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## **IPM Systems**

### **Contents**

Preface ..... v

Contents ..... vii

### **IPM Systems**

Combining pathogens and predators of insects in biological control.  
*D. Gillespie, J. Brodeur, C. Cloutier, M. Goettel, P. Jaramillo, R. Labbe,*  
*R. Roitberg, C. Thompson (Alma), S. VanLaerhoven* ..... 3

Integrated pest and disease management for greenhouse-grown vegetable  
crops in Cyprus  
*N. Ioannou, N. A. Seraphides* ..... 9

Status of biological and integrated pest control in CA&ES research greenhouses  
at UC Davis: Successes, challenges, and costs  
*G. Pearson, R. Starnes, T. Costamagna, R. Lane, S. Silva, A. Almedhi,*  
*A. Rumsey, M. Parrella* ..... 15

A biological pest control story  
*J. A. Sanchez, A. Lacasa* ..... 19

Implementing a Geographical Information System (GIS) for pepper greenhouse  
natural enemy and pest management in Southeast Spain  
*F. Cánovas, A. Lacasa, J. A. Sanchez* ..... 25

Mise en place d'une protection biologique intégrée préventive contre les ravageurs  
des cultures de rosiers sous serre dans le sud de la France  
*J. Pizzol, C. Poncet, S. Hector, M. Ziegler* ..... 31

Reduction of pesticide use on plastic house cucumber in Varamin and Shahriar  
region of Tehran Province of Iran through Participatory IPPM. (Abstract)  
*A. Nasrollahi, M. S. Moghaddam* ..... 37

Mechanical distribution of beneficials: laboratory tests  
*G. Tropea Garzia, L. Zappalà, G. Siscaro, G. Blandini, S. Failla, G. Manetto* ..... 39

## Whiteflies

Bumble bees: An effective delivery system for microbial control agents for arthropod pest and disease management <i>L. Shipp, J.P. Kapongo, P. Kevan, J. Sutton, B. Broadbent</i> .....	47
Current situation of <i>Bemisia tabaci</i> in protected vegetables crops in the South of France <i>Y. Trottin-Caudal, C. Chabrière, C. Fournier, J. M. Leyre, L. Schoen</i> .....	53
Natural parasitism of <i>Bemisia tabaci</i> and <i>Trialeurodes vaporariorum</i> in an horticultural area of Sardinia, Italy <i>M. Nannini, L. Manca, M. Giorgini</i> .....	59
Alternative whitefly biocontrol options for greenhouse tomatoes <i>M. Nannini, F. Foddi, G. Murgia, R. Pesci, F. Sanna, S. Spanedda</i> .....	65
Releases of <i>Eretmocerus mundus</i> and <i>Macrolophus caliginosus</i> for controlling <i>Bemisia tabaci</i> on spring and autumn greenhouse tomato crops <i>R. Gabarra, R. Zapata, C. Castañe, J. Riudavets, J. Arnó</i> .....	71
<i>Amblyseius swirskii</i> (Acari: Phytoseiidae) as a biological control agent of the tobacco whitefly <i>Bemisia tabaci</i> (Horn.: Aleyrodidae) in protected sweet pepper crops in Southern Spain <i>J. Calvo, P. Fernández, K. Bolckmans, J. E. Belda</i> .....	77
Efficacy of the <i>Beauveria bassiana</i> strain ATCC 74040 (Naturalis®) against whiteflies on protected crops <i>F. Mayoral, M. Benuzzi, E. Ladurner</i> .....	83
Efficacy of the technical grade product and commercial formulation based on <i>Paecilomyces fumosoroseus</i> for controlling whitefly under laboratory conditions <i>A. Padilla-Cubas, S. Amador, E. Hernández-Suárez, A. Carnero, J. M. Lara, C. Fernández</i> .....	89
Evaluation of the effect of two potassium based products on <i>Bemisia tabaci</i> in greenhouse tomatoes <i>L. Schoen</i> .....	95
Imidacloprid as soil application against whitefly <i>Bemisia tabaci</i> in greenhouse cucumber. (Abstract) <i>V. Baniameri, A. Sheikhi</i> .....	101
Laboratory screening of pesticides against <i>Lecanoideus floccissimus</i> . (Abstract) <i>E. Hernández-Suárez, C. Ramos-Cordero, A. Carnero</i> .....	103
Does the PGPR <i>Bacillus subtilis</i> induce plant resistance to whiteflies and Phythium in greenhouse tomato? (Abstract) <i>A. Hanafi, K. Fellah</i> .....	105

## Mites

- Crop loss assessment of *Pediculaster fletcheri* (Acari: Pygmephoridae) on button mushrooms  
*K. Kheradmand, K. Kamali, Y. Fathipour, E. M. Goltapeh A. R. Nemati* ..... 109
- Biology of the two spotted spider mite, *Tetranychus turkestani* (Acari: Tetranychidae) on four common varieties of eggplant in Iran  
*E. Soleimannejadian, A. Nemati, P. Shishehbor, K. Kamali, V. Baniameri* ..... 115
- Efficacy of *Phytoseiulus persimilis* versus *Neoseiulus californicus* for controlling spider mites on greenhouse sweet pepper  
*P. Weintraub, S. Kleitman, N. Shapira, Y. Argov, E. Palevsky* ..... 121
- Identification of pollens for small scale mass rearing of *Neoseiulus californicus* and a novel method for quality control  
*Y. Argov, M. Berkeley, S. Domeratzky, E. Melamed, P. Weintraub, E. Palevsky* ..... 127
- Are spider mites aware of the presence of thrips?  
*B. Ahmadi, S. H. Goldansaz, A. Ashouri* ..... 133
- Effect of different types of prey on fecundity of the phytoseiid mite *Typhlodromips swirskii*, a potential biological control agent for horticultural greenhouse pests in the Canary Islands. (Abstract)  
*E. Hernández-Suárez, M. C. Velásquez, M. I. Paz-González, F. J. González, A. Carnero, F. J. Ferragut* ..... 137
- Feeding rate of *Stethorus gilvifrons* on *Tetranychus urticae* in three greenhouse cucumber cultivars with different resistance levels  
*N. Kheradpir, J. Khalghani, H. Ostovan, M R. Rezapanah* ..... 139

## Thrips, Leafminers, Aphids and Lepidoptera Pests

- Development of traps for monitoring thrips (Thysanoptera: Thripidae)  
*C C Chu, M A. Ciomperlik, M. Richards, T. J. Henneberry* ..... 147
- Preliminary field trials with the synthetic sexual aggregation pheromone of *Frankliniella occidentalis* on protected pepper and tomato crops in South-east Spain  
*M. Gómez, F. García, R. GreatRex, M. Lorca, A. Serna* ..... 153
- The addition of potassium silicate to the fertilizer mix to suppress *Liriomyza* leafminers attacking chrysanthemums  
*M. P. Parrella, T. Costamagna* ..... 159
- Natural parasitism of *Liriomyza sativae* (Diptera: Agromyzidae) on cucumber under field and greenhouse conditions  
*Y. Fathipour, M. Haghani, A. A. Talebi, V. Baniameri, A. A. Zamani* ..... 163

First data on the population dynamics of aphidophagous syrphids in Mediterranean pepper greenhouses <i>A. Pineda, M<sup>a</sup> Á. Marcos-García</i> .....	169
Evaluation of two aphid parasitoids as candidates for biocontrol of aphid pests in protected cultivation in Brazil. <i>V. H. P. Bueno, M. V. Sampaio, J. C. van Lenteren, B. F. De Conti, R. J. Silva, S. M. M. Rodrigues, A. B. Carnevale</i> .....	175
Host stage preference by <i>Aphidius colemani</i> and <i>Aphidius matricariae</i> (Hymenoptera: Aphidiidae) as parasitoids of <i>Aphis gosoypii</i> (Hemiptera: Aphididae) on greenhouse cucumber <i>A. A. Talebi, A. A. Zamani, Y. Fathipour, V Baniamერი, K. Kheradmand and M. Haghani</i> .....	181
The number of <i>Cotesia plutellae</i> needed to suppress the population growth of diamondback moth, <i>Plutella xylostella</i> , in a greenhouse <i>S. Urano, J. Abe, M. Matsumura, K. Nagasaka, J. Takabayasi</i> .....	187
Functional response of <i>Chelonus oculator</i> (Hym.: Braconidae) in greenhouse conditions: influence of the parasitoid release ratio. (Abstract) <i>M. García-Martin, M. Gámez-Cámara, A. Torres-Ruiz, T. Cabello</i> .....	191
<b>Generalist Predators</b>	
When does alternative food promote biological pest control? <i>M. W. Sabelis, P. C.J. Van Rijn</i> .....	195
Feeding behavior of the rove beetle, <i>Atheta coriaria</i> Kraatz (Coleoptera: Staphylinidae) under laboratory conditions <i>E. M. Birken, R. A. Cloyd</i> .....	201
The predatory bug <i>Orius niger</i> : its biology and potential for controlling <i>Thrips tabaci</i> in Iran <i>V Baniamერი, E. Soleyman-nejadian, J. Mohaghegh</i> .....	207
Predatory capacity and longevity of adults of <i>Orius thyestes</i> (Hemiptera, Anthocoridae) on different prey .....	201
<i>E. C. Pedroso, V. H. P. Bueno, R. J. Silva, A. R. Carvalho, A. J. F. Diniz, M. P. F. Silva, L. M. Carvalho</i> .....	211
Disinfection of oviposition substrate with sodium hypochlorite: effects on some biological traits of <i>Orius thyestes</i> <i>A. J. F. Diniz, V. H. P. Bueno, A. R. Carvalho, E. C. Pedroso, R. J. Silva, L. M. Carvalho</i> .....	215

Intraguild predation between <i>Orius insidiosus</i> and <i>Aphidius colemani</i> , and biological control of <i>Aphis gossypii</i> <i>L. S. R. Pierre, V. H. P. Bueno, M. V. Sampaio, J. C. van Lenteren, B. F. De Conti, M. P. F. Da Silva, L. C. P. Silveira</i> .....	219
Differentiation of <i>Macrolophus pygmaeus</i> (Rambur 1839) and <i>Macrolophus melanotoma</i> (Costa 1853) (Heteroptera: Miridae) based on molecular data <i>J. I. Martinez-Cascales, J. L. Cenis, J. A. Sanchez</i> .....	223
Reproductive traits of the generalist predator <i>Maerolophus caliginosus</i> <i>C. Castañé, O. Alomar, J. Riudavets, C. Gemenó</i> .....	229
Rearing predatory bugs using the brine shrimp <i>Artemia</i> sp. as alternative prey food. <i>J. Riudavets, J. Arnó, C. Castañé</i> .....	235
Investigation on the efficiency of a predator: a strategy beyond satiation <i>D. Perdiki, P. Labropoulos, D. Maselou, A. Fantinou</i> .....	241
Zoophytophagy of the plantbug <i>Nesidiocoris tenuis</i> in tomato crops in southeast Spain <i>J. A. Sanchez, M del Pino-Pérez, M. M. Davó, J. I. Martinez-Cascales, A. Lacasa</i> .....	243
Characterization of damage to tomato plants produced by the zoophytophagous predator <i>Nesidiocoris tenuis</i> <i>J. Arnó, C. Castañé, J. Riudavets, R. Gabarra</i> .....	249
Susceptibility to virus infection of candidate plants used to enhance predatory dicyphine (Heteroptera: Miridae) <i>I. Morales, J. A. Sanchez, O. Alomar, A. Lacasa, A. Fereres</i> .....	255
<b>Plant Diseases</b>	
Biological Control of <i>Fusarium oxysporum</i> fsp. <i>melonis</i> race 1.2 by cross protection <i>H. Chikh-Rouhou, J. M. Álvarez, R. González-Torres</i> .....	263
Evaluation of susceptibility of varieties of <i>Gerbera jamesonii</i> to Fusarium wilt <i>A. Minuto, D. Bertetti, M. L. Gullino, A. Garibaldi</i> .....	269
Efficacy of <i>Ampelomyces quisqualis</i> isolate M-10 (AQ 10®) against powdery mildews (Erysiphaceae) on protected crops <i>M. Benuzzi, E. Ladurner, F. Mayoral</i> .....	275
Quantification of powdery mildew removal by the mycophagous beetle <i>Psyllobora vigintimaculata</i> (Coleoptera: Coccinellidae) <i>A. M. Sutherland, M. P. Parrella</i> .....	281
UV interfering nets reduce TYLCD incidence and progress in tomato crops: influence of host genotype <i>L. Velasco, D. Janssen, M. Catalá, J. Costa</i> .....	287

Iris yellow spot virus (IYSV): a new disease in Spain  
C. Córdoba, L. Martínez-Priego, R. Muñoz, C. Jordá ..... 293

Identification and determination of transmission ability of thrips species as vectors  
of two tospovirus, tomato spotted wilt virus (TSWV) and impatiens necrotic  
spot virus (INSV), on ornamental plants in Iran. (Abstract)  
T. Ghotbi, V. Baniaméri ..... 297

### Soil-borne Diseases

Effect of soil disinfestation on fungi in greenhouses planted with sweet peppers  
M. Á. Martínez, A. Lacasa, M. M. Guerrero, C. Ros, M. C. Martínez, P. Bielza, J. Tello .. 301  
Biofumigation as a technique for the control of pathogenic viruses and bacteria  
M. J. Zanón, J. C. Vilaseca, M.I. Font, C. Jordá ..... 307

Biofumigation vs. biofumigation plus solarization to control *Meloidogyne incognita*  
in sweet pepper  
M. M. Guerrero, C. Ros, M. A. Martínez, M. C. Martínez, A. Bello, A. Lacasa ..... 313

Integrated management of *Meloidogyne* resistance in sweet pepper in greenhouses  
C. Ros, M. M. Guerrero, M. A. Martínez, A. Lacasa, A. Bello ..... 319

Effect of organic amendments of *Ricinus communis* and *Azadirachta indica*  
on root-knot nematodes *Meloidogyne javanica* infecting tomatoes in Morocco  
Z. Ferji, E. H. Mayad, T. Laghdaf, E. M. Cherif ..... 325

### Natural Pesticides and Side Effects on Beneficials

Effects of natural insecticides on *Frankliniella occidentalis* and *Orius* spp  
J. Contreras, V. Quinto, J. Abellán, E. Fernández, C. Grávalos, L. Moros, P. Bielza ..... 331

Insecticidal activity of essential oil from *Vitex pseudo-negundo* against  
*Brevicoryne brassicae*  
S. Moharramipour, B. Z. Sahaf ..... 337

Evaluation de l'effet nématicide de l'extrait méthanolique de quelques plantes  
médicinales au Maroc  
E. H. Mayad, Z Ferji, L. M I. Hassani ..... 343

Side effects of pesticides on *Orius insidiosus* (Hemiptera: Anthocoridae)  
G. A. Carvalho, V. H. P. Bueno, A. P. Moura, L. C. D. Rocha, F. Z. V. Torres ..... 349

Side effects of pesticides on *Trichogramma pretiosum* (Hymenoptera: Trichogrammatidae)  
G. A. Carvalho, A. P. Moura, V. H. P. Bueno ..... 355

Compatibility of *Hyposoter didymator*, an endoparasitoid of *Spodoptera littoralis*,  
with several insecticides used on horticultural crops  
J. J. Morales, P. Medina, E. Viñuela ..... 361

## **Combining pathogens and predators of insects in biological control**

**Dave Gillespie<sup>1</sup>, Jacques Brodeur<sup>2</sup>, Conrad Cloutier<sup>3</sup>, Mark Goettel<sup>4</sup>, Patricia Jaramillo<sup>5</sup>, Roselyne Labbe<sup>6</sup>, Bernie Roitberg<sup>5</sup>, Colleen Thompson (Alma)<sup>5</sup>, Sherah VanLaerhoven<sup>7</sup>**

<sup>1</sup>*Agriculture and Agri-Food Canada, Research Centre, POB 1000, Agassiz, British Columbia,*  
<sup>2</sup>*Centre de Recherche en Horticulture, Université Laval, Québec, Québec,* <sup>3</sup>*Département de Biologie, Université Laval, Québec, Québec,* <sup>4</sup>*Agriculture and Agri-Food Canada Research Centre, POB 3000, Lethbridge, Alberta,* <sup>5</sup>*Department of Biology, Simon Fraser University, 8888 University Drive, Burnaby, British Columbia,* <sup>6</sup>*Institut de Recherche en Biologie Végétale, Département des Sciences Biologiques, Université de Montréal, Montréal, Québec,* <sup>7</sup>*Department of Biology, University of Windsor, 401 Sunset Ave, Windsor, Ontario, Canada.*

**Abstract:** When multiple natural enemies are used for biological control, the contribution of each to the combined mortality of the target is of concern. Using a functional response model, we show that, for the special case of a predator foraging after application of a microbial insecticide, competition should reduce the efficiency of the predator and result in a combined prey mortality that is less than additive over short intervals. We summarize results from three recent studies with microbial insecticides in combination with predators. Over time scales in excess of one generation, numerical response of the predator can reduce the importance of competition in these studies.

