

**IOBC-WPRS**

**12<sup>th</sup> Conference of the Working Group  
Integrated Protection of Stored Product**

**Program  
&  
Book of Abstracts**

**Pisa, Italy**

**3 – 6 September 2019**

**Editors  
Barbara Conti, Pasquale Trematerra**



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# PROGRAM

## TUESDAY 3 SEPTEMBER 2019

UNIVERSITY OF PISA, AULA MAGNA - DEPARTMENT OF AGRICULTURE, FOOD AND ENVIRONMENT

**16.00 –19.00 – REGISTRATION**

**17.30 - OPENING CEREMONY**

Alberto PARDOSSI - Director of the Department of Agriculture, Food and Environment, University of Pisa

Cristina CASTAÑÉ - Liaison of IOBC Working Group

Pasquale TREMATERRA - Convenor of the Working Group

Barbara CONTI - Local Organizer

**18.30 - WELCOME DRINK**

## WEDNESDAY 4 SEPTEMBER 2019

UNIVERSITY OF PISA, AULA MAGNA-POLO PIAGGE

**8.00 - REGISTRATION AND POSTER INSTALLATION**

**8.45 - SESSION 1: Physical, chemical and other techniques for stored product pest control**

Session Chair: Arthur F. (USA)

**Keynote Speaker: Athanassiou C.G.** (Greece), Götze C., Jakob G., Allegra J., Sakka M., Agrafioti P., Riga M., Vontas J.

“Phosphine tolerance/resistance in Europe: what do we know so far?”

**9.15 - Ocreto M. B., Fuertes L. A.P., Tala M.W., de Bruin T.**

“Monitoring Rice Storability Using Carbon Dioxide Sensors in Gastight Storage”

**9.30 - Kik O., Roth T.**

“Pressurized Pest Control with Carbon Dioxide for Biological Stock Protection”

**9.45 - Quinn E., Trostanetsky A., Rapaport A., Harush A., Gottlieb D.**

“Deltamethrin Emulsion Activity in Grain Warehouses”

**10.00 - Quellhorst H., Frank H. Arthur, W.R. Morrison III**

“Efficacy of novel, reduced-risk insecticides for inducing mortality and sublethal changes in behavior for the post-harvest beetles, *Prostephanus truncatus* and *Sitophilus zeamais* after exposure on concrete surfaces”

**10.15 - Nead-Nylander B., Hall W.**

“Evaluation of Sulfuryl Fluoride (ProFume® gas fumi-gant) for control of the flat Grain Beetle (*Cryptolestes pusillus* (Schönherr)) and Maize Weevil (*Sitophilus zeamais* (Motschulsky))”

**10.30** - Scully E.

“Using linked-reads to generate whole genome assemblies of stored product insects”

**10.45** - Işıkber A.A., Sağlam Ö., Henteş S., Altaş N.

“Residual contact toxicity of spinetoram against granary weevil (*Sitophilus granarius* L.) and confused flour beetle (*Tribolium confusum* Du Val.)

**11.00 - COFFEE BREAK and POSTER SESSION**

**11.30** - Gerken A.R., Abts S.R., Scully E.D., Campbell J.F.

“Adaptation to non-lethal cold stress in *Trogoderma variabile* shows cross-tolerances for chronic cold stress and body size”

**11.45** - Konemann C.E., Danso J.K., Opit G.P.

“Phosphine Discriminating Doses for Four Store-Product Psocid ('Psocoptera' – Psocodae: Liposcelididae)”

**12.00** - Guerra P., Radeghieri P., Montanari C.

“The effectiveness of high-temperature treatments against *Dermanyssus gallinae* in layer poultry farms with a commercial eggs production, and an evaluation of its secondary effects to Total Bacterial Load (TBL) and Enterobacteriaceae “

**12.15** - Adler C.

“Small particle size of flour limits efficacy of carbon dioxide-high pressure-treatment”

**12.30** - Nayak M.K., Daghli G.J., Byrne V., Burril P., Jagadeesan R., May P.

“Potential of Flavocide™ as a new grain protectant to manage major resistant stored grain pests: an Australian case study”

**12.45** - Sağlam Ö., Şen R., Bozkurt H., Işıkber A.A.

“Insecticidal efficacy of three commercial diatomaceous earths, Detech®, Demite® and Silicosec® against cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae: Bruchninae)”

