worm, *Phthorimaea operculella* (Zeller) caused problems in early identification. Samples were then sent for identification and classification at the Plant Protection Research Institute (PPRI) and British Museum to confirm its classification. A country-wide survey was carried out in different governorates of Egypt. Today, *T. absoluta* is a serious damaging pest on tomato plants and fruits in both greenhouses and the open field. According to the monitoring results using sex pheromone traps all over the country, the highest level of adult male moths was recorded in the governorates of Al-Wadi Al-Gadid and Alexandria, where the average trap was averaging 60 and 45 /trap/night. In contrast, the adult population in East delta (El-Sharkyia and Qalyoubia Governorates) was very low and ranged from 0.6 to 1.6 /trap/night. In addition, since there is no recommended insecticide for tomato borer in Egypt, pesticides registered against potato tuber worm were tested under laboratory conditions. Results indicated that pyrethroid insecticides, Lambda Cyhalothrin and deltamethrin were highly effective against the 4<sup>th</sup> instar larvae of *T. absoluta*. Percentage mortality ranged between 80 and 100%. Mortality was 100, 92 and 70% for the organophosphorus (OP) insecticides Profenofose, Chlopyrifose and Dimethoate, respectively. Regarding the efficacy of biological insecticides against *T. absoluta*, both Spinosade and Emamectin benzoate gave 100% mortality of 4<sup>th</sup> instar larvae, while Azadirachtin, *Bacillus thuringiensis* and *Metarhizium anisoplae* resulted in 90, 60 and 58%, respectively. As for anti-molting compounds, mortality percentage ranged between 84 and 100%. So it could be concluded that different groups of pesticides compounds could be used in different sequence control programs to avoid resistance development.

## **FRANCE**

### **Experimental studies on *Tuta absoluta* (Meyrick) in protected tomato crops in France: biological control and integrated crop protection**

**Y. Trottin-Caudal, V. Baffert, J.M. Leyre**

*Centre Technique Interprofessionnel des Fruits et des Légumes*

*Tuta absoluta* is a pest from South America and it has been detected in many European and Maghreb countries since 2006. It was identified in Corsica and the South of France in late 2008 and in 2011, this Lepidoptera species is present in different tomato production areas. This pest is mainly present on tomatoes in protected and field crops and damage on leaves and fruit can be so severe that it can lead to total destruction of the plant. Since 2010, studies have been carried out in experimental insect-proof glasshouses with artificial infestations of the pest. The objective was to have a better knowledge of this emergent pest and to develop adapted control strategies in our crop conditions. As integrated pest management is largely used on tomato crops in France, the predator *Macrolophus pygmaeus* and the parasitoid *Trichogramma achaeae* have been studied either alone or in combination. Best results were

obtained when these two beneficials were released in combination.

## **Efficacy of the combination of two beneficials to control *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) in tomato glasshouses in southern France**

**Séguret, J.<sup>1</sup>; Maignet, P.<sup>2</sup>; Ridray, G.<sup>3</sup>**

<sup>1</sup> *Invivo\Biotop ; 06560 Valbonne ; France*

<sup>2</sup> *Invivo\AgroSolutions ; 06560 Valbonne ; France*

<sup>3</sup> *Inra\Domaine Expérimental du Mas Blanc ; 66200 Alénia ; France*

The egg parasitoid *Trichogramma achaeae* Nagaraja & Nagarkatti, 1969 (Hymenoptera: Trichogrammatidae) in combination with the predator *Macrolophus pygmaeus* (Rambur, 1839) (Hemiptera: Miridae) was tested in 2010-2011 by the INRA of Alénia in experimental glasshouses in southern France, for controlling *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae). Two tomato crops were driven in parallel with two strategies: one using only *M. pygmaeus* and the other one *M. pygmaeus* and *T. achaeae*. In both cases, a similar and very high artificial infestation of *T. absoluta* and a monitoring of the population and damage of this pest were performed. In the glasshouse using *M. pygmaeus* alone, the population of *T. absoluta* could not be controlled (fruit damage >35%) and the crop could not be carried on even with the help of larval treatments, but in the glasshouse using *Trichogramma* in addition to the predator, the pest and its damage (<10%) were limited and finally declined. The success of *T. achaeae* to control *T. absoluta* is largely rooted in its good dispersal ability in tomato crops. In summer 2011, Biotop assessed the dispersal ability of the *Trichogramma* in five glasshouses of producers in southern France. It demonstrated in all cases, that the coverage of the crop was fine starting with 100 release points /ha with usual doses (from 250,000 to 1,000,000 individuals /ha). These recent results confirm the effectiveness of *T. achaeae* in association with *M. pygmaeus* to control *T. absoluta*.

## **Potential of European *Trichogramma* species for biological control of *Tuta absoluta* in Europe**

**Anaïs Chailleux<sup>1</sup>, Nicolas Desneux<sup>1</sup>, Elisabeth Tabone<sup>2</sup>**

<sup>1</sup> *INRA, Unité de Recherches Intégrées en Horticulture, UR880, 400 route des chappes, 06903 Sophia Antipolis, France.*

<sup>2</sup> *INRA, Unité Expérimentale de Lutte Biologique (UELB), 400 route des chappes, 06903 Sophia Antipolis, France.*

The South American tomato pinworm (*Tuta absoluta*) has recently invaded Europe and North Africa and rapidly became a major threat to tomato crops in this geographic area. Laboratory tests were undergone to evaluate the potential of 32 European species/strains of *Trichogramma* parasitoids for biological control of *Tuta absoluta* in Europe. The 32 species/strains tested were selected because (i) they represent the biodiversity in European *Trichogramma* species, (ii) they were collected on similar hosts (size and/or ecology) than *T. absoluta* or on hosts that were on tomato plants, and (iii) they have some potential for mass rearing (i.e. cost effective industrial production). Parasitism rate of *T. absoluta* eggs on tomato leaves was compared among species/strains. Four strains were selected as potentially efficient biological control agents because they showed higher or equal parasitism rate than

the currently available *Trichogramma* species already commercialized against *T. absoluta* in Europe (*T. achaeae*). The fitness was assessed for these four species on one generation, and sex-ratio, parasitism rate, longevity and morphological traits were also evaluated. For these four strains, parasitoids that emerged from *T. absoluta* eggs showed good parasitism capacity but some fitness-related traits proved to decrease. Implications of these results for developing a *T. absoluta* management program based on inundative releases of this species in glasshouse are discussed.

### ***Necremnus artynes* (Walker, 1839) (Eulophidae), a potential beneficial for the biological control of *Tuta absoluta* (Meyrick)**

**Gérard Delvare**

*Cirad / UMR CBGP, Campus International de Baillarguet, CS 30016, F-34988 Montferrier-sur-Lez Cedex France.*

**Anne-Isabelle Lacordaire**

*Koppert France, 147 avenue des Banquets, 84300 Cavaillon, France. Email*

**Jean-Marie Ramel**

*L.S.V., Station d'entomologie, CBGP UMR 1062, Campus international de Baillarguet, CS30016, 34988 Montferrier-sur-Lez Cedex. Email [jean-marie.ramel@anses.fr](mailto:jean-marie.ramel@anses.fr)*

Since its initial detection from Spain in 2006, the gelechiid *Tuta absoluta* spread rapidly in the Mediterranean Basin and even elsewhere in Europe. It is now a major constraint for all tomatoes growers. Hence it becomes necessary to quickly find complete alternate strategies to chemical control. At this moment, in IPM system, mass trapping with pheromone mimics is a possible way to catch mal adults associated with the use of natural enemies like predators and parasitoids which give quite good results in glasshouses tomatoes. Nevertheless, the ideal solution is not found. During the spring 2011 a larval parasitoid, tentatively identified as *Necremnus artynes* (Walker) was discovered for the first time in Southern France in tomatoes glasshouses crops. The same species is otherwise recorded from Italy especially Sardinia, Spain and Morocco; it is certainly also present in Algeria. Nevertheless its identification is somewhat problematic. The European *Necremnus tidius* (Walker) is also quoted as another parasitoid of *T. absoluta* but the specimens reared from the pest are morphologically quite variable; they are also somewhat different from the *N. artynes* specimens collected in Europe before the introduction of *T. absoluta*. A molecular study is therefore needed to assess the exact taxonomic status of these populations and check that these *Necremnus* are indigenous. During the summer 2011 a female of *N. artynes* was collected in a natural habitat near the sea side. It might therefore figure the original habitat from which the parasitoid shifted to *Tuta* and tomato plants.