## **Integrated pest and disease management for greenhouse-grown vegetable crops in Cyprus**

**Nicolaos Ioannou, Nicos A. Seraphides**

*Agricultural Research Institute, 1516 Nicosia, 22016 Cyprus*

**Abstract:** This study was carried out for three consecutive years at Zygi Experimental Station in Cyprus, with main objective to develop effective IPM programs for tomato, cucumber and pepper under greenhouse conditions. The study was carried out in two heated plastic greenhouses, one undergoing conventional pest management (CPM), based mainly on preventive chemical treatments applied on schedule, and the other under an IPM program, based primarily on the following elements: insect-proof construction of the greenhouse and mass trapping for managing insect pests and insect-borne viruses, weekly monitoring of plants for pests and diseases, soil solarization for control of soil-borne pathogens and pests and automatic mechanical regulation of the greenhouse environment for control of air-borne fungal and bacterial diseases. The main pests encountered in both greenhouses were the whitefly *Bemisia tabaci*, aphids and thrips. In the IPM greenhouse, insect populations were significantly lower compared to the CPM greenhouse. Soil-borne diseases were effectively controlled under both regimes. Similarly, no major virus or bacterial problems were encountered in either greenhouse. The most important fungal diseases were downey mildew on cucumber, and botrytis, sclerotinia and powdery mildew on all three crops. With the exception of powdery mildew, all air-borne fungal diseases were effectively controlled in the IPM greenhouse, enabling a reduction of pesticide applications by about 50%, compared to the CPM greenhouse.

## **Status of biological and integrated pest control in CA&ES research greenhouses at UC Davis: Successes, challenges, and costs**

**Garry Pearson, Robert Starnes, Thomas Costamagna, Ron Lane, Steve Silva, Ali Almedhi, Andy Rumsey, Michael Parrella**

*College of Agricultural and Environmental Sciences, University of California, Davis, CA 95616, USA*

**Abstract:** UC Davis is the major land grant research and teaching university within the ten campus University of California system. With almost 1500 faculty, 31,000 undergraduate and 5,000 graduate students, requests for greenhouse space on the campus are varied and complicated. We recently centralized all greenhouse space (approximately 150,000 sq. ft.) with the intent of increasing availability of space in addition to standardized overall greenhouse maintenance, including pest control. A major objective has been to reduce pesticide use and increase the use of biological control. Greenhouse pests originate primarily from outdoors or are introduced through specialized research projects. Past methods of pest control have been the use of organophosphates, carbamates or other broad spectrum pesticides. The UC Davis Greenhouse Operations Staff has embarked on an ambitious program to use biological control in several key research and teaching greenhouse crops.

### **A biological pest control story**

**Juan Antonio Sanchez, Alfredo Lacasa**

*Department of Biotechnology and Crop Protection, Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario (IMIDA), C/Mayor s/n, 30150 La Alberca, Murcia, Spain.  
E-mail: juana.sanchez23@carm.es*

**Abstract:** The use of biological pest control and IPM has quickly spread in pepper greenhouses in Campo de Cartagena (Spain) in the last ten years. IPM is currently applied in 90% (1,600 ha) of the greenhouse surface. The development of biological pest control in Campo de Cartagena is especially relevant for the whole Mediterranean area because it was possible despite of the high risk of pest outbreaks and the high incidence of insect-borne diseases (*Frankliniella occidentalis*-Tomato spotted wilt virus, TSWV). The first trials to investigate the potential of native *Orius* spp. for controlling *F. occidentalis* in Campo de Cartagena were carried out in 1994 in experimental greenhouses at the IMIDA research station. In the following years, the use of natural enemies was optimised and the economic viability of the program was tested. Further assays were carried out to study the epidemiology of TSWV and to establish cultural practices to reduce the incidence of this virus. The adoption of IPM strategies greatly reduced the use of pesticides. The incidence of TSWV experienced a great reduction in the years following the establishment of biological pest control: the incidence of the virus in IPM greenhouses in 2002 and 2003 was 1.2% and 0.87%, respectively.

## Implementing a Geographical Information System (GIS) for pepper greenhouse natural enemy and pest management in Southeast Spain

**Fernando Cánovas, Alfredo Lacasa, Juan Antonio Sanchez**

*Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario (IMIDA),  
Department of Biotechnology and Crop Protection, c/ Mayor, s/n, 30150 La Alberca, Murcia,  
Spain. E-mail: juana.sanchez23@carm.es*

**Abstract:** Biological pest control is applied in 90% of protected pepper crops in Campo de Cartagena (Southeast Spain). The quick transition from chemical to biological pest control methods was motivated in part by problems in controlling western flower thrips, *Frankliniella occidentalis*, using pesticides. Decision-making in greenhouses under biological pest control is based on periodical sampling that generates a great amount of information which can be stored and analysed using Geographical Information Systems (GIS). The aim of this work was to show the application of GIS in optimising management strategies in greenhouse pepper crops; *Orius laevigatus* release was analysed in relation to *F. occidentalis* and *Orius* spp. spatio-temporal population dynamics. Thrips and *Orius* spp. population abundance data were gathered weekly for 137-412 greenhouses in a 64 square km area. Greenhouses were located using Global Positioning System (GPS) and satellite digital images. Inverse distance weighted (IDW) interpolation was performed to estimate *F. occidentalis* and *Orius* spp. incidence at non-sampling points. *F. occidentalis* and *Orius* spp. showed an uneven geographical abundance distribution through time. High *F. occidentalis* incidence (percentage of occupied flowers) was in correspondence with areas of late *O. laevigatus* establishment. *O. laevigatus* was released during April, May and June in areas where it was already successfully established. GIS may be used to optimise *O. laevigatus* releases according to population dynamics.

## Mise en place d'une protection biologique intégrée préventive contre les ravageurs des cultures de rosiers sous serre dans le sud de la France

*Preventive IPM for greenhouse roses in the South of France*

**Jeannine Pizzol, Christine Poncet, Sandy Hector, Michel Ziegler**

INRA - URIH - 400, route des Chappes - BP 167 - 06 903 Sophia-Antipolis Cedex - France -

E-mail: [pizzol@antibes.inra.fr](mailto:pizzol@antibes.inra.fr)

**Résumé:** Le thrips, *Frankliniella occidentalis* et l'acarien, *Tetranychus urticae* sont les principaux ravageurs des cultures de rosiers sous serre, tout particulièrement en climat méditerranéen. Pendant l'été 2005, une stratégie biologique préventive fondée sur une succession raisonnée de lâchers d'auxiliaires a été testée sur rosiers en serre. Cette stratégie a permis d'éviter tout traitement chimique contre les ravageurs sur cette culture, de début juin à décembre 2005, soit plus de six mois incluant la période de risque maximal. Ces résultats nécessitent d'être confirmés dans différentes situations de production et la méthodologie employée peut être optimisée du point de vue du rapport coût/efficacité. Néanmoins, le niveau de protection déjà obtenu laisse entrevoir de réelles possibilités pour la mise en place d'une telle stratégie sur le rosier en serre.

**Abstract:** *Frankliniella occidentalis* Pergande and *Tetranychus urticae* Koch are the most serious pests on roses in greenhouses, particularly under Mediterranean climate. During the summer of 2005, a preventive biological control strategy founded on a well-planned succession of releases of predatory mites was tested. This strategy made it possible to avoid any chemical treatment against these pests from the beginning of June until December, more than six months including the period of maximum risk. This result has to be confirmed in various situations and the control method has to be optimized for cost/efficiency ratio. Nevertheless, the level of protection already obtained shows real possibilities for using such a strategy on roses under glass.

## **Reduction of pesticide use on plastic house cucumber in Varamin and Shahriar region of Tehran Province of Iran through Participatory IPPM**

**Abbas Nasrollahi, Mohammad S. Moghaddam**

*Department of Biotechnology, Iranian Research Organization for science & Technology,  
POBox 15815-3538 Tehran 15819 Iran [nasrollahi@irost.org](mailto:nasrollahi@irost.org)*

**Abstract:** Use of pesticides on greenhouse cucumbers in Iran has increased dramatically because of high infestation of diseases and pests, and due to lack of knowledge by growers. Use of IPM techniques by teaching the growers or selecting a strategy for pest control by extension workers usually does not work very well, unless the growers can see something such as use of biocontrol agents or etc. and then believe it. Even though, several thousands hectares of land are under greenhouse cultivation and the main crop is seedless cucumber. In general the average sizes of greenhouses are not very big and most of them are less than one hectare. Implementation of IPM programmes is a hard task because growers would not accept readily what you tell them, and they can not employ an agriculture specialist in their fields. For this reason we shifted from conventional methods to IPPM methods (Integrated Participatory Protection and Production Management) through FFS (Farmer Field Schools) and we followed the following criteria: 1) Production of healthy crop; 2) Protection of ecosystem by stakeholders; 3) Empowerment of stakeholders to understand what is going on in the field where they work; 4) Growers become experts. In the process of the work one plant protection specialist were assigned as facilitator and then we chose several agricultural graduates to do the job as TOTs (training of trainers) under the supervision of a facilitator and at the same time they could work in greenhouses to disseminate the IPPM knowledge to the growers. Greenhouse structure in these regions usually is not standard and ventilation does not take place very efficiently. Powdery mildew and downy mildew are big problems, and impose sever loses. Growers have to spray many times to overcome these losses. In the Varamin region growers usually do not do soil testing and rarely soil sterilization. They sow the seeds directly in the soil, but by implementing transplanting procedure damping off will be reduced in this way by almost 90%. Therefore, the use of fungicides will be eliminated except? in severe cases because they usually will use sterile soil in transplanting. In general, the problem which now exists throughout Iran is the dependency of all growers on chemicals pesticides for greenhouse crop protection, which poses severe contamination on harvested crops that can be eliminated to large extent by just only educating the growers. The mentioned problems are true for all regions in Iran, but nowadays people are realizing the danger of chemical pesticide residues in their food and the demand is toward chemical-free? goods. We believe the best solution for cutting pesticide use at the present time is to educate growers and let them to experiment and then believe they decide then proper measure for controlling the pests and diseases by IPPM method in greenhouses.

## Mechanical distribution of beneficials: laboratory tests

Giovanna Tropea Garzia<sup>1</sup>, Lucia Zappalà<sup>1</sup>, Gaetano Siscaro<sup>1</sup>, Giacomo Blandini<sup>2</sup>,  
Sabina Failla<sup>2</sup>, Giuseppe Manetto<sup>2</sup>

<sup>1</sup>Dipartimento di Scienze e Tecnologie Fitosanitarie, University of Catania, Via Santa Sofia 100, 95123 Catania, <sup>2</sup>Dipartimento di Ingegneria agraria, University of Catania, Via Santa Sofia 100, 95123 Catania, Italy.

**Abstract:** A first version prototype was projected and evaluated, in order to mechanically release *Phytoseiulus persimilis* and *Orius laevigatus*, commonly employed in biological and integrated control programs on protected vegetable crops. This machine was used to release the beneficials which were placed, together with the carrier material present inside the bottles (vermiculite and buckwheat husk), into a hopper equipped with a distributor. Preliminary trials were conducted under laboratory conditions to evaluate the vitality and the damages eventually caused to the predators and to determine the range of action of the machine at different working rates. No physical damages to the arthropods limiting their mobility and vitality were observed. Also the distribution, evaluated on a horizontal surface, seems to be suitable for applications in biological control programs.

## Bumble bees: An effective delivery system for microbial control agents for arthropod pest and disease management

Les Shipp, Jean Pierre Kapongo, Peter Kevan, John Sutton, Bruce Broadbent

Agriculture and Agri-Food Canada, Harrow, Ontario, Canada N0R 1G0; University of Guelph, Guelph, Ontario, Canada N1G 2W1; Agriculture and Agri-Food Canada, London, Ontario, Canada N5V

**Abstract:** Greenhouse trials were conducted to determine the optimal concentration of *Beauveria bassiana* (Botanigard 22WP<sup>®</sup> formulation) as vectored by the bumble bee (*Bombus impatiens*) pollinator for control of greenhouse sweet pepper pests (tarnished plant bug, *Lygus lineolaris* and green peach aphid, *Myzus persicae*) and the tomato pest (greenhouse whitefly, *Trialeurodes vaporariorum*), and the impact of *Beauveria* on *B. impatiens*. Three concentrations of *Beauveria*: low ( $9 \times 10^9$ ), mid ( $6.24 \times 10^{10}$ ), and high ( $2 \times 10^{11}$ ) conidia/g of inoculum and two control treatments were evaluated. Infection levels in all pests species by *Beauveria* were the greatest at the two higher concentrations of *Beauveria*. However, bee mortality was significantly greater at the highest *Beauveria* concentration ( $2.0 \times 10^{11}$  conidia/g of inoculum). Thus, the concentration of  $6.24 \times 10^{10}$  *Beauveria* conidia/g of inoculum provided optimal pest control and had the least negative impact on the bees. Also, *B. impatiens* demonstrated the ability to effectively disseminate two fungal control agents (*B. bassiana* and *Clonostachys rosea*) simultaneously for both insect pest and plant pathogen control.