**13.00** - Yasir M., ul Hasan M., Sagheer M., ur Rehman H., Amjad F.

“Residual efficacy of novaluron applied on grain commodities for the control of sawtoothed grain beetle (*Oryzaephilus surinamensis*) and red flour beetle (*Tribolium castaneum*)”

**13.15 - LUNCH and POSTER SESSION**

**14.30** - Boukouvala M.C., Kavallieratos N.G., Athanassiou C.G., Benelli G., Hadjarapoglou L.P.

“Insecticidal efficacy of six new pyrrole derivatives against four stored-product pests”

**14.45** - Bayram A., Işıkber A.A., Sağlam Ö., Şen R.

“Evaluation of repellency effect of diatomaceous Earth formulation (Detech®) on three coleopteran stored grain insects”

**15.00 - SESSION 2: Pest management in the food industry**

Session Chair: Savoldelli S. (Italy)

**Keynote Speaker: Mahroof R. M.** (USA)

“Pest Management in a Changing World: Challenges and Triumphs in the Food Industry”

**15.30** - Tamburro M., Ripabelli G., Sammarco M.L., Di Tella D., Guerrizio G., Fanelli I., Nakken L., Trematerra P.

“*Alphitobius diaperinus*: the potential role in the transmission of human pathogenic bacteria”

**15.45** - Arthur F.H., Scheff D.S., Domingue M.J.

“Research with Dermestid larvae: pitfalls and cautions”

**16.00**- Vukajlović F., Predojević D., Miljković K., Tanasković S., Gvozdenac S., Perišić V., Pešić S.  
“The growth dynamics of *Plodia interpunctella* (Lepidoptera: Pyralidae) larvae on dried fruits and nuts”

**16.15** - Guerra P., Conti G., Donati L.

“The practical application of mating disruption to population reductions of *Ephestia elutella* (Hb.) and *Plodia interpunctella* (Hb.) respectively in the chocolate and dried fruit processing industries and the reduction of disinfestation activities using biocidal products”

**16.30** - Guarino S., Caimi M., Peri E.

“Estimating the release rate of pheromone dispensers of stored product pests with the use of Solid Phase Micro-Extraction”

**16.45** - Boukouvala M.C., Kavallieratos N.G., Romano D., Athanassiou C.G., Stefanini C., Canale A., Benelli G.

“Impact of geographical origin on male mating success and behavioral asymmetries in the lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae) – implications for IPM”

**17.00** - Amjad F., Ashraf I., Qandeel A., ul Hasan M., Sagheer M., Yasir M.

“Assessment of different diet mediums for development of stored grain pest *Oryzaephilus surinamensis* (Coleoptera: Silvanidae)”

**17.15** - Mueller K.

“Long-time storage of grain”

**17.30** - Rumbos C.I., Rigopoulou M., Vrontaki M., Pantazis I., Athanassiou C.G.

“Stored-product insects as nutrient source: Challenges and perspectives”

**17.45** - Iturralde-García R., Castañé, C., Wong-Corral, F., Riudavets, J.

“Control of *Rhyzopertha dominica* (Coleoptera: Bostrichidae) in chickpeas with CO<sub>2</sub> modified atmosphere packaging”

**18.00** – Shivananjappa S., Wilches D., Floate K., Laird R., Fields P., Hervet V.

“Diapause, desiccation and cold tolerance in khapra beetle, *Trogoderma granarium*”

**18.15** - Agrafioti P., Athanassiou C.G., Subramanyam Bh.  
"Efficacy of heat treatment on phosphine resistant and susceptible populations of stored product insects"

**18.30** - Duarte S., Hilario C., Limão J., Cunha S., Cambeiro A.F., Magro A., Barros G., Alvito P., Ferreira R.B., Teixeira B., Mendes R., Alves V., Mourato M.P., Carvalho M.O.  
"SafeGrains: project to evaluate the contamination by insects and fungi on grains and derivatives in Portugal"

**18.45** - Zakladnoy G., Belov P.  
"Application of modified Silicium Dioxide in Grain storages pest control. Practical application, Industrial treatment results"