## **GERMANY**

### **Belt® (Flubendiamide), a new tool for effective control of the tomato borer, *Tuta absoluta***

**M. Elsherif, M. Haas & S. Lamprecht**

*Bayer CropScience Ag, Alfred-Nobel-Str. 50, D-40789 Monheim, Germany*

Belt is the first representative of the novel chemical class phthalic acid diamides, which is characterized by a new mode of action against a broad spectrum of all economically important



lepidopterous insect pests. After uptake Belt acts very fast by interfering selectively with insect intracellular ryanodine receptors, which results in immediate cessation of feeding, followed by irreversible muscle contraction and subsequently death of the pest. Due to the new mode of action, and a complete lack of cross resistance to any other chemical class of insecticides, Belt is considered as an ideal partner for resistant management programs. Field trials showed that Belt is providing an excellent residual efficacy against key lepidoperan pests on many crops such as pome fruits, tea, cotton, rice, corn, soybean and vegetables. Belt demonstrated very good crop compatibility, no adverse effect on non-target organisms and safety for key beneficial arthropods including honey bees. All these features qualify Belt as an excellent chemical option for effective long lasting control of the invasive pest *Tuta absoluta* (Meyrick, 1917). Greenhouse trials showed that Belt foliarly applied at 48g a.i./ha in combination with an adjuvant results in 80-100% protection of *T. absoluta* infested tomato leaves, while 72 g a.i./ha showed approx. 100% efficacy against *T. absoluta* in numerous field trials. Belt proved in semi-field and field trials to be harmless to main beneficial insects and predatory mites and consequently is highly suitable for IPM programs in tomato plantations.

## HUNGARY

### **Daily activity of *Tuta absoluta* based on automatic sex pheromone trap catches**

**Kitti Sipos and Béla Péntzes**

*Corvinus University of Budapest, Faculty of Horticultural Science, Department of Entomology, 29-43 Villányi str., H-1118, Budapest, Hungary*

In Hungary *Tuta absoluta* was found in 2010. The larvae have caused significant damage to tomatoes in greenhouses. Since the biology of *Tuta absoluta* was not known in Hungary, we aimed to investigate the activity of the insects by continuous monitoring of the males.

The flight dynamics of male adults was followed using an automatic trap system (Madomat Ltd.) which is a sex pheromone trap with a built-in meteorological meter, computer system and camera in 2011 (from April – to September). The camera of the equipment took photos of the sticky sheets hourly, and saved them in its memory. The computer sent the photos to a central server through internet connection. This trap was applied successfully to the monitoring of raspberry cane midge (*Resseliella theobaldi*). During our experiments the sticky inserts were changed twice a week and the lures were changed monthly. The number of trapped adult males was defined based on the photos. We have found that adult males were mainly active in the morning (from 5 to 7). Males did fly to the traps neither at night nor in the afternoon.

## INDIA

A novel process for industrial production of >98% pure E3,Z8,Z11-14:AC major isomer for effective mass trapping of *Tuta absoluta*

**Reddy Sirigireddy, Markandeya Gorantla, PRK Reddy**

*Eprheromone IPM Solutions, EPR Biotech Centre, Genome Valley, Hyderaabad, A.P. India-500078.*

Mass trapping, attract-and-kill applications and mating disruption techniques using pheromones are an effective alternative for limiting the population of *Tuta absoluta*. However, the major limitation is non availability of *Tuta absoluta* sex pheromones in bulk quantity with pure major isomer. We have developed as part of our research program a novel bulk production process for synthesis of E3,Z8, Z11-14Ac and E3, Z8-14Ac sex pheromone at a purity of >98%. This was evaluated on industrial scale in batch sizes of 25 kg. Consistent yields and pure major isomer have been obtained across all the batches during scale up. The validation of pure major isomer has been performed by gas-chromatography-mass spectroscopy, HPLC and NMR and the results varied from 98% to 100% major isomer across different batches. The other isomers constitute less than 2%. Field studies have revealed that contamination of other cis/trans isomers of E3,Z8,Z11-14:Ac has a drastic effect on insect catch rate. The effective catch rate is 30%- 45% higher with the >98% pure product than the commercially available mating disruption products. The present study focuses on the production of sex pheromones of *Tuta absoluta* on large scale by utilization of a wide range of catalysts minimizing the isomerization during the stereo-specific reduction of respective alkynes. Further, starting compounds were obtained in high yields with greater purity by novel methods including the concept of green chemistry. In our opinion a joint effort by all the countries where the pest is prevalent may utilize the efforts of our team to use sex pheromones of *Tuta absoluta* on large scale for mass trapping and develop attract-and-kill applications for effective control and eradication of this economically devastating pest.

## IRAN

### ***Tuta absoluta* (Lep., Gelechiidae): A serious threat to tomato farming in Iran**

**Shahram Farrokhi<sup>1</sup>, Khosro Zerehgar<sup>2</sup>, Hossein Heidari<sup>1</sup> and Rasoul Marzban<sup>1</sup>**

*1- Biological Control Research Department, Iranian Research Institute of Plant Protection (IRIPP), 1454, Tehran 19395, Iran;*

*2- Plant Protection Agent of Kermanshah Province, Iran*

The tomato borer, *Tuta absoluta* (Meyrick 1917), is one of the most devastating pest in protected and open field tomato cultivations in South America and other infested countries. Since the first detection in Spain in 2006, *T. absoluta* is spreading rapidly across North Africa, Southern Europe, West Asian and the Mediterranean countries. In 2011, the *Tuta absoluta* has been reported in some parts of Iran, which mostly located in west border (e.g. Kermanshah, Ilam, Kordestan, Boushehr, Khouzestan, Azarbajejane-Gharbi, Ardebil, Esfahan and Tehran provinces). In addition to boundary small markets between Iran, Iraq and Turkey, the ferry services of passengers and goods across the Persian Gulf present a potential bridge for the pest to cross from Arabian countries to southern ports of Iran. This severe pest could be damage to 165 thousands ha tomato farming and also pose a threat to new biocontrol program in tomato greenhouses. Host plants imported for planting and fruits are considered introduction pathways of tomato borer. The monitoring and preventive non-chemical measures are the most important practices in IPM. The use of pheromone traps in a sufficient density is a reliable methods for tracing and mass trapping of male adults. Other control methods include rotation with non-solanaceous crops, ploughing, soil solarization, weeds

control and use insect proof netting and double door in greenhouses. In the case of strong damage or hot spots, is important to emphasize remove and burning the infested leaves and fruits to avoid further infestation. The predatory bugs (*Macrolophus*, *Nesidiocoros*, *Podisus*), egg and larval parasites (*Trichogramma*, *Necremnus*) and regular use of *Bacillus thuringiensis* var. *kurstaki* contributes to control of *T. absoluta*. Selective pesticides (azadiractin, spinosad and indoxacarb) that can be successfully used at recommended doses to control pest without adverse side effects on natural enemies are highly required. Pest management will always require good understanding of issues such as pest life cycles, accurate identification of pests and beneficial organisms, and compatibility with other crop management practices. For this purpose, training of farmers and IPM/FFS facilitators conducted in *Tuta absoluta* workshops by FAO-GTFS/REM/070/ITA-Near East IPM Project in Kermanshah province.

## IRAQ

### **The optimization of pheromone traps for monitoring and mass attraction of tomato borer *Tuta absoluta* in greenhouses in Iraq**

**Mohammed A. Ali Alasady, Hamid A. Hadwan, Rayadh K. Hassan**

*Tuta absoluta* project, National Center for Organic farming, Ministry of Agriculture, Iraq.

Trials were conducted during 2011 to optimize the use of pheromones and pheromone traps for monitoring and mass attraction of tomato borer *Tuta absoluta* (Lepidoptera: Gelechiidae) in greenhouses in Iraq by studying the effect of type, design and trap elevation on capture of adults. Green (98 adult/ trap/week) and yellow (96 adult/ trap/week) delta traps recorded the total number of adults captured in greenhouses, while the house fly paper trap did not catch any adult. The maximum number (538) of captured adults was recorded in open water trap design (handmade) supported with a small amount of Efeskt insecticide and lowest number was captured in hanging water traps supported with Efeskt insecticide. All handmade water trap designs showed high efficiency in catching of adults. The traps that were hung 50 cm above the ground trapped the highest number of adults (61 adult/trap/week), while the lowest number was recorded at 300 cm. These results showed the possibility of usage of yellow and green delta traps at low levels for successful monitoring program and successful mass attraction control program by using the water traps.