## Current situation of *Bemisia tabaci* in protected vegetables crops in the South of France.

Yannie Trottin-Caudal<sup>1</sup>, Catherine Chabrière<sup>2</sup>, Christine Fournier<sup>1</sup>, Jean-Michel Leyre<sup>1</sup>, Leen Schoen<sup>3</sup>

<sup>1</sup>Centre Technique Interprofessionnel des Fruits et des Légumes, BP 32, 30127 Bellegarde, [trottiny@ctifl.fr](mailto:trottiny@ctifl.fr), [fournier@ctifl.fr](mailto:fournier@ctifl.fr), [leyre@ctifl.fr](mailto:leyre@ctifl.fr) <sup>2</sup>Association Provençale de Recherche et Expérimentation Légumière, Route de Mollégès, 13210 St Rémy de Provence, [chabriere@aprel.asso.fr](mailto:chabriere@aprel.asso.fr). <sup>3</sup>Centre Expérimental des Fruits et Légumes du Roussillon, 66440 Torreilles, France, [l.schoen@centrex66.com](mailto:l.schoen@centrex66.com)

**Abstract:** In 2001, IPM protected crops represented about 1800 ha in France, mainly tomatoes and cucumbers. The whitefly *Bemisia tabaci*, a pest and virus vector, was detected in 2001 in the South of France on different protected crops (tomato, cucumber but also on melon, courgette, eggplant and pepper). Its presence forced us to take measures and to provide more information to growers. Studies have been rapidly carried out in experimental and commercial greenhouses to better understand this pest and develop adequate control strategies. First results seem to prove that only the combination of beneficials with preventive measures could be efficient.

## Natural parasitism of *Bemisia tabaci* and *Trialeurodes vaporariorum* in a horticultural area of Sardinia, Italy

Mauro Nannini<sup>1</sup>, Lorena Manca<sup>1</sup>, Massimo Giorgini<sup>2</sup>

<sup>1</sup>Centro Regionale Agrario Sperimentale, V.le Trieste 111, 09123 Cagliari, E-mail: [laiu@cras.sardegna.it](mailto:laiu@cras.sardegna.it) <sup>2</sup>Istituto per la Protezione delle Piante – Sezione di Portici, C.N.R., Via Università 133, 80055 Portici (NA), Italy, E-mail: [giorgini@ipp.cnr.it](mailto:giorgini@ipp.cnr.it)

**Abstract:** A three-year survey was carried out in southern Sardinia (Pula, Cagliari) to assess natural whitefly parasitism on greenhouse tomatoes and to evaluate the contribution of parasitic wasps as biocontrol agents for *Bemisia tabaci* on other crops and weeds. The rates of apparent parasitism on protected tomato crops were low, reaching 18.8% in the most favourable of cases. The role played by parasitoids for the control of *B. tabaci* varied greatly among cultivated and weed species. Seven species of Aphelinid parasitic wasps were found to be associated with whiteflies. On this basis, the agroecosystem examined could be regarded as quite rich in terms of parasitoid species. This positive precondition did not, however, make a decisive contribution to whitefly management.

## Alternative whitefly biocontrol options for greenhouse tomatoes

**Mauro Nannini, Francesco Foddi, Giovanni Murgia, Riccardo Pesci, Francesco Sanna, Salvatore Spanedda**

Centro Regionale Agrario Sperimentale, Viale Trieste 111, 09123 Cagliari, Italy, E-mail: laiu@cras.sardegna.it

**Abstract:** An experiment has been carried out in Southern Sardinia (Pula, Cagliari) to evaluate the effectiveness of alternative options for whitefly biocontrol in greenhouse tomatoes. Four release programmes were carried out on different spring crops: (1) 2.0 *Macrolophus caliginosus*/m<sup>2</sup>, (2) 1.6 *M. caliginosus*/m<sup>2</sup> provided with *Ephestia kuehniella* eggs as alternative food source, (3) 1.0 *M. caliginosus*, 8.0 *Encarsia formosa* and 8.0 *Eretmocerus mundus*/m<sup>2</sup>, and (4) 16.0 *E. formosa* and 16.0 *E. mundus* / m<sup>2</sup>. The establishment of natural enemies was poor (mirid bugs) or failed completely (parasitic wasps), presumably owing to unfavourable climatic conditions, low prey/host availability and severe plant de-leafing. Consequently, the beneficials released to control whitefly did not produce satisfactory results. Differences in predatory bug abundance were observed in greenhouses with different leaf removal regimens. The results suggest that further work is necessary to adapt whitefly biocontrol tactics to the cultural practices and climatic conditions existing in tomato greenhouses in Sardinia.

## Releases of *Eretmocerus mundus* and *Macrolophus caliginosus* for controlling *Bemisia tabaci* on spring and autumn greenhouse tomato crops

**Rosa Gabarra, Rafael Zapata, Cristina Castañé, Jordi Riudavets, Judit Arnó**

Plant Protection Department, IRTA Centre de Cabrils, E-08348 Cabrils (Barcelona), Spain

**Abstract:** *Bemisia tabaci* is an important tomato pest in Mediterranean greenhouses and open field crops because it can build up important populations and can vector some important viral diseases. Biological control is necessary to improve *B. tabaci* control since this whitefly has become resistant to many available insecticides. We studied the efficacy of using two natural enemies, *Eretmocerus mundus* and *Macrolophus caliginosus*, either individually or in combination to control this whitefly on greenhouse tomatoes in spring and autumn crop cycles. *E. mundus* was effective in reducing whitefly populations in both crop cycles. However, the greatest reduction in terms of both adults and nymphs of *B. tabaci* was achieved with the combined use of *E. mundus* and *M. caliginosus*, especially in spring and with high whitefly populations. Releases of both natural enemies prevented adult whitefly emergence and the establishment of predators permitted to control subsequent crop colonization by whitefly.

## ***Amblyseius swirskii* (Acari: Phytoseiidae) as a biological control agent of the tobacco whitefly *Bemisia tabaci* (Hom.: Aleyrodidae) in protected sweet pepper crops in Southern Spain.**

**Javier Calvo<sup>1</sup>, Paloma Fernández<sup>1</sup>, Karel Bolckmans<sup>2</sup>, José Eduardo Belda<sup>1</sup>.**

<sup>1</sup>Departamento I+D, Koppert Biological Systems, P.O. BOX 286, 28880 Águilas (Murcia), Spain E-mail: jcalvo@koppert.es. <sup>2</sup>Koppert Biological Systems, P.O. BOX 155, 2650 AD Berkel en Rodenrijs, The Netherlands.

**Abstract:** The tobacco whitefly *Bemisia tabaci* is a key pest in horticultural crops in Southern Spain including sweet pepper. The parasitoid *E. mundus* is now the basis of biological control of tobacco whiteflies in biocontrol based IPM programs in sweet pepper crops in Spain. Nevertheless in case of high infestation levels of *B. tabaci* in sweet pepper crops chemical pesticides are usually needed in combination with *E. mundus*. Using incompatible pesticides can seriously hamper the establishment and development of *E. mundus* and other natural enemies in the crop. Therefore more effective biological control programs are needed. The focus of this study was to investigate the possibilities of the phytoseiid predatory mite *A. swirskii* as a biological control agent of *B. tabaci* in protected sweet pepper crops in Southern Spain. First the efficacy of *A. swirskii* was tested under semi-field conditions by releasing a total of 8 adults of *B. tabaci*/plant and comparing three release rates of the predatory mite *A. swirskii* (0, 25 and 100 *A. swirskii*/m<sup>2</sup>). In a second trial conducted under semi-field conditions, 4 different biological control strategies were compared: strategy “EM”, receiving 24 *E. mundus*/m<sup>2</sup>; strategy “NT”, receiving 24 *E. mundus* /m<sup>2</sup> and 2 *N. tenuis*/plant; strategy “AS”, receiving 12 *E. mundus* /m<sup>2</sup> and 50 *A. swirskii*/m<sup>2</sup>; and strategy “MIX”, receiving 12 *E. mundus*/m<sup>2</sup>, 50 *A. swirskii*/m<sup>2</sup> and 2 *N. tenuis*/plant. The plants were infested by releasing a total of 50 adults of *B. tabaci* per plant. Finally, the efficacy and establishment of *A. swirskii* against *B. tabaci* in sweet pepper were studied under field conditions. Under semi field conditions *A. swirskii* at a release rate of 25 and 100 mites/m<sup>2</sup> was able to suppress almost totally, a initial infestation of 8 *B. tabaci* adults per plant. The combination of 50 *A. swirskii*/m<sup>2</sup> and 12 *E. mundus*/m<sup>2</sup>, was the most efficient strategy against an initial infestation of 50 adults of *B. tabaci* per plant. These results were confirmed under field conditions, where the population of *B. tabaci* was always controlled very well in the plots where *A. swirskii* was released compared to the plots where the mite was not released. According to these results, *A. swirskii* proves to be a great candidate as biological control agent against *B. tabaci* in protected sweet pepper crops in Southern Spain making the control of *B. tabaci* possible by only using biocontrol agents, even in case of high infestation levels.

## Efficacy of the *Beauveria bassiana* strain ATCC 74040 (Naturalis®) against whiteflies on protected crops

Fernando Mayoral<sup>1</sup>, Massimo Benuzzi<sup>2</sup>, Edith Ladurner<sup>2</sup>

<sup>1</sup>Agrichem Bio S.A., Plaza Castilla 3-14 A, E-28046 Madrid, Spain; <sup>2</sup>Intrachem Bio Italia S.p.A., R&D Department, Via Calcinaro 2085/7, I-47023 Cesena, Italy

**Abstract:** In 2004, the efficacy of the *B. bassiana*-based bioinsecticide, applied at different doses, in controlling whiteflies was tested on protected tomato in Italy and on greenhouse eggplant in Spain. In Italy on tomato, all *B. bassiana* treatments, irrespective of the dose (doses tested: 125, 250, and 300 ml/hl), significantly reduced the whitefly infestation compared to the untreated control, with their efficacy ranging from 72.3 to 82.8%. Similar results were obtained in Spain on eggplant: all *B. bassiana* treatments significantly reduced the whitefly infestation compared to the untreated control, but a significant dose-response effect was recorded. The efficacy of Naturalis alone at 200 ml/hl was lower than that of the chemical imidacloprid-based reference product, of the bioinsecticide applied at the same dose in tank mixture with an adjuvant, and of the biocontrol agent alone at 300 ml/hl. However, when the product was applied at 200 ml/hl in tank mixture with the adjuvant and alone at 300 ml/hl, its efficacy was always comparable to that of the chemical standard. These trials, conducted on two different crops in two different mediterranean countries, confirm the results of previous trials carried out in other countries and on other crops: the *B. bassiana*-based product Naturalis is an efficient tool for controlling whitefly infestations on protected crops.

## Efficacy of the technical grade product and commercial formulation based on *Paecilomyces fumosoroseus* for controlling whitefly under laboratory conditions

Ángeles Padilla-Cubas<sup>1</sup>, Soledad Amador<sup>1</sup>, Estrella Hernández-Suárez<sup>1</sup>, Aurelio Carnero<sup>1</sup>, José Manuel Lara<sup>2</sup>, Carolina Fernández<sup>2</sup>

<sup>1</sup>Entomology Dpt., Instituto Canario de Investigaciones Agrarias (ICIA), Crta del Boquerón, 38080 La Laguna, Tenerife, <sup>2</sup>Research and Development Dpt., FuturEco S.L., Aragón 264, 5<sup>o</sup> 2<sup>a</sup>, 08007 Barcelona, Spain

The effects of the BCA *Paecilomyces fumosoroseus* strain FE 9901 on eggs and immature stages (N<sub>1</sub> and N<sub>4</sub>) of whiteflies *Trialeurodes vaporariorum* and *Bemisia tabaci*, was assessed under laboratory conditions. The ability to produce infections was compared between the technical grade product of BCA (freeze dried blastospores) and the commercial formulation (freeze dried blastospores plus adjuvants) named as FUTURECO NOFLY™. The immature whitefly individuals were exposed to fungus on tomato leaf discs sprayed with water suspensions of both products. The fungus susceptibility of immature stages of both whitefly species was the same except in eggs, where *T. vaporariorum* was more susceptible (70-80%) than *B. tabaci* (40-60%) and there were statistical differences between the formulation and the technical product in the capacity to infect *B. tabaci* eggs. The efficacy of *P. fumosoroseus* strain FE 9901 to produce mortality on N<sub>1</sub> and N<sub>4</sub> nymphal stages, was essentially the same (98-100%) when applied as either technical product (freeze dried blastospores), or as a commercial formulation. The selected adjuvants neither interfere with the mode of action of the fungus, nor have insecticide properties by themselves.

## Evaluation of the effect of two potassium based products on *Bemisia tabaci* in greenhouse tomatoes

**L. Schoen**

Sica CENTREX, 66440 Torreilles, France [l.schoen@centrex66.com](mailto:l.schoen@centrex66.com)

**Abstract:** Since the introduction of *Bemisia tabaci* Q type combined with several transmitted viruses in France the need of corrective compounds to manage the populations of this insect is very important. Several trials have been conducted with a multitude of pesticides and two Kalium-based products have been chosen for further investigations. The advantage of these products is their low toxicity for mammals and their possible integration in IPM programs under certain conditions. The results of the presented trials showed an interesting possible use of these products against *B. tabaci* and an important side-effect on *Oidium neolycopersici*.

## Imidacloprid as a soil application against whitefly *Bemisia tabaci* in greenhouse cucumber

**V. Baniameri, A. Sheikhi**

Plant Pests and Diseases Research Institute (PPDRI), P. O. Box: 19394/1454, Tehran, Iran.

**Abstract:** *Bemisia tabaci* is a serious pest of cucumbers in all greenhouses in Iran. The effect on *B. tabaci* of three different concentrations of Imidacloprid (Confidor 350 SC) (0.25, 0.50, and 0.75 ml/l) and a control treatment was tested in soil application. A Completely Randomized Block Design with 4 replications was applied. The percent mortality of larvae and decrease of eggs were analyzed after correcting by the Henderson-Tilton formula. After 7 days, the mean effect of 0.25ml/l of Imidacloprid on eggs and larvae were  $58.87 \pm 6.42$  % and  $43.81 \pm 6.9$  % mortality respectively. For the dose 0.75 ml/l were  $67.03 \pm 5.83$  % and  $50.56 \pm 5.5$  % mortality respectively. The mean decrease of egg numbers in leaf in concentration 0.75 ml/l was  $98.09 \pm 0.48$  % in 30 days. The comparison of means showed that there is no significant difference among treatments, but there is a significant difference with the control. According to our results, a dosage of 0.25 ml/l of imidocloprid was recommended in soil application, only at planting time and gets the final results 30 days after application. (*Abstract only*).