## **THURSDAY 5 SEPTEMBER 2019**

### **UNIVERSITY OF PISA, AULA MAGNA POLO PIAGGE**

#### **8.00 - POSTER INSTALLATION**

#### **8.45 - SESSION 3: Prevention of microflora infection and development of mycotoxins**

**Session Chair:** Carvalho M.O. (Portugal)

**Keynote Speaker: Sarrocco S.** (Italy), Vannacci G.  
"Field application of beneficial fungi to prevent postharvest mycotoxin contamination"

**9.15** - Zajc J., Černoša A., Gostinčar C., Gunde-Cimerman N., Ravnikar M.  
"Aureobasidium spp. as potent biocontrol yeasts for tackling fungal storage diseases"

**9.30** - Langsi D.J., Suh C., Fokunang C.N., Nukenine E.N.  
"Maize Biodegradation Control using Essential Oils from Bamenda"

**9.45** - Navarro S., Navarro H.  
"Prevention of condensation in shipping containers containing bagged stored products"

#### **10.00 - SESSION 4: Quarantine and regulatory issues**

**Session Chair:** Rozman V. (Croatia)

**Keynote Speaker: Hamel D.** (Croatia)  
"Regulations related to storing of agricultural products and other goods"

**10.30** - Kostyukovsky M., Kaspi R., Fallik E., Dobrinin S., Guinn E., Rappaport A., Harush A., Protasov A. "Development of postharvest quarantine treatment against the western flower thrips *Frankliniella occidentalis* in pepper fruit"

**10.45** - Navarro H., Navarro S.  
"Phosphine sorption at low temperature fumigation of pot plants"

**11.00** – Belcari A., Rosi C, Sacchetti P., Guidi R., Garbati Pegna F.  
“Dates disinfestation by Radio Frequency treatments”

**11.15 - COFFEE BREAK and POSTER SESSION**

**11.45 - SESSION 5: Biological control of stored product pests**

**Session Chair:** Riudavets J. (Spain)

**Keynote Speaker: Russo A.** (Italy), Suma P.

“Entomophagous insects as biocontrol agents of stored food pests”

**12.15** - Fürstenau B., Awater-Salendo S.D.

“Biologically-based control of *Tribolium confusum* using parasitoids and semiochemicals: from basic research to semifield application”

**12.30** - Riudavets J., Iturralde-García R., Castañé, C.

“Control of *Callosobruchus maculatus* (Coleoptera: Bruchidae) with natural enemies in chickpeas”

**12.45** - Thakur D.R., Devi A.

“Studies on developmental compatibility and botanical management of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) on different cultivars of *Vigna radiata* (L.) Wilczek”

**13.00** - Masoomah Moosavi, Nooshin Zandi-Sohani, Ali Rajabpour

“Influence of temperature on the functional response of *Anisopteromalus calandrae* (Hym: Pteromalidae) to different population densities of *Callosobruchus maculatus* (Col.: Bruchidae)”

**13.15** - Castañé, C; Iturralde-García, R.; Wong-Corral, F.; Riudavets, J.

“Possibilities for the biological control of the bean weevils *Acanthoscelides obtectus* and *Zabrotes subfasciatus* (Coleoptera: Bruchidae)”

**13.30** - Mbata G.N., Shapiro-Ilan D.I., Alborn H., Strand M.R.

“Preferential infectivity of entomopathogenic nematodes in an envenomed *Plodia interpunctella* larvae”

**13.45 - LUNCH and POSTER SESSION**

**15.00 - CONFERENCE TECHNICAL EXCURSION** (Bus stop at the lateral entrance of the Department)

**20.00 - CONFERENCE DINNER**

**FRIDAY 6 SEPTEMBER 2019**

UNIVERSITY OF PISA, AULA MAGNA POLO PIAGGE

**8.00 - POSTER INSTALLATION**

**8.45 - SESSION 6: Methods of pest prevention during storage, transportation and handling of stored products**

**Session Chair:** Stejskal V. (Czech Republic)

**Keynote Speaker: Campbell J.F. (USA)**

“Prevention of stored product insect infestations through management of the outdoor landscape”

**9.15** - Morrison W.R., Wilkins R.V.

“Long-lasting insecticide netting is effective at preventing dispersal to novel food patches against multiple stored product species and life stages”

**9.30** - Stejskal V., Vendl T., Li Z., Aulicky R.

“Lower temperature thresholds for development, locomotion, flight, respiration and sound production of stored product insects and mites”