## ITALY

### **Biological control of *Tuta absoluta* in Argentina and in Italy: evaluation of indigenous insects as natural enemies**

**Luna, M. Gabriela<sup>1</sup>, Norma E Sánchez<sup>1</sup>, Patricia C Pereyra<sup>1</sup>, Eliana Nieves<sup>1</sup>, Vivina Savino<sup>1</sup> & Stefano Speranza<sup>2</sup>**

<sup>1</sup>Centro de Estudio Parasitologicos y de vectores (CEPAVE) CCT-CONYCET y UNLP) La Plata, Argentine

<sup>2</sup>Department of Agriculture, Forests, Nature and Energy, University of Tuscia, Viterbo, Italy

Biological and ecological attributes of *Tuta absoluta*, as well as, some aspects of parasitoid-host interaction of *T. absoluta* egg and larval parasitoids in the laboratory and in the field.

Currently, results indicate that immature *T. absoluta* stages are attacked by a parasitoid community spontaneously present in tomato crops in Buenos Aires (Argentina) and in Italy. Especially for the larval stage, the parasitoid wasps *Pseudapanteles dignus* and *Dineulophus pthorimaeae* are proven to coexist in the field, and show characteristics that suggest that they could be considered as biocontrol agents against the pest by means of augmentative releases. Field evaluation of effective biological control achieved by *P. dignus* and/or *D. pthorimaeae* will assess their compatibility with IPM on tomato, and our assessment of economic feasibility of parasitoid mass rearing.

## **Biological control of *Tuta absoluta* (Meyrick) by native natural enemies in Italy**

**Luciana Tavella<sup>1</sup>, Barbara L. Ingegno<sup>1</sup>, Chiara Ferracini<sup>1</sup>, Paolo Navone<sup>1</sup>, Marco Mosti<sup>2</sup> and Alberto Alma<sup>1</sup>**

<sup>1</sup>DIVAPRA – Entomologia e Zoologia applicate all’Ambiente “C. Vidano”, University of Torino, via L. da Vinci 44 – 10095 Grugliasco (TO), Italy. E-mail: luciana.tavella@unito.it

<sup>2</sup>BIOPLANET – Strategie di Controllo Biologico, via Masiera prima 1195 – 47521 Cesena (FC), Italy

The South American tomato borer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), has been reported for the first time in southern Italy in 2008. In the two-year period 2009-2010 field surveys were carried out on infested tomato in different Italian horticultural areas to search for native natural enemies, and the most abundant species were tested for their efficiency in laboratory and olfactometer bioassays. From field-collected tomato leaves infested by *T. absoluta*, nine species of larval parasitoids emerged. In particular two species, *Necremnus* near *artynes* (Walker) and *N.* near *tidius* (Walker) (Hymenoptera: Eulophidae), collected in Sardinia and Sicily, and Liguria, respectively, were the most abundant. Moreover, in Piedmont on both tomato and European black nightshade, *Solanum nigrum* L., infested by *T. absoluta* an omnivorous predator species, *Dicyphus errans* (Wolff) (Heteroptera: Miridae), was widely found. In the laboratory, these species were shown to be effective biocontrol agents causing a high mortality of *T. absoluta*. Both *Necremnus* species controlled second and third instar larvae by host feeding and parasitisation activity, while the mirid bug preyed mainly eggs and first instar larvae. In olfactometer bioassays the three species were highly attracted to infested tomato plants compared to healthy ones. These preliminary results suggest a high suitability of these native natural enemies in controlling the exotic pest; further research is needed to assess their effectiveness in biological and integrated control programs.

## **IsoLure and IsoTrap a step ahead in the monitoring of *Tuta absoluta* (Meyrick)**

**Francesco Savino<sup>1</sup>, Andrea Iodice<sup>1</sup>, Vittorio Veronelli<sup>1</sup> and Fumiaki Mochizuki<sup>2</sup>**

<sup>1</sup> CBC (EUROPE) LTD - Milan Branch Via E. Majorana, 2 20834 Nova Milanese (MB) Italy;

<sup>2</sup> SHIN-ETSU Chemical Company Ltd; Niigata, 28-1, Nishifukushima, Kubiki-ku, Joetsu-shi Japan

Insect monitoring traps are an important tool in integrated pest management programs. Accurate pest identification is crucial to establish whether the economic threshold is exceeded and for the timing of control measures. Optimal timing of insecticide application permits a rationalization of agrochemicals use, reducing human and environmental exposure to

hazardous chemicals. There are two dispenser types to release pheromone for monitoring: matrix and reservoir dispensers. In the matrix type the matrix is impregnated with active substances. Because of this, the rate of the release is very high at the beginning of its exposure then decreases with time. In the reservoir type active substances fill an inner chamber and are released by diffusion through its wall made of specific polymer and of a set thickness. This gives a more constant and longer release. IsoLure Ta has been formulated to maintain the steady release of pheromone for up to 10-12 weeks. IsoLure Ta is used in association with IsoTrap IT 400. This trap is designed to serve as a versatile tool to capture a variety of insect species. IsoTrap has unique design with large platform and large entrance and it is built with UV resistant plastics.

### **Potential demographic effects of various bioinsecticides on *Bracon nigricans* (Hymenoptera: Braconidae) a new parasitoid of *Tuta absoluta* (Lepidoptera: Gelechiidae)**

**Antonio Biondi<sup>1,2</sup>, Lucia Zappalà<sup>1</sup>, John D. Stark<sup>3</sup> and Nicolas Desneux<sup>2</sup>**

<sup>1</sup> Department of Agri-food and Environmental Systems Management, University of Catania, Via S. Sofia 100 - 95123 Catania, Italy; antonio.biondi@unict.it

<sup>2</sup> French National Institute for Agricultural Research (INRA), UR 880, 400 Route des Chappes, 06903 Sophia-Antipolis, France

<sup>3</sup> Department of Entomology, Puyallup Research and Extension Center, Washington State University, Puyallup, WA 98371, USA

Integrated Pest Management (IPM) programs usually include pesticide applications. Therefore assessing the potential side effects of pesticides on biocontrol agents is of primary importance for implementing IPM efficiently. New biopesticides frequently cause no short-term effects to natural enemies but they may induce physiological and behavioural sublethal effects which may lead to important decreases in population growth. The invasion of Europe by the South American tomato borer, *Tuta absoluta* (Meyrick) (Lep.: Gelechiidae), has prompted farmers to use insecticides extensively, thus probably disrupting the pre-existing IPM programs already implemented in tomato crops. The parasitoid *Bracon nigricans* Szépligeti (Hym.: Braconidae) is an indigenous ectoparasitoid of Lepidopteran larvae which has been found parasitizing *T. absoluta* in Italy. Its efficacy as biocontrol agent of the pest is currently under evaluation and preliminary results show promising potential of biological control of *T. absoluta*. We assessed the effects of six bioinsecticides (abamectin, azadirachtin, *Bacillus thuringiensis* var *kurstaki*, borax salt plus citrus oil, emamectin benzoate and spinosad) used to control *T. absoluta*, on various physiological traits of *B. nigricans* adults, exposed either at the pupal (direct spray) or adult (exposure to dry pesticide residues on tomato sprouts) stage. The persistency of the bioinsecticides was also studied during the assays. *Bracon nigricans* survival was checked daily and the number of eggs laid and the rate of emerging adults were recorded for three days after exposure to the various pesticides. In addition, *B. nigricans* biocontrol activity, i.e. paralyzed and/or parasitized host larvae, of the surviving females on *T. absoluta* was recorded daily. Using the demographic data (life-history elements, survival and fecundity data) a delay model based on an age-structured *Leslie matrix* for estimating the potential *intrinsic rate of increase* ( $r_m$ ) and the *instantaneous rate of increase* ( $r_i$ ) was set. The results showed that the various products tested differed greatly in their toxicity and in their persistence. These findings stress the need for careful selection of bioinsecticides to be used in tomato crops for effective and sustainable IPM programs. Our data also indicate that some of these insecticides are incompatible with the parasitoid of *T. absoluta*, *B. nigricans*, and more broadly pose a potential threat to natural enemies.