## Laboratory screening of pesticides against *Lecanoideus floccissimus*

**Estrella Hernández-Suárez, Carina Ramos-Cordero, Aurelio Carnero**

*Entomology Department, Instituto Canario de Investigaciones Agrarias (ICIA). Ctra del Boquerón s/n, 38080 La Laguna, Tenerife-(Canary Islands), Spain*

**Abstract:** *Lecanoideus floccissimus* Martin *et al.* is a major pest in commercial banana greenhouses of the Canary Islands. Infestations on banana can be extremely heavy all year around, causing enormous damage to the plants and fruits. The most representative damage of this whitefly species is the development of black sooty mould fungi on plants due to the copious white flocculent wax secreted by nymphs, as well as the abundant excretion of whitefly honeydew. Although, chemical control against *L. floccissimus* is not practicable for long term and stable management of this pest, information on effective pesticides is important for commercial banana growers before a Classical Biological Control Programme can be implemented. We present the effects of eighteen foliar applied pesticides on *L. floccissimus* eggs and nymphal stages. Detached leaf-disc bioassays were conducted under controlled conditions (25±2°C, 60±5% R.H., 16L:8D) in the laboratory. In the study we evaluated only active ingredients authorized for Integrated and Organic banana production in the Canary Islands, i.e.: insecticidal soaps, horticultural mineral and vegetable oils, neem products containing azadirachtin, malathion and chlorpyrifos. Results indicated that there was significant difference (P<0.05) in the effectiveness of the different products evaluated but dependent on the whitefly instar. *L. floccissimus* eggs were much less affected by any of the products used than nymphal stages. Among the eighteen products evaluated, malathion 50% p/v and chlorpyrifos 48% gave the best egg control. However insecticidal soaps (made of the potassium salts of fatty acids) were more effective for nymphs and 100% mortality was observed with treatments of first nymphal instar. The highest mortalities of fourth nymphal instar were recorded with vegetable oil, insecticidal soaps and Pyrethrum extract treatments. (*Abstract only*).

## Does the PGPR *Bacillus subtilis* induce plant resistance to whiteflies and *Pythium* spp. in greenhouse tomato?

A. Hanafi, K. Fellah

Integrated Production and Protection Unit, Department of Plant Protection, Complexe Horticole IAV Hassan II, BP: 12042 Cité Balnéaire Agadir, 80000 Morocco.  
Hanafi@iavcha.ac.ma

**Abstract:** The development of biological products based on beneficial micro-organisms can extend the range of options for maintaining the health yield of crops. It has been recognized that the application of the rhizobacterium *Bacillus subtilis* (BS) confers vitality as well as the capacity of the plant to face the conditions of biotic and abiotic stress such as drought and salinity. These stress conditions prevail in the Mediterranean regions, where a proportion of farmers use saline water for the irrigation of their crops. In our experiments, we evaluated the impact of BS, used in salinity stress and non stress conditions, on the resistance and tolerance of soilless tomatoes grown under greenhouse, to the whitefly *Bemisia tabaci* and the root fungal pathogen *Pythium* Sp. Two levels of salinity (EC = 6dS/m and EC= 2.4 dS / m) were used for irrigation of tomato plants inoculated and non inoculated with BS. Two cultivars of tomato were evaluated in this experiment. On one hand, the cultivar *Durinta* (Western seeds) is relatively tolerant to salinity, whereas the cultivar *Tyjico* (Syngenta Seeds) is sensitive to salinity. On the other hand, the cultivar *Durinta* is sensitive to tomato Yellow leaf curl virus (TYLCV). In contrast, the cultivar *Tyjico* is tolerant to TYLCV. TYLCV is a Gemini virus exclusively transmitted by the whitefly *B. tabaci*. TYLCV is by far the number one virus disease of greenhouse tomatoes in the Mediterranean region. The objective of this study was to evaluate the effect of BS in stress (E C 6) and non stress (E C 2.4) conditions on the whitefly *B. tabaci* population dynamics in a salinity tolerant cultivar (*Durinta*) and a salinity sensitive cultivar (*Tyjico*). This study concluded that irrigation of tomato with saline water (E C 6) makes the plant less sensitive to the whitefly *B. tabaci*. On the other hand, the inoculation of plants with BS appears to induce plant resistance to *B. tabaci*, whether in salinity or non salinity stress conditions. Regarding the incidence of *Pythium*, the inoculation of plants with BS induced resistance to this root pathogen, especially under saline conditions. (Abstract only).

## **Crop loss assessment of *Pediculaster fletcheri* (Acari: Pygmephoridae) on button mushrooms**

**Katayun Kheradmand<sup>1</sup>, Karim Kamali<sup>1</sup>, Yaghoub Fathipour<sup>1</sup>, Ebrahim M. Goltapeh<sup>2</sup>  
Ali R. Nemati<sup>1</sup>**

<sup>1</sup>Department of Entomology, Faculty of Agriculture, Tarbiat Modarres University, P. O. Box 14115-336, Tehran. <sup>2</sup>Department of Plant Pathology, Faculty of Agriculture, Tarbiat Modarres University, P.O.Box 14115-336, Tehran, Iran.

**Abstract:** Certain fungivorous pygmephoride mites (red pepper mites, pygmy mites) periodically swarm in commercial mushroom houses, often carpeting the surface of the compost. Yield loss on button mushroom caused by *Pediculaster fletcheri* was studied at different mite densities (0, 10, 50, 100, 150 and 200 mites per kg compost). A significant difference between the control and the higher mite density was obtained. Regression analysis showed a significant negative relationship between mite density and mushroom yield ( $P < 0.05$ ), with yield decreasing when mite density increased. The slope of the line was -0.1312, so the yield loss per mite (LPM) was 0.1312 g/kg compost. The fact that these mites are becoming increasingly widespread, together with the losses caused by them throughout the mushroom-growing region, mean that they are considered of major threat to mushroom yield. Information provided in this study may also be used to develop alternative action levels in IPM programmes for *P. fletcheri* in cultivating button mushrooms in Iran. To provide a sustainable alternative to pest control, a variety of control methods must be integrated into pest control programs.

## **Biology of the two spotted spider mite, *Tetranychus turkestanii* (Acari: Tetranychidae) on four common varieties of eggplant in Iran**

**Ebrahim Soleimannejadian<sup>1</sup>, Alireza Nemati<sup>2</sup>, Parviz Shishehbor<sup>1</sup>, Karim Kamali<sup>2</sup>,  
Valiollah Baniameri<sup>3</sup>**

<sup>1</sup>Plant Protection Department, Agricultural College, Shahid –Chamran University, Ahwaz. <sup>2</sup>Department of Entomology, College of Agriculture, Tarbiat Modares University, Tehran. <sup>3</sup>Plant pest and Disease Research Institute, Tehran, Iran.

**Abstract:** Spider mites are important pests for various crops throughout the world. Host plants can exert profound effects on biological and ecological characteristics of tetranychid mites. In the southern provinces of Iran the major tetranychid species is *Tetranychus turkestanii*, which is called the strawberry or Atlantic mite. The life history parameters of *T. turkestanii* on four aubergine varieties, Esfahani, Qasri (two local varieties), Blackbeauty and Inerash (imported varieties) were studied on the lower surface of eggplant leaves under laboratory conditions. Survival rates of eggs on Qasri and Inerash cultivars were 100%, while on Esfahani and Blackbeauty they were 93% and 88% respectively. The larval developmental period of *T. turkestanii* differed on the four cultivars. Inerash had the shortest development time, while those of the other three cultivars were not significantly different. The pre-oviposition period of the mite was significantly different for Esfahani, Qasri, Inerash and Blackbeauty, with the longest pre-oviposition period relating to Inerash. There were major variations in the total number of eggs laid by each female mite. The total numbers of eggs laid by each female mite on the four cultivars during the oviposition period were 1-67 on Qasri, 3-95 on Esfahani, 2-61 on Blackbeauty and 37-104 on Inerash. Given its survival rate and the duration of the development time of its immature stages, the total longevity of adults, and the total number of eggs per female per day, it was concluded that the Qasri cultivar is not as suitable as a host as the other three cultivars in the south of Iran.

## Efficacy of *Phytoseiulus persimilis* versus *Neoseiulus californicus* for controlling spider mites on greenhouse sweet pepper

Phyllis Weintraub<sup>1</sup>, Sophia Kleitman<sup>1</sup>, Nurit Shapira<sup>2</sup>, Yael Argov<sup>3</sup>, Eric Palevsky<sup>4</sup>

<sup>1</sup>Agricultural Research Organization (ARO), Gilat Research Center, DN Negev, 85280; E-mail: [phyllisw@volcani.agri.gov.il](mailto:phyllisw@volcani.agri.gov.il); <sup>2</sup>Research and Development, Sapir Center, D.N. Arava, 86825; <sup>3</sup>Israel Cohen Institute for Biological Control, Plant Production and Marketing Board, Citrus Division, POB 80 Bet Dagan, 50250, Israel; <sup>4</sup>ARO, Neve Ya'ar Research Center, Ramat Yishay, 30095, Israel

**Abstract:** The efficacy of two predatory phytoseiid mites, *Phytoseiulus persimilis* and *Neoseiulus californicus* were compared for the biological control of *Tetranychus urticae* (TSSM) on greenhouse sweet peppers. We developed a simple and expedient rearing method for *N. californicus* solely on pollen. At the beginning of the trial there was a low-level spider mite infestation. Cohorts of *P. persimilis* (10/plant) and *N. californicus* (20/plant) were released in separate tunnels when the TSSM population was low and in additional tunnels 2 weeks thereafter. These treatments were compared with acaricide-treated and non-treated plants. Samples of leaves from the top and middle sections of plants from each tunnel were taken. There was no significant difference between the number of TSSM in the acaricide-treated and 1<sup>st</sup> *N. californicus*-release tunnels, but the number of TSSM in the acaricides-treated and *P. persimilis*-release tunnels were significantly different. At the higher spider mite population, there were significantly more TSSM in the *P. persimilis* release tunnels than in the *N. californicus*-release tunnels. We have confirmed laboratory trials and have shown that *N. californicus* is a superior TSSM predator at low humidities.

## Identification of Pollens for Small Scale Mass Rearing of *Neoseiulus californicus* and a Novel Method for Quality Control

Yael Argov<sup>P1</sup>, Martin Berkeley<sup>1</sup>, Silvi Domeratzky<sup>1</sup>, Eti Melamed<sup>1</sup>, Phyllis Weintraub<sup>2</sup>, Eric Palevsky<sup>3</sup>

<sup>1</sup>Israel Cohen Institute for Biological Control, Plant Production and Marketing Board, Citrus Division, POB 80 Bet Dagan, 50250, [yael@jaffa.co.il](mailto:yael@jaffa.co.il); <sup>2</sup>Agricultural Research Organization, Gilat Research Center, DN Negev, 85280, [phyllisw@volcani.agri.gov.il](mailto:phyllisw@volcani.agri.gov.il); <sup>3</sup>Agricultural Research Organization (ARO), Neve-Ya'ar Research Center, Ramat Yishay, 30095, Israel, [palevsky@volcani.agri.gov.il](mailto:palevsky@volcani.agri.gov.il)

**Abstract:** In this study we set out to identify indigenous pollen for small scale mass rearing of *Neoseiulus californicus*. From ca. 30 plant pollen evaluated, six species were found to be suitable: *Zea mays*, *Quercus ithaburensis* and four *Pistacia* species, *P. atlantica*, *P. vera*, *P. lentiscus* and *P. palestina*, the latter yielding the shortest duration of development and the highest fecundity. An improved method for monitoring development and fecundity of phytoseiid species on pollens using polyacrylamide gel (PAG) as a water source and barrier was evaluated. The proportion of replicates lost using the PAG method was substantially lower than the conventional wick method. Moreover the wick method took twice as long to complete each evaluation. We propose that the polyacrylamide gel method be adopted for quality control of phytoseiids reared by commercial insectaries.

## Are spider mites aware of the presence of thrips?

**Banafsheh Ahmadi, Seied Hossein Goldansaz, Ahmad Ashouri**

Plant Protection Dep., Faculty of Horticulture & Plant Protection Science, College of Agriculture & Natural Resources (UTCAN), University of Tehran, 31587-11167 Karaj, Iran.  
E-mail: ashouri@ut.ac.ir

**Abstract:** Onion thrips (*Thrips tabaci*) and spider mites (*Tetranychus urticae*) are serious pests of greenhouse crops and they co-occur on the same crop plants. Thrips are known to be omnivores and co-occurrence with their competitors (spider mites) on the same plant parts will cause them to eat mite eggs. We were eager to find out whether or not mites were aware of the presence of their competitors and predators.

## Effect of different types of prey on fecundity of the phytoseiid mite *Typhlodromips swirskii*, a potential biological control agent for horticultural greenhouse pests in the Canary Islands

**Estrella Hernández-Suárez<sup>1</sup>, M<sup>a</sup> del Cristo Velásquez<sup>1</sup>, M<sup>a</sup> Inmaculada Paz-González<sup>1</sup>, Francisco J. González<sup>2</sup>, Aurelio Carnero<sup>1</sup>, Francisco J. Ferragut<sup>3</sup>**

<sup>1</sup>Entomology Department, Instituto Canario de Investigaciones Agrarias. Ctra del Boquerón s/n, 38080 La Laguna –Tenerife (Canary Islands), Spain. <sup>2</sup>Koppert Canarias, C/ Roble s/n, Polígono Industrial de Arinaga, Agüimes-Gran Canaria (Canary Islands), Spain. <sup>3</sup>Instituto Agroforestal Mediterráneo, Dpt. Ecosistemas Agroforestales, Universidad Politécnica, C/ de Vera 14, 46022 Valencia, Spain

**Abstract:** An increasing number of commercial greenhouse growers from the Canary Islands employ beneficial insects to control pests, but effective biological control of some horticultural pests represent a handicap to the implementation of Integrated Pest Management Programs in our archipelago. That is the case of the western flower thrips *Frankliniella occidentalis* in cucumber, the broad mite *Polyphagotarsonemus latus* in sweetpepper, and the tomato russet mite *Aculops lycopersici* and the glasshouse whitefly *Trialeurodes vaporariorum* in tomato. *Typhlodromips swirskii* has shown a high efficacy against the sweetpotato whitefly *Bemisia tabaci*, and it has been evaluated as biocontrol agent of many other pests (*Tetranychus urticae*, *Eriophyes dioscoridis*, *Thrips tabaci*, *Aphis gossypii*, etc.). The present work aimed to study whether *T. swirskii* could be used for the biological control of different key pests in commercial horticultural greenhouses in the Canary Islands. As the first step, preliminary laboratory trials have been conducted to study the suitability of different types of prey and non-prey food substances (pollen) on the biology of a commercially available strain of the phytoseiid predator *T. swirskii*. We present the effect of the food type on the predator fecundity. The preys included in the study were *F. occidentalis*, *T. vaporariorum*, *P. latus* and *A. lycopersici*. The study has been conducted under a joint ICIA- Koppert Biological Systems research project.