**9.45** - Mutungi C., Gaspar A., Kabula E., Abass A.

“Quality of maize stored in hermetic bags by smallholder farmers in the Northern highlands of Tanzania: impact of farmer practices and agro-location”

**10.00** - Scheff D.S., Arthur F.H., Campbell J.F.

“Evaluation of long-lasting insecticide treated netting against a suite of stored product insects”

**10.15** - Reitter M.

“Protecting the Quality of Grain during storage through cool conservation”

**10.30 - COFFEE BREAK and POSTER SESSION**

**11.00 - SESSION 7: Natural products**

**Session Chair:** Adler C. (Germany);

**Keynote Speaker: Nayak M.K. (Australia)**

“Role of natural products in management of stored product pests: challenges and opportunities”

**11.30** - Ashamo M.O., Ileke K. D., Odeyemi O.O.

“Efficacy of *Alstonia boonei* De Wild essential oil as entomocides in the management of cowpea bruchid, *Callosobruchus maculatus* Fab.”

**11.45** - Gvozdenac S., Prvulović D., Bursić V., Ovuka J., Vukajlović F., Cvejić S., Tanasković S.

“The potential of *Ajuga* species as sunflower grain protectants against *Plodia interpunctella* Hübner”

**12.00** - Okweche S.I., Hilili P.M.

“Susceptibility and termiticidal activity of oil-seeds of *Jatropha curcas* and Neem tree on the management of wood termites”

**12.15** - Sabbour M.

“Effect of some natural oils against *Rhyzopertha dominica* (Coleoptera: Bostrichidae) under laboratory and store conditions”

**12.30** - Taleb-Toudert K., Khouja M.L., Ben Brahim S., Kellouche A.

“Bio insecticidal effect of *Jatropha curcas* oil of Tunisian origin on *Rhyzopertha dominica*”

**12.45** - Domingue M.J., Morrison W.R., Myers S.W.  
"Behavioral effects of naturally extracted fatty acid on *Trogoderma* larvae"

**13.00** - Gagnarli E., Tarchi F., Barzanti G., La Forgia F., Simoni S.  
"Effectiveness of propolis' extracts for storage mites' control"

**13.15 - LUNCH and POSTER SESSION**

**14.30 - SESSION 7: Natural products**

**14.30** - Ofuya T.  
"The potential for integration of insecticidal botanical products with other control methods for stored grain protection against insect infestation and damage in Nigeria"

**14.45** - Sagheer M., ul Hasan M., Ali Raza, Ali K., Rehman H.A., Gul Zaheer A., Iqbal M.  
"Insecticidal bioactivity of extract of basil plant (*Ocimum basilicum*) in combination with *Metarhizium anisopliae* against saw toothed beetle *Oryzaephilus surinamensis* (Coleoptera: Silvanidae)"

**15.00** - ul Hasan M., Zaman S., Anwar T., Ali Q., Ayyub M.B., Sadiq M.A., Amjad F., Mehmood R.  
"Efficacy of plant extracts against *Tribolium castaneum* (Herbst) in two types of flours"

**15.15** - Abada M.B., Hamdi S.H., Gharib R., Boushieh E., Messaoud C., Fourmentin S., Greige-Gerges H., Médiouni-Ben Jemâa J.  
"Essential oils loaded in nano-delivery systems: a developing technique for the control of the date moth *Ectomyelois ceratoniae* under storage conditions"

**15.30** - Korunić Z., Liška A., Hamel D., Lucić P., Rozman V.  
"Effectiveness of new developed natural and safe insecticide formulations against stored product insects"

**15.45** - Babarinde S.A., Babarinde G.O., Adebayo T.A., Olaniran O.A., Akani R.A., Shittu R.O., Adeleye A.D.  
"Response of saw-toothed grain beetle *Oryzaephilus surinamensis* (Linnaeus, 1758) (Coleoptera: Silvanidae) to *Piper guineense*-based biopesticides infesting melon"

**16.00** - Giunti G., Algeri G.M., Campolo O., Laudani F., Palermo D., Palmeri V.  
"Habituation of the lesser grain borer, *Rhyzopertha dominica*, to essential oil-based repellents"