## **Use of predatory mirids for the control of the tomato borer *Tuta absoluta* (Meyrick) in Sardinian greenhouse tomatoes**

**Mauro Nannini, Fabrizio Atzori, Giovanni Murgia, Riccardo Pesci, Francesco Sanna**  
*AGRIS Sardegna - DIRVE, V.le Trieste 111, 09123 Cagliari, Italy*

The introduction of the tomato borer *Tuta absoluta* in Sardinia (Italy) has caused a noteworthy increase in the number of insecticide treatments applied on the island for the management of pests on tomatoes under protected cultivation, thus raising growers' demand for alternative control options. To evaluate the efficacy of releasing two *Macrolophus pygmaeus* or *Nesidiocoris tenuis* per m<sup>2</sup> for the control of tomato borer infestations, between August 2010 and July 2011, a set of trials was conducted under field conditions. The tests were carried out in Santa Margherita di Pula (Cagliari, Italy) on 18 commercial greenhouse crops (6 autumn, 6 spring and 6 long-cycle crops). Five greenhouses per crop cycle, where no biocontrol agents were released, were also surveyed as controls. The release of the mirid bugs resulted in poor establishment of predators in tomato greenhouses, which reached a peak density of 1.8 individuals per plant. In approximately half of the cases, this was caused by the application of pesticides highly toxic to the predatory mirids (usually abamectin and oxamyl, used respectively for the control of eriophyid mites and nematodes). However, even in crops where only products regarded as harmless for biocontrol agents were used (e.g. *Bacillus thuringiensis*-based insecticides), both *M. pygmaeus* and *N. tenuis* failed to achieve the abundance levels necessary for effective pest control. Presumably, factors other than pesticide-related mortality significantly contributed to delaying mirid population build-up.

## **JORDAN**

### **The impact of Farmer Field School based Integrated Pest Management in controlling *Tuta absoluta*, a case from Jordan**

**Ashraf Saber Alhawamdeh<sup>1</sup> and Marwan Abed el-Wali Jaddou<sup>2</sup>**

<sup>1</sup>*National Center for agriculture Research and Extension NCARE, National coordinator of IPM Programme*

<sup>2</sup>*National Center for agriculture Research and Extension NCARE, Director of Plant Protection Department*

Integrated Pest Management (IPM) is a concept which promotes the use of biological control, good agronomic practices and other means before using chemical pesticides – as last resource - to control pests. The Regional IPM Programme in the Near East -GTFS\REM\070\ITA, executed by FAO with funds from the Italian Government, was launched in 2004 in the region including Jordan. One of the aims of the programme is to educate farmers in IPM using Farmer Field Schools (FFS) extension approach to provide practical training to farmers based on adult education. FFS proved to be successful in “less developed” rural communities and considering to gender issues. IPM FFS is a very useful tool to validate and adopt the plant protection research outcomes directly with farmers through practical field testing. IPM FFS introduced in Jordan by FAO through the National Center for Agricultural Research and Extension (NCARE) in 2004. In 2010, a “new” tomato pest, *Tuta absoluta*, was found in Jordan, the infestation of this pest reach in some area up to 100%. Farmers members of the IPM/FFS programme started using the IPM techniques to control Tuta. More than 800

farmers participating at the IPM/FFS programme used pheromones trap for monitoring the pest, and 86% of them used these traps for mass trapping as a method of control. All farmers of the IPM/FFS adopted the Agro-Ecosystem analysis (AESAs) as a method for monitoring and deciding the control methods to be used with *T. absoluta* infection and other pest infection as well. Approximately 80% of farmers were using IPM techniques instead of preventive chemical applications (spraying calendar) as a method to control the pest; this approach also decreased the cost of chemical pesticides procurement down to 60% and increased farmer's profit.

## MAURITANIA

### Poster de sensibilisation sur *Tuta absoluta* . 'Attention à la mineuse de la tomate'

**Sow Moussa Mamadou**

*Chef de Service de la Protection des Végétaux,*

*Direction de l'Agriculture/Service Protection des Végétaux, BP 180 Nouakchott, Mauritanie*

La production de la culture de tomate en Mauritanie connaît déjà de sérieux problèmes à cause de la pression de quelques ravageurs tels que le ver de la tomate, les sauteriaux, les chenilles défoliatrices en général, les acariens rouges et les nématodes à gales. Ceci veut dire donc que toute introduction nouvelle d'autres ennemis pourrait réduire d'avantage ou anéantir le rendement de cette spéculacion au niveau national. Bien que *Tuta absoluta* ne soit pas encore officiellement signalé en Mauritanie, sa présence au Maroc, un pays limitrophe, constitue une réelle menace, compte tenu du voisinage immédiat d'une part, et de l'importance des importations de produits agricoles en provenance de ce pays d'autre part. Dans la mesure où le contrôle phytosanitaire mauritanien ne couvre pas à présent les points d'entrée prévus par la loi de la Protection des végétaux (4 postes opérationnels sur 31 arrêtés) et que les techniciens et agriculteurs ne connaissent pas le nouveau déprédateur, une large sensibilisation est une nécessité capitale. Le présent poster (méthode de vulgarisation) a été développé à travers la FAO par le TCP/MAU/3104 « Renforcement du secteur de la Protection des végétaux en Mauritanie » afin d'alerter les inspecteurs phytosanitaires, les agriculteurs lettrés et les importateurs, du danger que présente *T. absoluta*. Cent cinquante exemplaires (150) du poster ont été distribués aux différentes structures techniques et administratives impliquées directement ou indirectement dans la gestion de cet insecte. L'édition du poster est réalisée à partir des recherches effectuées sur Internet, plusieurs sites ont été consultés, dont parmi les plus utilisés sont : [www.tutaabsoluta.fr](http://www.tutaabsoluta.fr), <http://draaf.france-comte.agriculture.gouv.fr> et [www.koppert.fr](http://www.koppert.fr)

### Utilisation des graines de neem comme insecticide naturel contre quelques ravageurs importants des cultures maraichères

**Sow Moussa Mamadou**

*Chef de Service de la Protection des Végétaux,*

*Direction de l'Agriculture/Service Protection des Végétaux, BP 180 Nouakchott, Mauritanie*

L'utilisation abusive de pesticides dans la protection des cultures maraichères est une pratique à proscrire. Certaines cultures comme la tomate ont une production continue, les récoltes sont

échelonnées et peuvent parfois être quotidiennes, ceci entraîne le producteur de poursuivre les traitements à cause de la pression de certains ravageurs comme *Helicoverpa armigera*. Cette pratique, en plus de la pollution qu'elle occasionne sur l'environnement, est aussi un gaspillage et constitue un grand risque sanitaire pour les consommateurs. L'utilisation des graines de neem comme insecticide naturel contre quelques ravageurs importants des cultures maraîchères peut pallier quelques grands problèmes phytosanitaires de la tomate en Mauritanie comme le ver de la tomate, les larves des sauteriaux, les chenilles défoliatrices en général et les nématodes à gales, sans pollution ni intoxication humaine ou animale. Les graines de neem étant toxique pour les larves des lépidoptères, peuvent combattre efficacement *Tuta absoluta* aux différents stades larvaires, quand les traitements sont effectués précocement et régulièrement appliqués sur les parties inférieures des feuilles et les jeunes fruits. Les techniques de préparation et de pulvérisation de la bouillie de neem ont été vulgarisées au niveau de plusieurs coopératives féminines en Mauritanie; malgré l'efficacité observée, le nombre insuffisant d'arbres de neem disponibles constitue encore un frein à la pratique généralisée de ce moyen de lutte. Le présent exposé décrit les conditions d'utilisation des graines de neem, les ennemis cibles, les étapes de préparation de la bouillie insecticide et les méthodes de pulvérisation.