## Feeding rate of *Stethorus gilvifrons* on *Tetranychus urticae* in three greenhouse cucumber cultivars with different resistance levels

Neda Kheradpir<sup>1</sup>, Jafar Khalghani<sup>2</sup>, Hadi Ostovan<sup>1</sup>, Mohammad Reza Rezapanah<sup>3</sup>.

<sup>1</sup>Islamic Azad university, Science and Research Branch, Faculty of Agriculture and Natural Sources, Department of Entomology. Poonak, Tehran, <sup>2</sup>Plant Pests and Diseases Research Institute, Velenjak, Teharn, <sup>3</sup>Biological Control Research Department, Plant Pests and Diseases Research Institute, Velenjak, Tehran, Iran.

**Abstract:** The aim of this study was to determine the effect of three greenhouse cucumber cultivars (Sina, Sultan and Fadia) on the feeding rate of *S. gilvifrons* on two-spotted spider mites. The experiment was conducted in a growth chamber (25±0.5°C, RH= 65±5% and 16L:8D) on leaf disks with 5 replications. The results were compared among different developmental stages of the predator and the prey. Sultan had the highest predator feeding rate and Fadia had the lowest. Females were observed to have the highest feeding rate, consuming adult mites, while larvae had the lowest feeding rate, mainly consuming mite eggs.

## Development of traps for monitoring thrips (Thysanoptera: Thripidae)

Chang-chi Chu<sup>1</sup>, Matthew A. Ciomperlik<sup>2</sup>, Marcus Richards<sup>3</sup>, Thomas J. Henneberry<sup>2</sup>

<sup>1</sup>USDA, ARS WCRL, Phoenix, AZ 85040; <sup>2</sup>USDA, APHIS, PPQ, CPHST, PDDML, Edinburg, TX 78541; <sup>3</sup>MAF, St. Vincent and the Grenadines, W.I., USA.

**Abstract:** *Scirtothrips dorsalis* was identified as an invasive pest in the Caribbean area in 2004 and was recognized as established in Florida in 2005. The species is recognized as a significant threat to agriculture and trade in both regions and potentially worldwide. Methods are urgently needed to detect, monitor, and manage the pest. We developed traps for detection and monitoring *Frankliniella occidentalis* in cotton *Gossypium hirsutum* and alfalfa *Medicago sativa*, and *S. dorsalis* and other thrips on chilli peppers *Capsicum chinense* in the field.

## Preliminary field trials with the synthetic sexual aggregation pheromone of *Frankliniella occidentalis* on protected pepper and tomato crops in South-east Spain

M. Gómez<sup>1</sup>, F. García<sup>1</sup>, R. GreatRex<sup>2</sup>, M. Lorca<sup>1</sup>, A. Serna<sup>1</sup>

<sup>1</sup>Syngenta Bioline España. <sup>2</sup>Syngenta Bioline Ltd. Telstar Nursery. Holland Road, Essex, CO16 9QG - UK

**Abstract** An aggregation pheromone produced by males of *Frankliniella occidentalis* has recently been identified and synthesised. Results of two trials of a commercial product containing this pheromone are presented here. In protected Sweet Pepper and Tomato crops grown in South East Spain, the addition of pheromone to blue sticky traps produced a significant increase in the numbers of thrips caught. The role of this pheromone as a monitoring tool within IPM programmes is discussed.

## The addition of potassium silicate to the fertilizer mix to suppress *Liriomyza* leafminers attacking chrysanthemums

Michael P. Parrella, Tom Costamagna

Department of Entomology, University of California, Davis, CA 95616, USA

**Abstract:** Silicon is the second most abundant element in soils, and is essentially the mineral substrate for most of the world's plant life. This material has long been associated with increasing a plant's ability to withstand attack by pests, but data in this area are limited. We examined whether the addition of potassium silicate to potted chrysanthemum plants would reduce development of the leafminer, *Liriomyza trifolii*. A range of silicate concentrations were made on a regular basis for the full duration of a potted chrysanthemum crop, and then individual plants were repeatedly challenged with mated pairs of leafminers in caged studies. At silicon concentrations of 200 ppm and higher we observed a significant reduction in leafminers emerging from treated plants vs. the control. These results suggest that the addition of silicon may increase the chrysanthemum's ability to withstand attack by leafminers, and may be an additional cultural tool in the IPM arsenal.

## Natural parasitism of *Liriomyza sativae* (Diptera: Agromyzidae) on cucumber under field and greenhouse conditions

Yaghoub Fathipour<sup>1</sup>, Mostafa Haghani<sup>1</sup>, Ali A. Talebi<sup>1</sup>, Valiollah Baniameri<sup>2</sup>, Abbas A. Zamani<sup>1</sup>

<sup>1</sup>Department of Entomology, Faculty of Agriculture, Tarbiat Modares University, P. O. Box: 14115-336, Tehran, E-mail: [fathi@modares.ac.ir](mailto:fathi@modares.ac.ir). <sup>2</sup>Department of Agricultural Entomology, Plant Pests & Diseases Research Institute, P. O. Box: 19395-1454, Tehran, Iran.

**Abstract:** *Liriomyza sativae* is one of the most important pests affecting cucumber in Iran and is mainly controlled by applying chemical products. The main purpose of this study was to determine the rate of natural parasitism of *L. sativae* in the Tehran region, Iran. From September to December 2004 surveys were carried out on cucumbers in sprayed fields and also in sprayed and non-sprayed greenhouses in Varamin and Pishva, near Tehran. A sampling program was designed to estimate the population density and parasitism rate of *L. sativae* larvae on cucumber leaves. In this study we determined the average percentage and trend of parasitism associated with each parasitoid species. The results showed that in the study area *L. sativae* larvae were parasitized by three eulophid parasitoid species including *Diglyphus isaea*, *Hemiptarsenus zilahisebessi* and *Closterocerus formosus*. *D. isaea* was the most frequent species at all three sampling sites, followed by *C. formosus* and *H. zilahisebessi*. The overall percentages of parasitism on cucumber caused by these three parasitoids in the field and in sprayed and non-sprayed greenhouses were 21.36 (8.44-39.32), 10.26 (8.01-15.66) and 39.31 (29.45-54.51), respectively. These results indicated that sequential application of insecticides on cucumber led to a significant reduction in the rate of natural parasitism in the field and in sprayed greenhouses. The highest rate of parasitism was observed in non-sprayed greenhouses. It was finally concluded that illogical and inappropriate use of insecticides for controlling pests affecting field and greenhouse crops can reduce the population density and efficacy of natural enemies.

## First data on the population dynamics of aphidophagous syrphids in Mediterranean pepper greenhouses

Ana Pineda, M<sup>a</sup> Ángeles Marcos-García

University of Alicante, Research Institute of Biodiversity CIBIO, 03080 San Vicente del Raspeig, Spain

**Abstract:** Aphids are an important pest in pepper greenhouses and one group of their natural enemies are hoverflies (Diptera, Syrphidae). This work presents the first results about the main aphidophagous syrphid species found in Mediterranean greenhouses in Spain and certain aspects concerning the monitoring of their mobility from and to greenhouses. *Eupeodes corollae* was the first species to emerge from a two-year sampling of immature stages. It was followed by *Episyrphus balteatus* and finally by *Sphaerophoria rueppellii*. A modified Malaise trap was tested and revealed an adult syrphid population dynamic comparable with data obtained from direct sampling of immature stages. We suggest placing these modified Malaise traps outside greenhouses in order to understand what proportion of adult syrphids go inside greenhouses. This could be a method for monitoring syrphid populations in a given area, for both outdoor and protected crops.

## Evaluation of two aphid parasitoids as candidates for biocontrol of aphid pests in protected cultivation in Brazil

Vanda H. P. Bueno<sup>1</sup>, Marcus V. Sampaio<sup>2</sup>, Joop C. van Lenteren<sup>3</sup>, Bruno F. De Conti<sup>1</sup>, Robson J. Silva<sup>1</sup>, Sandra M. M. Rodrigues<sup>4</sup>, Ariana B. Carnevale<sup>1</sup>

<sup>1</sup>Federal University of Lavras, Department of Entomology, P.O.Box 3037, 37200-000 Lavras, MG, <sup>2</sup>Federal University of Uberlandia, Faculty of Agriculture, 38400-902 Uberlandia, MG, Brazil; <sup>3</sup>Laboratory of Entomology, Wageningen University, Wageningen, The Netherlands; <sup>4</sup>Embrapa-Algodão, 78850-000 Primavera do Leste-MT, Brazil.

**Abstract:** Several aphid species can be important pests in greenhouse vegetables and ornamentals and biological control is a desirable option to control aphids in protected cultivation in Brazil. To select and evaluate the local aphid parasitoids, *Aphidius colemani* and *Lysiphlebus testaceipes*, tests are performed involving host suitability and preference, and evaluation of biological parameters of both species at different temperatures. Host preference indicated that *A. colemani* and *L. testaceipes* prefer *A. gossypii* above *M. persicae* as a host. Both aphid hosts are suitable for the development of both parasitoid species. However, *A. gossypii* is a more suitable host than *M. persicae* for *L. testaceipes*. A temperature of 22°C for *A. colemani* and 25°C for *L. testaceipes* are the most adequate for reproduction and mass rearing. Host' quality for *A. colemani* was decreasing as follows: *M. persicae* = *R. maidis* > *S. graminum* > *A. gossypii*. The development time, rate of parasitism and longevity of *L. testaceipes* were decreasing from *S. graminum* = *R. maidis* > *M. persicae*. Honey is an important food and increases the longevity of *A. colemani*, and water is a good complement to the diet of this parasitoid. The two parasitoid species are good candidates to use as biocontrol agents in protected crops in Brazil.

## Host stage preference by *Aphidius colemani* and *Aphidius matricariae* (Hymenoptera: Aphidiidae) as parasitoids of *Aphis gossypii* (Hemiptera: Aphididae) on greenhouse cucumber

Ali Asghar Talebi<sup>1</sup>, Abbas Ali Zamani<sup>1</sup>, Yaghoob Fathipour<sup>1</sup>, Valiollah Baniameri<sup>2</sup>,  
Katayun Kheradmand<sup>1</sup> and Mostafa Haghani<sup>1</sup>

<sup>1</sup>Department of Entomology, Faculty of Agriculture, Tarbiat Modares University, P. O. Box: 14115-336, Tehran, <sup>2</sup>Department of Agricultural Entomology, Plant Pests & Diseases Research Institute, P. O. Box: 1454-19395, Tehran, Iran.

**Abstract:** *Aphidius colemani* Viereck and *A. matricariae* (Haliday) (Hymenoptera: Aphidiidae) have a high potential as effective biological control agents for the cotton aphid, *Aphis gossypii* Glover in greenhouse crops. In this study, the host stage preferences of *A. colemani* and *A. matricariae* were determined in a growth chamber at 25°C, 65 % relative humidity and during a photoperiod of 16L: 8D hours. In choice and no-choice experiments, individual females of *A. colemani* and *A. matricariae* were offered first, second, third and fourth instar nymphs of *A. gossypii*, as well as adults. The results showed that there were significant differences between the mean percentages of parasitized hosts at different stages ( $P < 0.05$ ). Under no-choice conditions, the highest value was registered for parasitism of third instar nymphs of *A. gossypii* by *A. colemani* and of third and fourth instar nymphs by *A. matricariae*. In choice experiments, females of *A. colemani* and *A. matricariae* consistently preferred third and fourth instar nymphs of *A. gossypii*. Mean percentages for parasitism by *A. colemani* and *A. matricariae* on the third nymphal instar of *A. gossypii* were  $23.6 \pm 3.69$  and  $18.4 \pm 2.42$ , respectively. The progeny body size of *A. colemani* and *A. matricariae* at emergence increased with host stage at the time of parasitization. The greenhouse release of parasitoids would be best timed to coincide with the period when third and fourth nymphal instars of cotton aphid are most abundant.

## The number of *Cotesia plutellae* needed to suppress the population growth of diamondback moth, *Plutella xylostella*, in a greenhouse

Satoru Urano<sup>1</sup>, Junichiro Abe<sup>2</sup>, Masaya Matsumura<sup>1</sup>, Koukichi Nagasaka<sup>2</sup>, Junji Takabayasi<sup>3</sup>

<sup>1</sup>National Agricultural Research Center for Kyushu Okinawa Region; 2421 Suya, Nishigoshi, Kikuchi, Kumamoto 861-1192, Japan, <sup>2</sup>National Agricultural Research Center for Western Region; 200 Ueno, Ueno, Ayabe, Kyoto 623-0035, Japan, <sup>3</sup>Center for Ecological Research, Kyoto University; 2-509-3, Hirano, Otsu, Shiga 520-2113, Japan

**Abstract:** We have been studying the use of host plant volatiles that attract carnivorous natural enemies of herbivorous pest (diamondback moth larvae, *Plutella xylostella*) from the viewpoint of integrated pest management. Here, we showed the number of *Cotesia plutellae*, a parasitoid of *P. xylostella* larva, which is needed to suppress the population growth of *P. xylostella* in a greenhouse. By using the mathematical model and the previously reported data on the biology of both *P. xylostella* and *C. plutellae*, we evaluated the number of wasps needed for the management of *P. xylostella* to be 7 wasps in one greenhouse (ca. 150 m<sup>2</sup>). We then conducted the experiments in two greenhouses to confirm the evaluation. When no wasps were released, the growth rates between two generations of *P. xylostella* were 5 – 27 times. By contrast, when the wasps were released, the rate remained 0.13 – 0.8, suggesting that constant recruitment of a relatively small number of the wasps (ca. 20) from the surroundings of a greenhouse could suppress the population growth rates of *P. xylostella*.

## Functional response of *Chelonus oculator* (Hym.: Braconidae) in greenhouse conditions: influence of the parasitoid release ratio

M. García-Martín<sup>1</sup>, M. Gámez-Cámara<sup>2</sup>, A. Torres-Ruiz<sup>1</sup>, T. Cabello<sup>1</sup>

<sup>1</sup>Dpto. Biología Aplicada, <sup>2</sup>Dpto. Estadística y Matemática Aplicada, Universidad de Almería, 04120-Almería, Spain

**Abstract:** *C. oculator* is an endoparasitoid of Lepidoptera. In laboratory conditions, this parasitoid exhibited a type III functional response. This is the unique one that is considered adaptive, host density dependent and being able to regulate the pest population in a conventional program of Biological Control. The objective of this work was to verify the parasitoid functional response in greenhouse conditions, as well as the influence of the parasitoid release ratio and, therefore, to evaluate its potentiality as a natural enemy of beet armyworm *Spodoptera exigua*. The trials were carried out from May to June of 2005 in greenhouse crops placed at F.I.A.P.A. research station. Several parasitoid release ratios and host densities were employed. The data were fitted to type I, II and III models, to a newly developed equation (type III with 2 parameters) and to a functional response surface. Total parasitization and percentage of discovered egg masses were significantly greater in the highest release ratio (1.5 ♀/m<sup>2</sup>). Moreover, in field conditions the functional response was of type III. The best fit was obtained with the new equation, with exception for the density of 1.5 ♀/m<sup>2</sup>. The parameters *handling time* ( $T_h$ ) and *parasitism potential* ( $\alpha$ ) were well correlated to those found in our previous laboratory test. Our results show this parasitoid species could be a good pest control agent in greenhouse crops in southeast Spain.