**16.15** - Wicochea-Rodríguez J.D., Ruiz T., Gastaldi E., Chéreau S., Chalier P.  
"Biopesticide granules based on essential oils for the protection of wheat grain during storage"

**16.30** - Bedini S., Farina P., Conti B.  
"Repellence and attractiveness: the double effect of essential oils on insect pests"

**16.45** - Baltaci D.  
"Control effect of an almond and black cumin seed oil mixture towards four stored product pests"

**17.00 - SESSION 8: Wood-boring, urban and museum pests**

Session Chair: Guedes R.N.C. (Brazil)

**Keynote Speaker: Plarre R.** (Germany)

“Uninvited Guests in Museums – Management of Wood Worms and Clothes Moths”

**17.30** - Savoldelli S., Farris S.

“Coating technology to preserve bread-made museum collections against *Sitophilus granarius*”

**17.45**- Kassel A., Opitz C., Auer J.

“Biological control of wood destroying beetles with *Spathius exarator*”

**18.00** - Cosme Jr. L., Turchen L.M., Guedes R.N.C.

“Tropical woods and the West Indian drywood termite *Cryptotermes brevis*”

**18.15 - CONFERENCE CLOSING REMARKS, AWARD FOR THE BEST sS AND ELECTION NEW CONVENOR**

**POSTERS**

**WEDNESDAY 4 SEPTEMBER 2019**

- Physical, chemical and other techniques for stored product pest control

- Pest management in the food industry

1. Kordan B., Gabryś B.  
“Effect of barley and buckwheat grain processing on the development and feeding of the confused flour beetle”
2. AlJabr A.M., Bukowah I.A.  
“The development of *Ephestia cautella* (Lepidoptera: Pyralidae) under different temperature regimes”
3. Gvozdenac S., Ovuka J., Tanasković S., Vukajlović F., Prvulović D.  
“The tolerance of external (*Plodia interpunctella*) and internal (*Sitophilus oryzae* and *S. zeamais*) grain feeders to high temperatures”
4. Iwamoto H., Takahashi R., Imai T.  
“Effective light device for trapping stored products pyralid moths”
5. Lemic D., Jemberk D., Jantolek L., Šimunović K., Genda M., Andrijana Galešić Marija  
“Ozone efficiency in insect suppression”.
6. Cabacos M., Duyme F., Crepon K.  
“The effects of grain cleaning on the development of *Sitophilus oryzae* infestation”.
7. Khalaf M. Z., Naher F.H., Abdulhamza B.H., Sami R.A., Alshamari H.E.  
“The effect of time's exposure and thickness of material on efficacy of microwave energy in some different stages for some storage insects”.

8. Kern P., Böttger G., Hentschel C., Höpfner D., Mattmüller B., Große K., Adler C.  
“Insect laser optical detection and control of stored product insect pests with laser beams”
9. Iakovlev P.A.  
“Preliminary tests of spinosad for grain treatment against stored product pests in Russia”.
10. Shah J.A., Aulicky R., Ryšánek P., Stejskal V.  
“Controlled atmospheres to control an internally feeding stored product pests *Sitophilus granarius* and *Callosobruchus chinensis*”.
11. Tanguy A., Deudon O., Crepon K.  
“Average cooling availability for grain aeration in France over the last 20 years”.
12. Aulicky R., Vendl T., Stejskal V.  
“Is Indian meal moth good at playing “oviposition-darts” when searching for holes in fruit bar packages?”
13. Domingue M.J., Morrison W.R., Agrafioti P., Baliota G., Sakka M., Scheff D., Lampiri E., Gourgouta M., Boukouvala M.C., Myers S. W., Athanassiou C.G.  
“Assessment of different traps and attractants in three processing facilities in Central Greece”
14. T.N. Vassilakos, J. Riudavets, C. Castañé, R.D. Iturralde-Garcia, C.G. Athanassiou  
“Efficacy of modified atmospheres on *Trogoderma granarium* and *Sitophilus zeamais*”
15. Süß L., Cagnola A., Zanoni D., Cassani G.  
“Resistance test for different pasta packagings to the massive and repeated attack by *Plodia interpunctella* larvae (Lepidoptera: Pyralidae) and *Sitophilus oryzae* adults (Coleoptera: Dryophthoridae)”
16. Oke M.A.  
“Agricultural production, distribution and the demands for pesticides in Nigeria”
17. Simoni S., Gargani E., Tarchi F., Tirinnanzi L., Gagnarli E., Roversi P.F.  
“Microwave technology: post harvest effectiveness on bruchid pests and mites on legumes”
18. Cominelli F., Reguzzi M.C., Mazzoni E., Nicoli Aldini R.  
“Experimental investigations on infestation of grains and seeds recently introduced into Italy by stored product insects”
19. Predojević D., Vukajlović F., Rudnjanin I., Pešić S.  
“Susceptibility of dried mushrooms (*Boletus edulis*, *Cantharellus cibarius* and *Agaricus bisporus*) to the attack of some storage insect pests (preliminary results)”