## MONTENEGRO

### **Tomato borer, *Tuta absoluta* Meyrick (Lepidoptera, Gelechiidae): the current status in Montenegro**

**Snježana Hrnčić and Sanja Radonjić**

*University of Montenegro, Biotechnical Faculty, Department for Plant Protection, Mihaila Lalića 1, 81000 Podgorica, Montenegro*

Tomato borer *Tuta absoluta* has recently spread through Mediterranean countries and now it has been considered to be a serious threat to tomato production. In Montenegro its presence was detected for the first time in the middle of July 2010 in greenhouses in one location at the Montenegrin seacoast. After the first detection, monitoring with pheromone traps included main Montenegrin tomato production area (seacoast and surrounding of the city of Podgorica) where tomato is typically grown in greenhouses, and partially outdoors. According to our survey in 2010, *T. absoluta* was present in greenhouses in all tomato producing area, while outdoors only in coastal areas. Apart from tomato, symptoms of attack were also recorded on aubergine leaves, as well on *Solanum nigrum* leaves which, as a weed, is commonly present around and inside greenhouses. Monitoring and population dynamic of *T. absoluta* has been continued in 2011. Pheromone traps were set up in five locations in main tomato producing areas, both inside greenhouses and outdoors in period from 4<sup>th</sup> to 15<sup>th</sup> May. First captured moths were detected after 7-15 days from all inspected locations and were found to be captured until end of September. According to number of captured moths and damages it can be concluded that population level was lower in comparison with previous year. In 2011 tomato producers were already have been informed about the pest and ways of its control, so most of them applied cultural and chemical control measures.



## MOROCCO

### Larvicidal effect of ethanol extracts of seven Moroccan plants on *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae)

Abdelaziz Nilahyane<sup>1</sup>, Abderrahim Hormatallah<sup>1</sup>, Nezha Ait Taadaouit<sup>2</sup> and **Rachid Bouharroud**<sup>3\*</sup>

<sup>1</sup> Institut Agronomique & Veterinaire Hassan II, Complexe Horticole d'Agadir, Morocco.

<sup>2</sup> Faculty of Science Ben M'sik, University Hassan II-Mohammedia, Casablanca, Morocco.

<sup>3</sup> Institut National de la recherche Agronomique, Centre Régional d'Agadir, Morocco.

bouharroud@yahoo.fr

The Ethanol extracts of *Thymus vulgaris*, *Ricinus communis*, *Ononis natrix*, *Peganum harmala*, *Argania spinosa*, *Urtica dioïca*, and *Lawsonia inermis*, collected in the Souss Massa, were tested as part of an original work, for their insecticidal effects on the larvae of *Tuta absoluta* Meyrick, a pest of tomato, under laboratory conditions, in order to integrate biological control methods. After maceration in ethanol, the extracts are obtained by using the rotary evaporator. For each extract, the concentrations of 100%, 20%, 10%, 2% and 1% were being prepared for bioassays on the larvae of *T. absoluta* according to Leaf-dip bioassay method. The results showed that the extracts tested demonstrate varying toxicity on the larvae. The extracts that showed the highest rate of mortality were those of *T. vulgaris* leaves (95%) and the seeds of *R. communis* (58%) in response to a concentration of 46667 mg/l and 77500 mg/l, respectively. Other plant extracts had also a larvicidal effect. In fact, *O. natrix*, *P. harmala*, *U. dioïca*, *L. inermis* and *A. spinosa* caused respectively 45%, 43%, 42%, 32% and 28% of mortalities for the highest concentration. The LD90 of these extracts revealed that the ethanol extract of *T. vulgaris* is the most toxic (LD90 = 89383 mg / l).  
Keywords: *Tuta absoluta*, Plant extracts, *Thymus vulgaris*, *Ricinus communis*, *Ononis natrix*, *Peganum harmala*, *Argania spinosa*, *Urtica dioïca*, *Lawsonia inermis*, Biological control, Ethanol, Leaf dip bioassay, DL90.

### Effect of methanolic extracts of plant on *Tuta absoluta* (Lepidoptera: Gelechiidae)

Nezha Ait taadaouit<sup>1</sup>, Mohammed Hsaine<sup>1</sup>, Abderrahim Rochdi<sup>1</sup>, Abdelaziz Nilahyane<sup>2</sup>, and **Rachid Bouharroud**<sup>3</sup>

<sup>1</sup> Faculty of Science Ben M'sik, Universty Hassan II-Mohammedia, Casablanca, Morocco.

<sup>2</sup> Institut Agronomique & Veterinaire HASSAN II, Complexe Horticole d'Agadir, Morocco.

<sup>3</sup> Institut National de la recherche Agronomique, Centre Regional d'Agadir, Morocco.

bouharroud@yahoo.fr

After the introduction of *Tuta absoluta* (Meyrick) in 2008, this lepidopteran pest causes a serious damage for the production of tomato in Morocco. The chemical control was the quick, easy and efficient measure to prevent this pest. However, the heavy use of these chemicals presents potential risks to health and environment. In order to skirt this disadvantage, this study is a trial to give other alternatives based on the use of natural products "Bio-insecticide". Seven plants (*Thymus vulgaris*, *Ononis natrix*, *Lawsonia inermis*, *Ricinus communis*, *Argania spinosa*, *Urtica dioïca* and *Peganum harmala*) were collected in different

area of the Souss valley. Using rotary evaporator (40 °C) and methanol as a solvent we have trying to extract active ingredients. Leaf dip bioassay was adopted to evaluate the toxicity of these endemic plants against larval stage of *T. absoluta*. POLO-PC software was used to determine lethal dose at 90% of mortality (LD90). The extract of *T. vulgaris* showed the most important rate of mortality (97 %) followed by *R. communis*, *P. harmala* and *U. dioïca* with more than 50% of mortality. The lowest LD90 recorded was obtained with *T. vulgaris* extracts (156 023, 36 mg/l).

## **Lutte intégrée contre *Tuta absoluta* au Maroc**

**El Hajja Ben cheikh, Meriem Mouftakir et El Mostafa Laftah**  
*Office Nationale de la Sécurité Sanitaire des Produits Alimentaire*  
*Service de la Protection des Végétaux d'El Jadida*

L'introduction de *Tuta absoluta* a sérieusement entravé le développement de la lutte intégrée en culture de tomate en obligeant les producteurs à adopter une lutte chimique intensive et abusive. Le présent travail a donc pour objectif de promouvoir la gestion intégrée en culture de tomate sous abri.. Le travail est mené dans le cadre des Champs Ecoles des Paysans (CEP) dont le principe consiste à conduire dans les conditions locales et avec les producteurs une parcelle de tomate menée selon les bases de la lutte intégrée en comparaison avec une autre parcelle gérée selon les pratiques paysannes axées principalement sur le recours aux pesticides. La combinaison des moyens de lutte physiques, culturaux, biocides et l'emploi judicieux des pesticides compatibles avec la lutte intégrée a permis de contrôler la présence de *T. absoluta* dans la serre en lutte intégrée et par conséquent de diminuer considérablement les dégâts du dit ravageur. Les interventions chimiques ont été réduites de 66% par rapport à gestion conventionnelle. Par ailleurs, la méthode des champs Ecoles des Paysans a montré aux agriculteurs l'importance de la connaissance du cycle de développement du ravageur et de la surveillance phytosanitaire dans le raisonnement et la prise de décision pour entreprendre la lutte contre *T. absoluta*.

## **The costs of the control of *Tuta absoluta* (Lepidoptera: Gelechiidae) in the Souss valley of Morocco**

**Rachid Bouharroud<sup>1</sup>, Saadia Lhaloui<sup>2</sup>, Fatima Gaboun<sup>3</sup> and Abderrahman Ait Lhaj<sup>1</sup>**

<sup>1</sup>*Institut National de la recherche Agronomique, Centre Regional d'Agadir, Morocco.*  
*bouharroud@yahoo.fr*

<sup>2</sup>*Institut National de la recherche Agronomique, Centre Regional de Settat, Morocco.*

<sup>3</sup>*Institut National de la recherche Agronomique, Centre Regional de Rabat, Morocco*

After the introduction of the tomato borer *Tuta absoluta* (Lepidoptera: Gelechiidae) to Morocco in 2008, it became the pest number 1 on the protected tomato crops in the Souss valley. During the 2009-2010 season and as a part of study on diagnostic of plant protection on tomato crops, 600 ha (78 farms) was surveyed which represent 13% of the total tomato crops in the Souss valley. The aim of this inquiry was to evaluate the economic impact of the introduction of *T. absoluta* in Morocco. The statistical analysis of means was done using SAS software. Then, the mean of total cost of chemical and biological products purchased to control this pest was increased by 22.47 %. We have seen a very significant variability of this rate (from 0.34% to 54.74%) depending of the farms management and attack severity of the pest. The strict control at the borders is justified to prevent the introduction of other world quarantine pests. According to the planting date we have classified farms into 5 classes: Extra-

early (before July 15), Early (July 16 to 31), Semi-early (August 01 to 15), Late (August 16 to 31) and Extra-late (after September 01). During the same season, the means of chemical and biological products purchased to control *T. absoluta* were increased by 21%, 21%, 22%, 22% and 27%, respectively. Regarding to the total costs of plants protection products in tomato crops (insecticides, acaricides, fungicides, bactericides and nematocides), the statistical analysis showed that the extra-early plantations were, significantly, the most costly than the 4 other classes and almost a third of farms surveyed were planted in extra-early. Despite the measures and practices adopted by farmers (insect nets, certified plants, cultural practices, pheromone traps, etc. ...), the pressure outside the greenhouses of this pest is more important given the overlap with end tomato crops. This choice (Extra-early) is enforced by the need to be as early as possible in the European market and take advantage of significant price of tomatoes. The gross and export yields, number of sprays and insect-nets used were also investigated in this study.