## When does alternative food promote biological pest control?

Maurice W. Sabelis<sup>1</sup>, Paul C. J. Van Rijn<sup>2</sup>

<sup>1</sup>Section Population Biology, Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Amsterdam, [sabelis@science.uva.nl](mailto:sabelis@science.uva.nl); <sup>2</sup>Institute of Terrestrial Ecology, Heteren, The Netherlands, [p.vanrijn@nioo.knaw.nl](mailto:p.vanrijn@nioo.knaw.nl)

**Abstract.** That alternative food, whether or not provided by a plant or introduced artificially, promotes biological pest control via its effect on predators, is not immediately obvious. On the one hand it enhances survival, reproduction and searching. On the other hand it may reduce the rate of predation, which is the case when alternative food and prey are substitutable – as opposed to complementary – food sources. Moreover, it is not immediately obvious how the impact of alternative food on the outcome of biological pest control differs depending on the type of dynamics (e.g. equilibrium vs transient dynamics), the type of predator (e.g. stage-related consumption and life history effects of alternative food) and food web structure (presence of hyperpredators or intraguild predators). We review the conditions under which alternative food can lead to either pest extermination, to a decline of the pest towards a positive, asymptotic density or to no effect on pest density at all.

## Feeding behavior of the rove beetle, *Atheta coriaria* (Coleoptera: Staphylinidae) under laboratory conditions

Eva M. Birken, Raymond A. Cloyd

Department of Natural Resources and Environmental Sciences, University of Illinois, Urbana, IL 61801, USA, E-mail: rclloyd@uiuc.edu

**Abstract:** Laboratory choice tests were conducted to determine the feeding behavior, based on food preference, of the adult and larval stage of *Atheta coriaria* when presented with both fresh moistened oatmeal and second instar fungus gnat, *Bradysia* sp. nr. *coprophila* larvae. In all tests, *Atheta coriaria* adults and larvae preferred to feed on fungus gnat larvae more so than oatmeal based on the amount of oatmeal and number of fungus gnat larvae consumed after 4 and 6 hours.

## The predatory bug *Orius niger*: its biology and potential for controlling *Thrips tabaci* in Iran

Valiollah Baniameri<sup>1</sup>, Ebrahim Soleyman-nejadian<sup>2</sup>, Jafar Mohaghegh<sup>1</sup>

<sup>1</sup>Plant Pest and Disease Research Institute (PPDRI), P. O. Box: 19395/1454 Tehran, <sup>2</sup>Plant Protection Department, University of Sh. Chamran, Ahwaz, Iran

**Abstract:** We measured the basic life-history parameters of *Orius niger* on a diet of corn pollen and eggs of the moth *Ephesia kuehniella* at 3 constant temperatures (26, 29 and 32°C under 16L – 8D, 65±5 % RH) to provide information for the application of this predator in biocontrol programs. Bean pods were supplied as oviposition substrates. Results showed that the mean development times from egg to adult were 16.71, 13.16 and 13.42 days, sex ratios were 0.59, 0.56 and 0.52 females, respectively. The observed rates of sterile females were 20, 25 and 5 % and the longevity of adult females was 38, 25 and 24 days, respectively. This species preys upon thrips and is commonly found attacking *T. tabaci* throughout Iran. It was concluded that *O. niger* is an ideal predator to use as a biological agent in greenhouse crops which have enough pollen, or when they are mixed with banker plants.

## **Predatory capacity and longevity of adults of *Orius thyestes* (Hemiptera, Anthocoridae) on different prey**

**Elizabeth C. Pedroso, Vanda H. P. Bueno, Robson J. Silva, Alessandra R. Carvalho, Alexandre J. F. Diniz, Murilo P. F. Silva, Livia M. Carvalho**

*Laboratory of Biological Control, Department of Entomology, Federal University of Lavras, P.O.Box 3037, 37200-000, Lavras, MG, Brasil.*

**Abstract:** The predator *Orius thyestes* was recently found in Brazil but knowledge of its biology and food consumption including its different prey is still limited. The purpose of this work was to evaluate consumption and male and female longevity of *O. thyestes* preying upon *Aphis gossypii*, *Schizaphis graminum* and *Caliothrips phaseoli*, and eggs of *Anagasta kuehniella*. The experiment was conducted in a climatic chamber at  $28 \pm 1\text{C}^\circ$ ,  $70 \pm 10\%$  RH and with photophase of 12h. Both male and female *O. thyestes* showed highest levels of consumption ( $P < 0.05$ ) for *A. kuehniella* eggs, these were followed by *C. phaseoli* and the aphids *A. gossypii* and *S. graminum*. As for *C. phaseoli* and *A. kuehniella* eggs, consumption was higher amongst females than males. Nevertheless, there was no difference in male and female consumption when aphids were the prey. There was greater longevity amongst females than males when they were fed on *C. phaseoli* and *A. kuehniella* eggs. *A. kuehniella* eggs and *C. phaseoli* seemed to be more nutritionally fit to the predator, which was shown by good results for the biological parameters analyzed.

## **Disinfection of oviposition substrate with sodium hypochlorite: effects on some biological traits of *Orius thyestes***

**Alexandre J. F. Diniz, Vanda H. P. Bueno, Alessandra R. Carvalho, Elizabeth C. Pedroso, Robson J. Silva, Livia M. Carvalho**

*Laboratory of Biological Control, Department of Entomology, Federal University of Lavras, P.O.Box 3037, 37200-000, Lavras, Minas Gerais, Brazil.*

**Abstract:** The predator *Orius thyestes* (Hemiptera: Anthocoridae) was recently found in Brazil and its potential as a biological control agent as well as the possibilities of rearing it under laboratory conditions are currently being investigated. Rearing implies using farmer's friend inflorescences (*Bidens pilosa*), previously disinfected with sodium hypochlorite, before introducing females of this predator into the rearing chamber. This work aimed to evaluate the effects of applying commercial formulations and analytical sodium hypochlorite on biological traits of *O. thyestes*. The experiment was carried out in a climatic chamber at  $27 \pm 1^\circ\text{C}$ ,  $70 \pm 10\%$  RH and with a photophase of 12 hours. For disinfection, the substrates were immersed in 0.12% of commercial solutions of sodium hypochlorite (Tandira and Q'boa® brands) and analytical sodium hypochlorite (PA) as treatments, and in distilled water as a control. Tandira proved inadequate for our purposes due to its negative interference with the reproduction and longevity of the predator.

## **Intraguild predation between *Orius insidiosus* and *Aphidius colemani*, and biological control of *Aphis gossypii***

Leonardo S. R. Pierre<sup>1</sup>, Vanda H. P. Bueno<sup>1</sup>, Marcus V. Sampaio<sup>2</sup>, Joop C. van Lenteren<sup>3</sup>, Bruno F. De Conti<sup>1</sup>, Murilo P. F. Da Silva<sup>1</sup>, Luís Cláudio P. Silveira<sup>4</sup>,

<sup>1</sup>Universidade Federal de Lavras, Departamento de Entomologia, Caixa Postal 3037, 37200-000 Lavras, MG, <sup>2</sup>Universidade Federal de Uberlândia, Caixa Postal 593, 38400-902, ICIAG, Campus Umuarama, MG, Brazil, <sup>3</sup>Laboratory of Entomology, Wageningen University, Wageningen, The Netherlands, <sup>4</sup>APTA Regional Centro Norte, Caixa Postal 24, 15830-000 Pindorama, SP, Brazil.

**Abstract:** Biological control of pests in greenhouses crops may involve the introduction of more than one species of natural enemies, and this can result in intraguild predation. This work aimed at evaluating the effect of the intraguild predation between *Orius insidiosus* (Say) and *Aphidius colemani* Viereck, natural enemies of *Aphis gossypii* Glover. Aphids were kept on caged cucumber plants and the treatments were: a) control without natural enemies; b) parasitoid only; c) predator only; d) parasitoid + predator. The parasitoid *A. colemani* appeared to be an effective biological control agent of *A. gossypii* even in the presence of the predator. The average number of *A. gossypii* on the plants in the presence of the predator *O. insidiosus* was similar to that as in the treatment with only aphids. The predator *O. insidiosus* did have no effect on the action of the parasitoid *A. colemani* in the reduction of *A. gossypii* and on the numbers of mummies, percentages of parasitism and emergence of the parasitoid.

## **Differentiation of *Macrolophus pygmaeus* (Rambur 1839) and *Macrolophus melanotoma* (Costa 1853) (Heteroptera: Miridae) based on molecular data**

Jose Isidro Martinez-Cascales, José Luis Cenis, Juan Antonio Sanchez

Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario (IMIDA), Department of Biotechnology and Crop Protection, c/ Mayor s/n, 30150 La Alberca, Murcia, Spain. E-mail: juana.sanchez23@carm.es

**Abstract:** Several species of the *Macrolophus* genus are well known predators of small pests such as whiteflies, aphids and mites. *Macrolophus melanotoma* (Costa 1853) (Syn. *Macrolophus caliginosus* Wagner 1951) and *Macrolophus pygmaeus* (Rambur 1839) are the most economically important species. In spite of their economic importance the classification of these two species has not received comprehensive treatment until recently. The lack of discontinuity in the taxonomical characters used to differentiate *M. melanotoma* from *M. pygmaeus* made it difficult to define species boundaries and conspecificity was not excluded. In this work we use molecular information to clarify the identity of *M. melanotoma* and *M. pygmaeus*. The phylogenetic analysis using cytochrome b sequences grouped the specimens studied in two distinct clades, corresponding to insects classified as *M. melanotoma* and *M. pygmaeus* using key morphological characters. Commercial insects, labelled and sold as *M. caliginosus*, were classified as *M. pygmaeus*. Based on molecular phylogenetic and morphological evidences we conclude that *M. melanotoma* and *M. pygmaeus* are two different species. The biology, ecology and role as pest control agents of *Macrolophus melanotoma* and *M. pygmaeus* may have been messed up due to misidentification.

## Reproductive traits of the generalist predator *Macrolophus caliginosus*

Cristina Castañé<sup>1</sup>, Oscar Alomar<sup>1</sup>, Jordi Riudavets<sup>1</sup>, César Gemenó<sup>2</sup>

<sup>1</sup>Departament de Protecció Vegetal, IRTA-Centre de Cabrils, Ctra. Cabrils s/n, 08348 Cabrils, Barcelona, <sup>2</sup>Universitat de Lleida, Centre UdL-IRTA, Rovira Roure 191, 25198 Lleida, Spain. [crisrina.castane@irta.es](mailto:crisrina.castane@irta.es)

**Abstract:** The objectives of this study were to describe the copulatory behaviour and maturation of the sexual organs of the predator *Macrolophus caliginosus* with the aim of implementing its use in augmentative releases in greenhouses. Results indicate that males actively pursue females but that courtship is almost non-existent; more mating take place during night hours and in the first half of the day than during the second half of the day; 5 and 7 day-old females tend to mate more than younger ones; and the mating propensity of males is not affected by age. This is consistent with the physiological maturation of sexual organs.

## Rearing predatory bugs with the brine shrimp *Artemia* sp. as alternative prey food

Jordi Riudavets, Judit Arnó, Cristina Castañé

Plant Protection Department, IRTA. Centre de Cabrils, Ctra. Cabrils s/n, 08348 Cabrils (Barcelona), Spain. [jordi.riudavets@irta.es](mailto:jordi.riudavets@irta.es)

**Abstract:** We compared the number of individuals of the mirid *Macrolophus caliginosus* and the anthocorid *Orius majusculus* mass-reared in the laboratory, using dry cysts of *Artemia* sp. or frozen *Ephestia kuehniella* eggs as food sources. Numbers of *M. caliginosus* individuals produced using the two diets were similar. However, the survival of *O. majusculus* adults and the number of *O. majusculus* produced were greater when fed with *E. kuehniella* eggs than with *Artemia* sp. cysts. The alternative food prey, *Artemia* sp., seems to offer a feasible and economical alternative to the mass rearing of *M. caliginosus* but not to that of *O. majusculus*.

## Investigation on the efficiency of a predator: a strategy beyond satiation

Dionyssios Perdikis<sup>1</sup>, Panagiotis Labropoulos<sup>2</sup>, Dionyssia Maselou<sup>2</sup>, Argyro Fantinou<sup>2</sup>

<sup>1</sup>Laboratory of Agricultural Zoology and Entomology; <sup>2</sup>Laboratory of Ecology and Environmental Sciences, Agricultural University of Athens, Iera Odos 75, 118 55, Athens, Greece

**Abstract:** The predation efficiency of the polyphagous predator *Macrolophus pygmaeus* (Hemiptera: Miridae) was investigated using the aphid *Myzus persicae* (Homoptera: Aphididae) as prey. One 5<sup>th</sup> instar nymph of the predator that had been caged on an eggplant without prey for 24h prior to the experiments was released in a plastic Petri dish of 9cm in diameter. In each dish an eggplant leaf was placed on which 2, 4, 8, 12, 16, 20 or 24 nymphs of only one of the 4 instars of the aphid were introduced. The experiments were conducted at 20, 25 and 30°C, under a L16:D8 photoperiod and 65±5% R.H. In each case 10 replicates (predators) were performed. The sucked (consumed) aphids were measured 24h after the introduction of the predator in the dish. It was observed that apart from the consumed aphids, killed but unconsumed aphids were also present in the dish. The number of these killed aphids was highest at 20°C and decreased with temperature increase whereas were much more frequently recorded in the 4<sup>th</sup> and the 3<sup>rd</sup> than in the younger instars. Most interestingly, these aphids were recorded mainly in the higher densities of prey used. Therefore, it seems that apart from killing aphids for direct consumption this predator causes aphid mortality by killing them without sucking them. This behavior increases the rate of pest killed with considerable implications in the effectiveness of this predator in biological control.

## Zoophytophagy of the plantbug *Nesidiocoris tenuis* in tomato crops in southeast Spain.

Juan Antonio Sanchez, Modesto del Pino-Pérez, M<sup>a</sup> del Mar Davó, José Isidro Martínez-Cascales, Alfredo Lacasa

Department of Biotechnology and Crop Protection, Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario (IMIDA), c/ Mayor, s/n, 30150 La Alberca, Murcia, Spain.  
E-mail: juana.sanchez23@carm.es

**Abstract:** *Nesidiocoris tenuis* (Heteroptera: Miridae) is one of the most abundant zoophytophagous plantbugs in tomato crops in southeast Spain. It preys on whiteflies and other small pests such as spider mites, leafminers and early instars of Lepidoptera. It also feeds on plants producing necrotic rings in stems and leaves, flower abortion and fruit blemishing. However, the intensity of the damage seems to vary from one geographical region to another. The aim of this assay was to determine the role of *N. tenuis* as a whitefly predator and to quantify damage in tomato crops in southeast Spain. Assays were carried out in four mesh-houses from July to October. Two of the greenhouses had screened vents while in the other two, the vents were unscreened. *Trialeurodes vaporariorum* was much more abundant than *Bemisia tabaci*. There were no differences in whitefly and *N. tenuis* population dynamics between greenhouses with screened and unscreened vents. Damage to flowers and stems followed *N. tenuis* population dynamics. *N. tenuis* caused the abortion of around 50% of the flowers during the four weeks following the population outbreak. We advise caution when using this plantbug as a biological control agent until management strategies have been better defined.

## Characterization of damage to tomato plants produced by the zoophytophagous predator *Nesidiocoris tenuis*

Judit Arnó, Cristina Castañé, Jordi Riudavets, Job Roig, Rosa Gabarra

Departament de Protecció Vegetal, IRTA-Centre de Cabrils, E-08348 Cabrils (Barcelona), Spain.

**Abstract:** *Nesidiocoris tenuis* is a zoophytophagous predator that is native to the Mediterranean. It is known to prey on different pests of vegetables but also to damage plants. As a consequence, whereas some authors regard it as an interesting biological control agent, for others it is a pest. To assess the importance of damage caused by this mirid bug, we surveyed commercial crops and conducted greenhouse and laboratory experiments to characterize the kind of damage caused in both the presence and absence of prey. Although, necrotic rings in the apex, leaf and leaflet petioles have been observed in crops with established *N. tenuis* populations, the densities reported for commercial fields in our region do not seem to cause severe damage to tomato plants. Greenhouse experiments showed that nymphs potentially caused more damage than adults. Even so, the damage caused by *N. tenuis* feeding tended to disappear or attenuate with time and did not affect plant growth. In laboratory experiments, the presence of prey significantly reduced the number of necrotic rings caused. In this preliminary study, no flower abortion was observed but more specific experiments need to be done to address this question of capital importance.

## Susceptibility to virus infection of candidate plants used to enhance predatory dicyphine (Heteroptera: Miridae)

Ignacio Morales<sup>1</sup>, Juan Antonio Sanchez<sup>2</sup>, Oscar Alomar<sup>3</sup>, Alfredo Lacasa<sup>2</sup>, Alberto Fereres<sup>1</sup>

<sup>1</sup>Instituto de Ciencias Agrarias (CCMA-CSIC). Serrano 115 dpdo, 28006 Madrid. <sup>2</sup>Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario, IMIDA. 30150 La Alberca, Murcia. <sup>3</sup>Departament de Protecció Vegetal, IRTA-Centre de Cabrils, 08348 Cabrils, Barcelona, Spain.

**Abstract:** Selecting candidate plants in order to enhance predators for conservation biological control not only has to consider their contribution to enhancement of predators, but also avoid the risk of acting as reservoirs of potential pests or diseases. Mirid bugs are effective biological control agents of tomato pests and the introduction of insectary plants has been shown to be an effective means for the conservation of these important natural enemies. We studied the degree of susceptibility and the role of selected insectary plants as reservoirs of the most important viruses found in tomato crops in Spain. A virus survey conducted in the regions of Murcia and Barcelona, and a series of transmission experiments conducted under controlled conditions indicated that the species *Dittrichia viscosa* and *Marrubium vulgare* are susceptible and may play a significant role in *Potato virus Y* and *Cucumber Mosaic Virus* epidemics, whereas virus were never detected in *Carlina corymbosa* and *Ononis natrix* collected in the field and were immune to the transmission of both viruses by aphids. Our work suggests that there is a potential risk for virus epidemics to occur if *M. vulgare* and *D. viscosa* are introduced as insectary plants to attract and enhance biological control by predatory mirids. Further research is needed to confirm the role that *M. vulgare* and *D. viscosa* and *Verbascum thapsus* may play in the epidemics of PVY and CMV in tomato crops. *C. corymbosa* and *O. natrix* appear to be the species that show the lowest risk as reservoirs of viruses that commonly infect tomato crops.

## Biological Control of *Fusarium oxysporum* f.sp. *melonis* race 1.2 by cross protection

**Hela Chikh-Rouhou, José Maria Álvarez, Rafael González-Torres**

*Centro de Investigación y Tecnología Agroalimentaria de Aragón, Unidad de Tecnología en Producción vegetal, Unidad de Sanidad Vegetal, P.O. Box 727, 50080 Zaragoza, Spain*

**Abstract:** The melon cultivar ‘Charentais T’ susceptible to *Fusarium oxysporum* f.sp. *melonis* (*Fom*) race 1.2 was pre-inoculated with a non-pathogenic isolate of *Fom*. The biocontrol agent was only effective when it was applied one or two days before a challenge inoculation with the pathogen. Simultaneous inoculation did not provide any durable protection. The effectiveness of cross-protection was not evident in the case of the pathogenic isolate belonging to pathotype 1.2Y, since all plants died by the end of the test. However, this did not happen when the pathogenic isolate was from pathotype 1.2W. Protection, consisting of a delay in the expression of symptoms and a reduction in the disease index, was apparent from the beginning of the experiments. Similarly, the ratio between inducer and challenger ( $3 \cdot 10^7$  spores/ml :  $3 \cdot 10^6$  spores/ml) gave the highest cross protection. These results indicate that cross-protection required a certain time and an adequate concentration of the inducer organism to become effective. The need for a time interval between induction and challenge inoculation for maximum protection suggests that protection is conditioned by prolonged fungus-plant interaction and regulated by the consequent metabolic changes in the plant.

## Evaluation of susceptibility of varieties of *Gerbera jamesonii* to *Fusarium* wilt

**Andrea Minuto, Domenico Bertetti, Maria Lodovica Gullino, Angelo Garibaldi**

*Center of Competence for Innovation in the agro-environmental sector, University of Torino, Via Leonardo da Vinci 44, 10095 Grugliasco, Italy. E-mail: [marialodovica.gullino@unito.it](mailto:marialodovica.gullino@unito.it)*

**Abstract:** This paper reports an evaluation of the sensitivity of gerbera cultivars to *Fusarium* wilt. The data obtained by inoculating 79 cultivars with a strain of *Fusarium oxysporum* (MASS1) originating from gerbera and with a strain of *F. oxysporum* f.sp. *chrysanthemi* (REP8) obtained from chrysanthemum allowed us to classify the gerbera strain as *F. oxysporum* f.sp. *chrysanthemi*. Moreover, the percentage of resistant and tolerant varieties was considered sufficient to satisfy grower needs in the cut flower sector.

## **Efficacy of *Ampelomyces quisqualis* isolate M-10 (AQ 10®) against powdery mildews (Erysiphaceae) on protected crops**

**Massimo Benuzzi<sup>1</sup>, Edith Ladurner<sup>1</sup>, Fernando Mayoral<sup>2</sup>,**

<sup>1</sup> *Intrachem Bio Italia S.p.A., R&D Department, Via Calcinaro 2085/7, I-47023 Cesena, Italy;*

<sup>2</sup> *Agrichem Bio S.A., Plaza Castilla 3-14 A, E-28046 Madrid, Spain*

**Abstract:** In the two mediterranean countries, Italy and Spain, the efficacy of the *A.quisqualis*-based biofungicide AQ10 for the control of powdery mildews has been evaluated for several years in numerous field and greenhouse trials. As an example of the trials conducted on protected crops, in this paper we report the results of two GEP trials carried out in 2004: one in Italy on protected cucumber and one in Spain on greenhouse pepper. In Italy, on protected cucumber, *A. quisqualis* treatments significantly reduced powdery mildew incidence and severity compared to the untreated control. The biofungicide showed highest efficacy in reducing both powdery mildew incidence and severity, when applied in tank mixture with a pine oil adjuvant, followed by the biocontrol agent applied alone. Similar results were obtained in Spain on pepper: *A. quisqualis* treatments resulted in a significant reduction of powdery mildew severity compared to the untreated control. In both trials, the efficacy of the *A. quisqualis*-based treatments was comparable to or higher than that of the chemical reference treatments.

## **Quantification of powdery mildew removal by the mycophagous Beetle *Psyllobora vigintimaculata* (Coleoptera: Coccinellidae)**

**Andrew M. Sutherland<sup>1</sup>, Michael P. Parrella<sup>2</sup>**

<sup>1</sup>*Graduate Student Researcher, Entomology Graduate Program.* <sup>2</sup>*Professor of Entomology, Department of Entomology, University of California-Davis, USA*

**Abstract:** The coccinellid tribe Psylloborini (Halyziini) is entirely comprised of obligate consumers of powdery mildew (PM) fungi (Ascomycota: Erysiphales). The small ashy gray ladybird beetle, *Psyllobora vigintimaculata*, a North American species, is being evaluated for use as a biological control agent against PM in greenhouse systems. Individual larvae were reared on PM-infected leaf discs in a laboratory incubator to quantify the removal of PM due to this insect's feeding. The leaf area cleaned and the background growth of PM were measured with image analysis software using periodic digital images. Leaf discs exposed to neonate larvae for 192 hours showed a significant decrease in PM growth as compared to an untreated control, and leaf discs exposed to 3<sup>rd</sup> instar larvae for 96 hours showed a significant decrease in infected leaf area. A simple model based on these data predicts that an individual larva cleans  $6.3 \pm 3.3 \text{ cm}^2$  leaf area of all visible PM hyphae and conidia from the time of egg eclosion until successful pupation.

## **UV interfering nets reduce TYLCD incidence and progress in tomato crops: influence of host genotype**

**Leonardo Velasco<sup>1</sup>, Dirk Janssen<sup>3</sup>, Marisol Catalá<sup>2</sup>, Joaquín Costa<sup>2</sup>**

<sup>1</sup>*Departamento de Biotecnología y Protección Vegetal.* <sup>2</sup>*Departamento de Horticultura. Instituto Murciano de Investigación y Desarrollo Agrario y alimentario (IMIDA). c/ Mayor s/n. E-30150 La Alberca – Murcia,* <sup>3</sup>*CIFA Almería (IFAPA, CICE, Junta de Andalucía), Autovía del Mediterráneo, Km 420. E-04745 La Mojonera – Almería, Spain. E-mail: leonardo.velasco@carm.es*

**Abstract:** Four tomato cultivars, tolerant and non-tolerant to tomato yellow leaf curl disease, were grown under UV-blocking and non-UV-blocking nets and TYLCD incidence and progression were compared. Squash-blot followed by molecular hybridization was used to monitor disease incidence and severity. Severity was recorded as hybridization signal intensity. Results of AUDPC analysis showed that there were significant differences in disease incidence and severity between the two nethouses. Disease intensity was not enough to explain the results, where severity was a more explanatory parameter for quantifying disease incidence. The four cultivars showed lower mean AUPDC incidence and severity in the UV-blocking nethouse. Differences in TYLCD between tolerant or non-tolerant cultivars were only significant when severity was considered. There were also marked differences among cultivars: the tolerant cultivar *Boludo* showed no significant differences in incidence and severity when compared with the non-tolerant cultivar *Izabella* in the UV-blocking nethouse. Finally, all of the cultivars, including the tolerant ones, proved good sources of virus inoculum, which made them unsuitable for virus control.

## **Iris yellow spot virus (IYSV): a new disease in Spain**

**Carmen Córdoba<sup>1</sup>, Lluçia Martínez-Priego<sup>1</sup>, Ramona Muñoz<sup>2</sup>, Concepción Jordá<sup>1</sup>.**

<sup>1</sup>*Departamento de Patología Vegetal-Unidad de Virología, Universidad Politécnica de Valencia, Camino de Vera s/n, 46022 Valencia, (E-mail: mjordag@upv.es );* <sup>2</sup>*ITAP: Instituto Tecnológico Agronómico Provincial. Albacete, Spain.*

**Abstract:** *Iris yellow spot virus* (IYSV) was detected recently in onions in the central region of Spain, causing straw colored ringspots or diamond-shaped lesions on leaves and flower stalks, and eventually leading to the death of the plant. The identification was carried out by double antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) of leaf sap extracted from symptomatic plants, using specific antisera against IYSV. The ELISA result was verified with a one step reverse transcription-polymerase chain reaction assay (RT-PCR) using primers specific to the nucleocapsid gene of IYSV. The identity of the PCR product with an expected size of approximately 790 bp. was confirmed by sequencing. This is the first report on the detection of a new tospovirus in Spain that causes disease in onions.

## Identification and determination of transmission ability of thrips species as vectors of two tospovirus, tomato spotted wilt virus (TSWV) and impatiens necrotic spot virus (INSV) on ornamental plants in Iran

T. Ghotbi, V. Baniameri

Plant Pests and Diseases Research Institute (PPDRI) P.O. Box 19395/1454, Tehran, Iran

**Abstract:** Tomato spotted wilt virus (TSWV) and impatiens necrotic spot virus (INSV) infect several ornamental plants and cause different level of losses to ornamental and also other cultivated crops. Therefore identification of the thrips vector is of importance and can help in selecting the proper control management measures. We have collected 220 ornamental plant samples from glasshouse and cultivations areas of Pakdasht and Mahallat that were suspicious to be infected by virus. Infections of collected plants by INSV and TSWV were rechecked and confirmed using specific antibody by Tissue blot immunoassay (TBIA) and ELISA. Samples of thrips infesting ornamental plants that showed virus like symptoms were also collected. In this study, 5 colonies of different thrips species from each plant were collected and from each thrips population, 2-3 thrips were preserved in 75% alcohol for species identification. Five thrips species were identified: *Thrips tabaci*, *Microcephalothrips abdominalis*, *Tenothrips frici*, *Tenothrips discolor* and *Frankliniella intonsa*. 2-3 thrips from each thrips populations were rechecked for the presence of INSV and TSWV using ELISA. Of the 220 ornamental plants collected, 158 were shown to be infected with TSWV (95) and INSV (63). Mix infections with both viruses were also recorded in few samples. Of the 68 ornamental plant samples which were infested by thrips populations, 45 plant samples were tested by ELISA to be positive for INSV and TSWV. The colonies of *T. tabaci* were infected by TSWV and INSV. Colonies of *M. abdominalis* and *T. discolor* were not found to be infected by these viruses. Colonies of *T. frici* and *F. intonsa* only in mixture with *T. tabaci* were positive in ELISA test to TSWV and the pure colonies of these two thrips species were not infectious. Only *T. tabaci* transmitted TSWV isolate in transmission tests in greenhouse, but did not transmitted INSV in biological tests. The high transmission ability, their population abundance in greenhouses and the existence of virions in this vector are the main results of this survey.