## QATAR

### **Current Status and Future Outlook of Tomato Borer (*Tuta absoluta*) in the State of Qatar**

**Emad Hussain Al-Turaihi**

*Agricultural Affairs Department, Ministry of Environment, P.O. Box 1966, Doha-Qatar*

Tomato Borer or South American Tomato Moth (*Tuta absoluta* Meyrick 1917, Lepidoptera: Gelechiidae) was found for the first time in the State of Qatar in February 2011 at Al-Khor area located in the northern area of the country. The infestation was observed on tomato plants growing inside two neighboring farms (# 960 & 969). A survey was carried out immediately in the region but no further infestation was recorded. Some tomato plants growing in open field in the same site of infestation has been noticed as infested by the insect. An eradication programme has been implemented by removing and burning all infested plants, spraying pesticides, pest monitoring by placing water and pheromone traps. The possible source of infestation may be from the tomato fruits imported from outside the country. *Tuta absoluta* has been detected again in June 2011 at tomato production farm located in the central area of Qatar. Precautions are being taken to prevent any further spread of the insect (i.e. prohibition to move plant material from the infested site including composted material, disinfection of all equipment used for plants destruction, warning notices for visitors and elimination all residues of previous plants and wild host weeds of the Solanaceous family).

## SAUDI ARABIA

### **Status of *Tuta absoluta* in the Kingdom of Saudi Arabia: Efforts of the Ministry of Agriculture in the management of this invasive species**

**Abdul Aziz Sharidi<sup>1</sup>; Fahad B. Mohamed Al Saqan<sup>1</sup>; Saud Hajraf Al saadi<sup>1a</sup>; Faisal Nazzal<sup>1</sup>; Awaji Abul Algith; Naif M. Al Behairi<sup>1</sup>; Ahmed M. Khawaji<sup>1</sup>; Yahia Msheikhi<sup>1</sup>; Hussein Msheikhi<sup>1</sup>; Amar Sihat<sup>1</sup> and Abdelhaq Hanafi<sup>2</sup>**

<sup>1</sup> *Directorate of Plant Protection, Ministry of Agriculture, Riyadh, Kingdom of Saudi Arabia;*

The invasive species *Tuta absoluta* was recorded for the first time by the Directorate of Plant Protection of the Ministry of Agriculture in August 2010. Prior to this date, the Directorate of Plant Protection became alerted when the invasive species was reported in the Kingdom of Jordan in 2009. Therefore, and as early as January 2010, the Directorate of Plant Protection in collaboration with the Food and Agricultural Organization (FAO) has launched an extensive monitoring network of pheromone traps of the Delta type at the level of all ports of entry of imported vegetables as well as at the level of major tomato production areas in the kingdom of Saudi Arabia. Also, the Directorate of Plant Protection in collaboration with FAO, the Directorate of Extension and the General Directorates of the Ministry of Agriculture have organized over 30 training workshops at regional level and published an identification card and three booklets illustrating *T. absoluta* and the symptoms of damage on tomato leaves and fruits. The first occurrence of *T. absoluta* in pheromone traps was recorded in the first week of August 2010, in Tabuk the most northern region of Saudi Arabia. By the end of September 2010, *T. absoluta* adults were captured in the neighboring northern regions of Jouf and Hail. Six month later *T. absoluta* was recorded in pheromone traps in several regions of Saudi Arabia including the most southern regions of the Kingdom. The Ministry of Agriculture with the assistance of the FAO and international experts on *T. absoluta* from Europe and North Africa has developed a strategy for the management of *T. absoluta*. Aware of the danger of *T. absoluta*, the Ministry of Agriculture has secured a total funding of approximately 26 Million US dollars for the management of *T. absoluta* during a period of three years starting in April of 2011. These funds were partly used to secure sufficient quantities of bio-pesticides, biological control agents, pheromone traps (delta) and light/water pheromone traps among other entrants, to implement an integrated approach for the management of *T. absoluta* at the level of 5000 ha of tomatoes (open fields and greenhouses). The strategy of the Ministry of Agriculture for the management of *T. absoluta* has included the following components:

- 1- Use of pheromone traps of the type delta for the monitoring and follow up of adult populations
- 2- Use of water traps and light/water traps baited with pheromones for the mass trapping of adults male of *T. absoluta* (30-40 traps/ha).
- 3- Use of two beneficial insects for the management of *T. absoluta*: the egg parasitoid, *Trichogramma acheae* and the predator bug *Nesidiocoris tenuis*. Both natural enemies were mass produced locally at the Biological Control Laboratories of the Ministry of Agriculture in Riyadh, supplemented with import from Europe (Koppert Biological Systems, Agrobio and Biotop).
- 4- Use of insect nets on aeration opening and secure double door systems equipped with insect nets at the level of greenhouses.
- 5- Use of bio-pesticides and chemical pesticides for the management of outbreaks of *T. absoluta*.

The strategy of the Ministry of Agriculture for the management of *T. absoluta* used private farms for the implementation of the pilot IPM package outlined above, in the major tomato production areas. As a result of these efforts, *T. absoluta* is nowadays under satisfactory control in the Kingdom of Saudi Arabia.

## SPAIN

### **Retenol® improves efficacy of control treatments of *Tuta absoluta***

**Eitán Martín, Enrique Iñigo, Carlos Solans, David Bernad**

*DAYMSA (Desarrollo Agrícola y Minero, S.A.) Camino de Enmedio, 120 50013 Zaragoza Spain*

Retenol® improves the efficacy of control treatments for *Tuta absoluta*.

*Tuta absoluta* (Meyrick) is today a key pest in the tomato industry worldwide. The damage caused by this pest is severe. Larvae of *T. absoluta* attack leaves, buds, stems, flowers, calyces, and tomato fruit. Both yield and fruit quality can be significantly reduced and severely attacked tomato fruits lose their commercial value. Because of its biology and behavior, *T. absoluta* is a challenging pest to control. *T. absoluta* has several generations per year. Retenol® improves the quality and efficacy of foliar treatments by giving spray solutions optimum spreading properties and ability to hold ingredients on to the plant surfaces treated. It also improves wetting, retention and sticking of foliar sprays and has anti-drift properties. It has been approved for use in Organic Agriculture according to EC 834/2007 and NOP (USA) by Ecocert. Field trial was conducted in a tomato greenhouse on “Fyper” cultivar in Malaga (Spain). Two foliar applications were made at 7 days interval. Bacillus thuringiensis Kurstaki and Emamectin were two insecticides evaluated without and with the addition of Retenol® at a dose of 2 cc/L. Spray volume of applications was 1000 L/ha. The number of mines and affected foliar surface were the parameters assessed on T1+0, T1+7=T2+0, T2+7 and T2+14 days. The trial design was set up as a randomized block in 4 replicates per treatment; each replicate composed of 30 plants. Trial results show the increase of control efficacy of both active substances. Severity and number of mined leaves were reduced when Retenol® was added to pesticides sprays, with statistically significant differences. No phytotoxicity symptoms were observed.