## Effect of soil disinfestation on fungi in greenhouses planted with sweet peppers

M<sup>a</sup> Ángeles Martínez<sup>1</sup>, Alfredo Lacasa<sup>1</sup>, M<sup>a</sup> Mar Guerrero<sup>1</sup>, Caridad Ros<sup>1</sup>, M<sup>a</sup> Carmen Martínez<sup>1</sup>, Pablo Bielza<sup>2</sup>, Javier Tello<sup>3</sup>

<sup>1</sup>*Biotecnología y Protección de Cultivos, IMIDA, C/Mayor, s/n. 30150 La Alberca (Murcia)*

<sup>2</sup>*Producción Vegetal, ETSIA, Universidad Politécnica de Cartagena, Paseo Alfonso XIII, s/n 30203 Cartagena (Murcia)* <sup>3</sup>*Producción Vegetal, Edificio CITE-II Universidad de Almería, 04120 Cañada de San Urbano, Almería, Spain.*

**Abstract:** In Region of Murcia (Spain), sweet pepper has been a monoculture in greenhouses over twenty years. Soils are usually disinfested with methyl bromide for pathogens control and to avoid soil fatigue effects. Soil disinfestation with biofumigation plus solarization had been evaluated by the presence of soil fungi and its evolution along the crop in the root colonized area. This method had been compared with methyl bromide, biofumigation alone and untreated soil in one greenhouse free of pathogens. The most reduced total fungal density was obtained with methyl bromide but at the end of the crop, population levels were similar in all treatments because there was an increase along the crop season. Biofumigation alone was not able to decrease fungal density in relation to untreated soil. Marketable yield was lower in the biofumigation alone treatment than in biofumigation plus solarization or methyl bromide. The accumulation of soil fungi could be related with the soil fatigue.

## Biofumigation vs. biofumigation plus solarization to control *Meloidogyne incognita* in sweet pepper

M<sup>a</sup> Mar Guerrero<sup>1</sup>, Caridad Ros<sup>1</sup>, M<sup>a</sup> Ángeles Martínez<sup>1</sup>, M<sup>a</sup> Carmen Martínez<sup>1</sup>, Antonio Bello<sup>2</sup>, Alfredo Lacasa<sup>1</sup>

<sup>1</sup>*Biotecnología y Protección de Cultivos, IMIDA, C/Mayor, s/n. 30.150 La Alberca (Murcia).*

<sup>2</sup>*Agroecología, Centro de Ciencias Medioambientales, CSIC, C/Serrano, 115, 28.006 Madrid, Spain*

**Abstract:** In Region of Murcia (Spain), *Meloidogyne incognita* is one of the main phytopathological problems in soils where sweet pepper is grown under greenhouse conditions. Biofumigation efficacy when local amendments are used has been compared with biofumigation plus solarization, which is considered as an alternative to methyl bromide in soil disinfestation. When biofumigation plus solarization is repeated in the same soil, *M. incognita* control levels and marketable yield were similar to that of methyl bromide. Biofumigation alone was not efficient to control the nematode. If this method is repeated one time, marketable yield is better when it is compared with untreated soil but this improvement is not sustainable along the next growing seasons.

## Integrated management of *Meloidogyne* resistance in sweet pepper in greenhouses

Caridad Ros<sup>1</sup>, M<sup>a</sup> Mar Guerrero<sup>1</sup>, M<sup>a</sup> Ángeles Martínez<sup>1</sup>, Alfredo Lacasa<sup>1</sup>, Antonio Bello<sup>2</sup>

<sup>1</sup>Biotecnología y Protección de Cultivos, IMIDA, C/Mayor, s/n. 30.150 La Alberca (Murcia).

<sup>2</sup>Agroecología, Centro de Ciencias Medioambientales, CSIC, C/Serrano, 115, 28.006 Madrid, Spain

**Abstract:** In Region of Murcia (Spain), *Meloidogyne* causes important damages in sweet pepper crops. Restricted use of methyl bromide as soil disinfectant suggests the use of cultivars or rootstocks resistant to nematodes. The reiteration in the use of resistant rootstocks to *Meloidogyne* causes the selection of populations which are able to overcome resistance. Grafting on resistant rootstocks to nematode combined with biofumigation + solarization has been assayed using a mixture of fresh sheep manure and chicken manure in two greenhouses infested with *M. incognita*. In biofumigated and solarized soils, resistance showed efficacy after three years of monoculture. In non disinfected soil, nematode resistance was overcome the second year of monoculture in one of the greenhouses, while the other one was not affected. Combination of grafting and biofumigation plus solarization was shown as a feasible alternative to methyl bromide in sweet pepper greenhouses in the South East of Spain.

## Effect of organic amendments *Ricinus communis* and *Azadirachta indica* on root-knot nematodes *Meloidogyne javanica* infecting tomato in Morocco

Zahra Ferji<sup>1</sup> El Hassan Mayad<sup>2</sup>, Taoufiq Laghdaf<sup>1</sup>, Elbouchtaoui med Cherif<sup>1</sup>

<sup>1</sup>Laboratoire de Nématologie, Institut Agronomique et vétérinaire Hassan II Complexe Horticole d'Agadir; B.P 18/S, Agadir. [Ferji@iavcha.ac.ma](mailto:Ferji@iavcha.ac.ma) <sup>2</sup>Laboratoire de Symbiotes Racinaires et Biochimie végétale, Faculté des Sciences, B.P. 28/S, Agadir, Maroc. [h\\_mayad@yahoo.fr](mailto:h_mayad@yahoo.fr)

**Abstract:** Field investigation on the use of three organic amendments (oil cake of Neem *Azadirachta indica* "TN", oil cake "TR" and ground aerial parts "BR" of *Ricinus communis*) and a chemical product, Agrocelhone (Dichloropropene + Chloropicrine) "DDC" for the control of *Meloidogyne javanica* infecting tomato "CALVI" grafted on Beaufort was conducted in Morocco. Nematode control with the ground aerial parts of *Ricinus communis* was more effective than with the other treatments. Higher tomato yields were obtained from treatments with DDC than from either of the organic amendments. However, the use of organic materials increased the nutrient status of the soil, which resulted in increased yields in comparison with the control.

## Effects of natural insecticides on *Frankliniella occidentalis* and *Orius* spp.

Josefina Contreras, Vicente Quinto, Jaime Abellán, Esther Fernández, Carolina Grávalos, Laura Moros, Pablo Bielza

Escuela Técnica Superior de Ingeniería Agronómica, Universidad Politécnica de Cartagena, Paseo Alfonso XIII, 48, 30203 Cartagena, Spain, [josefina.contreras@upct.es](mailto:josefina.contreras@upct.es)

**Abstract:** The use of Integrated Pest Management (IPM) programs on sweet pepper greenhouses against *Frankliniella occidentalis* that include insecticides with minimal impact on associated biological control agents is difficult: The pest develops insecticide resistance and the number of permitted insecticides is very limited. Therefore, there is a need to identify novel insecticides for use in IPM programs. In laboratory, toxicity of pyrethrum, spinosad, soap and mineral oil using topical and residual methods were tested for adults and larvae of *F. occidentalis* and adults of *Orius* spp. Results showed that spinosad had potential for use in IPM programs that include *Orius* spp while pyrethrum can have a detrimental effect to this natural enemy. Soap and the mineral oil had not effectively controlled *F. occidentalis*.

## Insecticidal activity of essential oil from *Vitex pseudo-negundo* against *Brevicoryne brassicae*

Saeid Moharramipour, Bibi Zahra Sahaf

Department of Entomology, College of Agriculture, Tarbiat Modarres University, P.O. Box 14115-336, Tehran, Iran

**Abstract:** An experiment was conducted to investigate the fumigant toxicity of an essential oil obtained from dry *Vitex pseudo-negundo* leaves against *Brevicoryne brassicae*. Nymph mortality increased with concentrations of 1.6 to 12  $\mu\text{L/L}$  air and with exposure times from 3 to 24 h. A bioassay conducted with the oil showed the  $\text{LC}_{50}$  and  $\text{LC}_{95}$  values to be 6.565 and 26.706  $\mu\text{L/L}$  respectively. This suggested that *V. pseudo-negundo* oil may offer potential as a control agent for Integrated Pest Management programs in protected crops.

## Evaluation de l'effet nematicide de l'extrait methanolique de quelques plantes médicinales au Maroc

El Hassan Mayad<sup>1</sup>, Zahra Ferji<sup>2</sup>, Lala Mina Idrissi Hassani<sup>1</sup>

<sup>1</sup>Laboratoire de Symbiotes Racinaires et Biochimie végétale, Faculté des Sciences, B.P. 28/S, Agadir, [h\\_mayad@yahoo.fr](mailto:h_mayad@yahoo.fr); [aminaidrissi@yahoo.fr](mailto:aminaidrissi@yahoo.fr) <sup>2</sup>Institut agronomique et vétérinaire Hassan II, Département de Protection des Plantes, Nématologie. Agadir, Maroc. [Ferji@iavcha.ac.ma](mailto:Ferji@iavcha.ac.ma)

**Résumé:** Les extraits méthanoliques de quatre plantes médicinales *Artemisia herba-alba*, *Thymus satureioides*, *Peganum harmala* et *Ricinus communis* ont été évalués pour déterminer leur impact sur les juvéniles J2 des nématodes à galles *Meloidogyne javanica in vitro*. Quatre concentrations ont été testées 10, 20, 50 et 100µg/ml à différentes périodes d'incubation à la température ambiante pendant 72 heures. Le taux de mortalité s'accroît avec l'augmentation de la concentration de l'extrait et du temps d'incubation. Aucun effet sur les *Meloidogyne javanica* n'a été obtenu avec la plus faible concentration (10 µg/ml) pour tous les extraits des plantes examinées. Le taux de mortalité le plus élevé a été obtenu avec l'extrait du *Ricinus communis* (30 %) suivi de celui de l'*Artemisia herba-alba*, (26%) à 100µg/ml après 72 heures. L'extrait méthanolique de *Peganum harmala* s'est avéré moins toxique contre les larves J2 de *Meloidogyne javanica*.

## Side effects of pesticides on *Orius insidiosus* (Hemiptera: Anthocoridae)

Geraldo A. Carvalho, Vanda H. P. Bueno, Alexandre P. Moura, Luiz C. D. Rocha, Fabrícia Z. V. Torres

Department of Entomology, Federal University of Lavras, P.O. Box 3037, 37200-000, Lavras MG, Brazil

**Abstract:** The predatory bug *Orius insidiosus* plays an important role as a biocontrol agent of thrips in protected cultivation in Brazil. As control of thrips still involves chemical methods, and *Orius* spp. can invade greenhouses spontaneously, this work was aimed at testing the side effects of nine insecticides/acaricides, six fungicides and one natural soap on eggs, nymphs and adults of *O. insidiosus*. The tests were conducted under laboratory conditions and following the approved international guidelines described by the IOBC/WPRS. Vertimec (abamectin), Orthene (acephate), Decis (deltamethrin) and Tamaron (methamidophos) were the most harmful compounds to *O. insidiosus*, whereas Pirate (chlorfenapyr), Endosulfan Fersol (endosulfan), Dicarzol (formetanate), Provado (imidacloprid) and Tracer (spinosad) showed intermediate toxicity. Biosoap (soap) was harmless to eggs, and harmful to fifth-instar nymphs and adults. Benlate (benomyl), Ridomil (metalaxyl+mancozeb) and Saprol (triforine) were harmless to all stages of *O. insidiosus* tested. Amistar (azoxystrobin), Manage (imibenconazole) and Rovral (iprodione) showed to be harmless to almost all stages of *O. insidiosus*. The fungicides evaluated were less toxic to *O. insidiosus* when compared to the insecticides/acaricides. The tested fungicides can be recommended for use on an IPM program, but further evaluation of the other tested pesticides should be carried out under semi-field and field conditions.

## Side effects of pesticides on *Trichogramma pretiosum* (Hymenoptera: Trichogrammatidae)

Geraldo A. Carvalho, Alexandre P. Moura, Vanda H. P. Bueno

Federal University of Lavras, Department of Entomology, P.O. Box 3037, 37200-000, Lavras MG, Brazil

**Abstract:** One of the most promising biological agents for controlling the tomato moth *Tuta absoluta* under protected cultivation in Brazil is the egg parasitoid *Trichogramma pretiosum* (Hym., Trichogrammatidae). However, there is currently little knowledge of the toxicity of pesticides commonly used in tomato crops to this parasitoid. This work aimed to analyse the side-effects of 24 pesticides on *T. pretiosum*. These compounds are all commonly used to control tomato crop pests and diseases in Brazil. The pesticides assessed: Orthene (acephate), Mospilan (acetamiprid), Atabron (chlorfluazuron), Trigard (cyromazine), Forum (dimethomorph), Pirimor (pirimicarb), Mimic (tebufenozide), Nomolt (teflubenzuron), Actara (thiamethoxam), Alsystin (triflumuron), Dipel (*Bacillus thuringiensis*), Benlate (benomyl), Bravonil (chlorothalonil), Rovral (iprodione) and Dithane (mancozeb) were shown to be harmless to *T. pretiosum*. Calypso (thiacloprid), Confidor (imidacloprid), Cartap (cartap), Decis (deltamethrin), Karate (lambda-cyhalothrin), Pirate (chlorfenapyr) and Tamaron (methamidophos) showed the highest toxicity to this parasitoid species. The pesticides belonging to the organophosphate and pyrethroid classes presented the greatest toxicities to *T. pretiosum*, whereas the neonicotinoids, insect growth regulators, fungicides and microbial *B. thuringiensis* tested proved harmless to *T. pretiosum*.

## Compatibility of *Hyposoter didymator*, an endoparasitoid of *Spodoptera littoralis*, with several insecticides used on horticultural crops.

José Javier Morales, Pilar Medina, Elisa Viñuela

Unidad de Protección de Cultivos. Escuela Técnica Superior de Ingenieros Agrónomos. Ciudad Universitaria, s/n. 28040. Madrid. Spain. E-mail: [pilar.medina@upm.es](mailto:pilar.medina@upm.es)

**Abstract:** *Hyposoter didymator* is a solitary endoparasitoid of *Spodoptera littoralis* larvae, occupying a select position among our native biocontrol agents. To obtain good results from the joint use of pesticides and natural enemies, the side effects of five insecticides (fipronil, imidacloprid, natural pyrethrins + piperonyl butoxide (PBO), pymetrozine and triflumuron) with very different modes of action were evaluated. Tests were carried out in Spain on all developmental stages and at their respective maximum recommended field rates. Topical and ingestion bioassays were carried out whenever possible. The results obtained were classified according to IOBC standards. In the case of parasitized larvae treatments, fipronil always proved very toxic, while imidacloprid killed 100% of host insects by ingestion, but resulted completely innocuous to both hosts and parasitoids in topical applications. Natural pyrethrins+PBO and triflumuron showed different degrees of toxicity and only pymetrozine was totally harmless. Parasitoid cocoons proved to provide very efficient protection against all of the insecticides tested except fipronil. Adult insect life spans were significantly reduced when treated at field rates by all of the insecticides tested except pymetrozine, irrespective of the uptake route. Fipronil was clearly the most toxic insecticide.