## SUDAN

### **Effect of pheromone traps on mass trapping of tomato borer, *Tuta absoluta* (Lepidoptera: Gelechiidae) in Sudan**

**Ensaf S.I. Mohamed and Khalid Siam**

*Agricultural Research Corporation, Shambat Research Station, P.O. Box, 30, Khartoum North, Sudan*

The tomato borer, *Tuta absoluta* (Meyrick) is recently becoming a serious problem of tomato production in Sudan. Experiments were carried out during the 2010/2011 season in Khartoum State, Sudan, to evaluate the effectiveness of different pheromone traps to capture *T. absoluta* males for future development of a mass trapping technique. The preliminary test of three types of pheromone traps captured sufficiently high populations of males and reflected in high recovery of the tomato foliage after complete leaf die-back. Moreover, a study was conducted to evaluate the combined effect of using mass trapping of males by pheromone with the recommended insecticides. Results showed that larger numbers of males were captured, resulting in a significant reduction of pest population, yield loss and percentage of damage fruits and increasing the tomato yield compared with chemical insecticides alone.

## TUNISIA

### **Bioassays with two trap models and different sex pheromone capsules of the tomato borer *Tuta absoluta* Povolny 1994**

**Dhouibi Mohamed Habib, Titouhi Faten and Smaan Meriem**

*Laboratoire d'Entomologie Institut National Agronomique de Tunisie*

*43, Avenue Charles Nicole, 1082 Tunis-Mahrajène- Tunisie*

Tomato borer *Tuta absoluta* Povolny 1994 (Lepidoptera: Gelechiidae) was introduced in Tunisia in 2008. This study was carried out with the intention of contributing to the search of more efficient control processes of *T. absoluta*. We compared the efficiency of two trap patterns (delta and water trap) and different commercial lures of *T. absoluta* sexual pheromone Russel IPM, Russel Optima, Russel Long Life, Atlas Agro, Atlas Agro (Gray, White and Red) and Koppert. In glasshouse conditions, the water trap is more efficient than Delta trap and Russel IPM lures are better than Koppert lures. In open field, Delta traps are more efficiency than water traps. Russel IPM lures are better than Koppert and Atlas Agro lures. Among the three Atlas Agro lures (Gray, White and Red) the gray is the best one. Finally Russel Optima lures showed better effect than Gray Atlas Agro, Koppert and Russel Long Life. All these results are statistically confirmed at ( $P \leq 0,05$ ).

### **Integrated Pest Management against the tomato borer *Tuta absoluta* Povolny 1994**

**Dhouibi Mohamed Habib and Titouhi Faten**

*Laboratoire d'Entomologie Institut National Agronomique de Tunisie*

*43, Avenue Charles Nicole, 1082 Tunis-Mahrajène- Tunisie*

Tomato borer *Tuta absoluta* Povolny 1994; (Lepidoptera: Gelechiidae), is a serious pest that causes great damages. The integrated pest management can be considered as the most efficient strategy to face up this insect. This study was carried out to test the combined effect of different chemical products, bio pesticides, mass trapping and a new management technique "Attract and Kill".

The emamectin benzoate: 20mg (30cc/hl) was the most efficient chemical treatment with a mortality ratio of 60% under glasshouse conditions. In open field the chlorfenapyr (50cc/hl) caused 84.78% of population mortality followed by spinetoram: 120 SC (50cc/hl) with 70% and azadirachtin: 0.03% (250cc/hl) with 65.66% which are bio pesticides.

Attract and Kill technique reduced the population to 91.66% putting into consideration that the infestation is very high up to 96%. However, in combination with mass trapping its effect has diminished by 50% regarding the infestation is in the order of 64%.

### **Updated review of morphological characteristics and new molecular data for an accurate identification of *Macrolophus* species (Hemiptera: Miridae)**

**Faten Hamdi, Tunisia**

*Macrolophus* spp. (Hemiptera: Miridae) is a natural enemy used since the 1990s to control whitefly populations in protected tomato crops. Recently, its efficiency in regulating the

tomato borer, *Tuta absoluta* (Lepidoptera: Gelechiidae), considered as a key pest of tomato both in field and under protected conditions, has been reported in the Mediterranean zone of tomato production. However, morphological similarities exist within the eight Palaearctic species belonging to the *Macrolophus* (Fieber 1858) genus. Although, the biological agent marketed by firms specialized in biological control, is labelled as *M. caliginosus* there is a taxonomic confusion between *M. melanotoma/caliginosus* and *M. pygmaeus*. These two previous species are also morphologically similar to *M. costalis*. A wrong determination of a biological control agent can lead to the failure of a whole IPM program or a scientific study, and can induce important economical losses for farmers as well. To undertake more advanced studies for agronomical applications and fundamental issues, this discrimination problem must be resolved. This study was proposed to overcome the lack of consistency on the morphological characters. A global literature review of the last forty years on *Macrolophus* taxonomy supported by new molecular data was made to correctly identify these three species. This study brings additional information to the two papers which combine morphological and molecular characters to discriminate the closely related species of *Macrolophus* species (Perdikis *et al.*, 2003; Martinez *et al.*, 2006). A mitochondrial and a nuclear fragment genes were sequenced to establish: *i.* diagnostic nucleotide sites specific to each species and *ii.* phylogenetic relationships between the three species. Based on molecular data, only three morphological characters appeared to be congruent. Two were used to discriminate *M. melanotoma* from *M. pygmaeus* (the form of the black band-shaped macula behind the eye and the colour of the first antennal segment), another one allowed the discrimination of *M. costalis* from the two previous ones (the black colour of the apex of scutellum). The efficiency and reliability of these two methods of identification were validated on a large number of *Macrolophus* spp. specimens sampled from different northern and southern Mediterranean areas (France, Greece, Italy, Morocco, Spain, Tunisia, ...).

## **Reaction of the tomato borer *Tuta absoluta* (Lepidoptera: Gelechiidae) to some bio-insecticides in semi-natural conditions**

**Abir Hafsi<sup>1</sup>, Khaled Abbes<sup>1</sup>, Brahim Chermiti<sup>1</sup>, Adel Jemmazi<sup>2</sup> and Bouzid Nasraoui<sup>2</sup>**

<sup>1</sup> Higher Institute of Agronomy of Chott-Meriem, University of Sousse, Tunisia

<sup>2</sup> General Directorate of the Protection and Control of the Agricultural Product Quality, Tunisia

Experiments using bio-insecticide products in semi-natural conditions showed a medium to low efficiency on all instars of *T. absoluta* with the exception of *Bacillus thuringiensis* which had on average mortality of 67.5%. The bio-insecticides *Verticillium lecanii* and azadirachtin had low efficacy against caterpillars with 14.4 and 10% average mortality respectively. In contrast, the bio-insecticides azadirachtin + neem oil (ANO) and azadirachtin + *Sophora flavescens* + emamectin benzoate gave mortality rates of 36% and 41%, respectively. This study also showed an ovicide effect of ANO which gave a 46.3% mortality.

## **Management of the tomato borer, *Tuta absoluta* with novel insecticides and plant extracts**

**Mohamed Braham and Lobna Hajji**

Centre régional de recherche en Horticulture et Agriculture Biologique.  
Laboratoire d'Entomologie - Ecologie. 4042. Chott-Mariem. Tunisia.

Tomato, *Lycopersicon esculentum* Mill is a vegetable crop of large importance in Tunisia. Since its detection, the tomato borer, *Tuta absoluta* Meyrick, (Lepidoptera : Gelechiidae) became a serious insect attacking both outdoor and glasshouse tomatoes. Its control relies mostly on insecticides; hence the diversification of active ingredients including natural products is urgently required. The efficacies of novel insecticides and plant extracts for the control of *T. absoluta* were investigated in Tunisia on tomatoes raised under glasshouse and in the laboratory in 2011. Under tomato glasshouse, the following products were evaluated: Ampligo 150ZS (Chlorantraniliprole + lambda-cyhalothrin), VoliamTargo 063 SC (chlorantraniliprole + abamectin), Tracer240 SC (spinosad), Nimbecidine (azadirachtine 0.03%), Tutafort (plant extracts), Vydate (oxamyl) and Biocatch (*Verticillium lecanii*). In the laboratory the compounds evaluated were: Ampligo 150ZS (Chlorantraniliprole + lambda-cyhalothrin), Movento OD (spirotetramat), Evisect SP (thiocyclam), Challenger SC (chlorfenapyr), Cyproma WP (cyromazine), Vydate (oxamyl), Armorex (plant extracts), Konflic (plant extracts) and Deffort (plant extracts). Field trials show the good efficacy of the following products Tracer, Nimbecidine, Biocatch, Voliam Targo, Tutafort and Vydate. However, laboratory trials demonstrate the good performance of Challenger, Ampligo, Movento, Armorex, Deffort and Konflic. The integration of these products in an integrated pest management approach is discussed.

## **Evaluation of the basic components for the protection of tomato crops against the tomato borer *Tuta absoluta* (Povolny) under glasshouses in Tunisia**

**Ahlem Harbi et Brahim Chermiti**

*High Agronomic Institute of Chott-Mariem, University of Sousse, Tunisia.*

The comparison of three strategies of plant protection in tomato crops cultivated under glasshouses against *Tuta absoluta* in the region of Teboulba in Tunisia based on the single use of proper insect-proof screens, or in association with either one sex pheromone water trap or with mass trapping and the release of *Nesidocoris tenuis* (Heteroptera: Miridae); allowed confirmation that the use of one sex pheromone water trap combined with insect-proof protected doors and aerations windows is sufficient to guarantee a good protection of the crop. This control system allowed to maintain an infestation rate under 23.33% and a mean number of mines below 1mine/leaf.

## **Comparative study of two protection strategies against *Tuta absoluta* (Povolny) in late open field tomato crops**

**Khaled Abbas, Ahlem Harbi et Brahim Chermiti**

*High Agronomic Institute of Chott-Mariem, University of Sousse, Tunisia.*

A comparative study of two protection strategies against *Tuta absoluta* in late open field tomato crops, the first conducted with integrated pest management (IPM) through mass trapping, the release of *Nesidiocoris tenuis* (Heteroptera: Miridae) and spraying with three compatible insecticides; while the second is based on conventional single use of synthetic insecticides with nine treatments. At the end of culture, the study revealed an infection rate of leaves of 20% in the IPM crop against 98% in the conventional one. Additionally,



the infestation rate of fruit was 18.2% in the IPM crop against 46.8% where only insecticides were used.

## TURKEY

### **Efficacy of 7 different insecticides on a population of *Tuta absoluta* from Turkey in laboratory bioassays**

**Fatih Dađlı, Cengiz İkten, Elvan Sert and Esra Bölücek**

*Akdeniz University, Faculty of Agriculture, Plant Protection Department, Antalya, Turkey.*

The tomato borer, *Tuta absoluta* (Meyrick), was first recorded in Turkey in August 2009. It has rapidly become a serious pest in the Mediterranean and Aegean coastal regions of Turkey in field and greenhouse grown tomatoes. Currently, insecticides are considered one of the major tool for the management of *T. absoluta* in Turkey. In current study, efficacies of 7 different insecticides, namely spinosad, chlorantraniliprole + abamectin, indoxacarb, metaflumizone, azadirachtin, abamectin and pyridalyl, were investigated against larvae of *T. absoluta* populations from Antalya, Turkey; in laboratory bioassays in 2011. To determine the LC values and feeding activity of the larvae, tomato leaf parts mined by 1-3 day old young larvae were dipped into a series of insecticide concentrations. Mortality and total leaf area fed were recorded after 5 days of insecticide treatments. Spinosad, chlorantraniliprole + abamectin, indoxacarb applications resulted in 100% mortality with minimal or no feeding in all populations at their recommended doses of 120, 50.4 and 60 mg a.i./ l, respectively. In general, the LC<sub>99</sub> values of populations for these insecticides were similar and lower than that of the recommended field doses. The effect of pyridalyl was low, resulting in low mortality with serious feeding damage at the dose of 125 mg (a.i.)/ l. The efficacies of abamectin, metaflumizone and azadirachtin were found to be moderate to low level at the recommended doses (4.5, 240 and 50 mg a.i./l, respectively). However, a 5 day monitoring for mortality of larvae may not be long enough to reveal the potential effects of abamectin, metaflumizone and azadirachtin for this pest. Therefore, pupation and adult emerge rates should also be monitored in bioassays employing these insecticides.

### **Current status of tomato borer (*Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Turkey**

**Tülin Kiliç**

*Plant Protection Research Station, Gençlik Caddesi No:6, 35040 Bornova, Izmir, TURKEY*

Turkey has suitable ecological and geographical conditions to produce high quality tomatoes throughout the year all over the country and one of the lead crop grown in country is tomato among other vegetables. Turkey tomato production was 10 052 000 tones in 2010. *Tuta absoluta* (Meyrick) (Lepidoptera:Gelechiidae) was firstly determined in Urla district of Izmir province (Turkey) in August 2009 by pheromone trap and visual inspections in tomato fields. Therefore, studies on the identification of infested areas have begun by pheromone traps and visual observations in other tomato production sites of Turkey. The pest, present in the quarantine list of EPPO, was mainly detected in the Aegean and Mediterranean basin, besides Marmara, Black Sea, South-eastern, Central and Eastern Anatolia Regions, gradually. Infested plants and host wild plants were destroyed by quarantine measures and technical

control instructions and the standard for efficacy evaluation of plant protection products were prepared. Four insecticides (azadirachtin, metaflumizone, spinosad, indoxacarb) were advised to use, temporarily. Seedling transport from infested to uninfested areas was prohibited. Certain difficulties have been faced in the management of the pest because of its damage in plant tissue and ability to produce many generations in a short period in warm climates such as Mediterranean. For this reason, financial support to the growers who applied biotechnical and biological control methods against *T. absoluta* has been given by the Ministry of Agriculture and Rural Affairs and also the IPM project on *T. absoluta* started. *Macrolophus caliginosus* Wagner and *Nesidiocoris tenuis* Reuter (Hemiptera: Miridae) were determined in outdoor and greenhouse crops, in Aegean and Mediterranean basins as predators of this pest. Using possibilities of predatory with parasitoids, side effects of the pesticides on these natural enemies, toxicities of the insecticides and the efficacy of mass trapping have been investigated in outdoor and greenhouse crops. Besides five insecticides (azadirachtin, chlorantraniliprole+abamectin, spinosad, metaflumizone, *Bacillus thuringiensis* var. kurstaki), one biological control agent (*Nesidiocoris tenuis*) and two commercial pheromone traps were registered during this period. More individual and cooperated researches are essential in order to control this pest and the cost effective practices derived from the results of these researches should be shared with tomato producers as soon as possible.

## UNITED KINGDOM

### **Investigating the molecular mechanisms of insecticide resistance in the tomato borer, *Tuta absoluta***

**Madeleine Berger<sup>1</sup>, Khalid Haddi<sup>2</sup>, Lin Field<sup>1</sup>, Martin Williamson<sup>1</sup>, Kevin Gorman<sup>1</sup>, Chris Bass<sup>1</sup>**

<sup>1</sup>Centre for Sustainable Pest and Disease Management, Rothamsted Research, Harpenden, AL5 2JQ, United Kingdom

<sup>2</sup>Dipartimento di Gestione dei Sistemi Agroalimentari e Ambientali, Sezione Entomologia Agraria, Catania, Italy

The tomato borer, *Tuta absoluta*, is an economically significant pest of tomatoes and has recently become a major problem for European tomato growers. Unfortunately, the intensive use of chemical insecticides has led to the development of resistance. To date, the molecular mechanisms underlying resistance in this pest have not been well characterised, however, research on other major crop pests has shown that insecticide resistance is most commonly caused by modification of the target-site protein or enhanced enzymatic detoxification. The latter results from the increased production of enzymes such as esterases, glutathione transferases and P450-dependent monooxygenases. In a studentship project commencing in October 2011, funded by the Biotechnology and Biological Sciences Research Council (BBSRC) of the UK, we will use state of the art post-genomic and molecular biology techniques to investigate insecticide resistance in this pest. High-throughput sequencing will generate a *T. absoluta* transcriptome and identify detoxification enzymes that are candidates for a role in insecticide resistance. This dataset will facilitate the design of a microarray to identify genes that are differentially transcribed between resistant and susceptible strains. The genomic resources developed in this project will be made publically available and are expected to be of significant value to the wider research community investigating the fundamental biology of *T. absoluta* and its interactions with plant hosts.

## SPONSORS AND PARTNERS

الجمعية المغربية



وزارة الفلاحة