20. Mostoviak S., Sedyk V.  
“Storage pests and pest control methods in Ukraine”

## **THURSDAY 5 SEPTEMBER 2019**

- **Prevention of microflora infection and development of mycotoxins**
- **Quarantine and regulatory issues**
- **Biological control of stored product pests**

1. Mebarkia A., Meghazi N.  
“Antifungal activity of essential oils against post-harvest wheat pathogen of *Aspergillus* sp.”
2. Giunti G., Reale G., Santelmo M., Palermo D., Campolo O., Russo A., Palmeri V., Zappalà L.  
“Oviposition deterrent activity of essential oil-based gel formulations against *Plodia interpunctella*”
3. Hamdi S.H., Abdelkader N., Hedjal-Chebheb M., Boushah E., Médiouni-Ben Jemâa J.  
“Biological control of *Callosobruchus maculatus* using the parasitoid wasp *Dinarmus basalis*: Effects of host fitness”.
4. Pampiglione G., Piombo C., Caimi M.  
“Food Safety Standards positive contribution to Pest Management activities”.
5. Rumbos C.I., Pantazis I., Athanassiou C.G.  
“Population growth of the lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae) on amylaceous commodities”.
6. Vendl T., Stejskal V., Aulicky R.  
“Food packages invasion by Silvanid and Laemophloeid stored pests: morphological adaptations and climbing abilities”.
7. Preißel S., Adler C., Kühne S.  
“Online identification guide for stored product pests:  
<https://pflanzenschutz.oekolandbau.de>”
8. Pimentel M.A.G., Mendes S.M., de Meneses C.B., Fernandes D.K.S., de Oliveira I.R., Cota R.A.  
“Choosing a suitable sorghum hybrid helps control the maize weevil in the tropic region?”
9. Cunningham N.M., Bellati J.  
“Surveying for stored product pests in the South Australian agricultural environment - insights into diversity, sampling design and methodology”
10. Abdel M., Amro R.M.  
“The influence of plant characters on the field infestation and resistance status of certain cowpea cultivars to the lima bean pod borer *Etiella zinckenella* Treitschke and the southern cowpea weevil *Callosobruchus maculatus* (Fabricius)”.

11. Kordan B., Gabryś B., Laszczak Dawid A.  
“Assessment of flour beetle *Tribolium confusum* Duv. infestation risk to compound animal feed”
12. Riemenschneider L., Panes-Ruiz L.A., Bezugly V., Cuniberti G.  
“Carbon nanotube based gas sensors for application in stored product protection”

## FRIDAY 6 SEPTEMBER 2019

- **Methods of pest prevention during storage, transportation and handling of stored products**
- **Natural products**
- **Wood-boring, urban and museum pests**

1. Stejskal V., Kolar V., Nakic N., Moravcik C., Aulicky R.  
“New machinery for rapid detection of pests of grain, rice and pulses during a loading process of a new commodity into a store”
2. Bohinc T., Trdan S.  
“First results on potential insecticidal activity of plant powders of invasive alien plants against rice weevil under laboratory conditions”
3. Ajayi O.E., Oladele O.O., Ajayi O.G.  
“Efficacy of *Elaeis guineensis* (Jacq) kernel oil against the bruchid pest, *Callosobruchus chinensis* (L.) (Coleoptera: Chrysomelidae) and two *Aspergillus* species: extraction methods and potency”.
4. Belaid M., Acheuk F., Baouche N., Bellazouz H., Lakhdari W., Dahliz A.  
“Bio-pesticides potentialities of the Algerian Saharian plant *Euphorbia guyoniana* (Euphorbiaceae) against *Tribolium castaneum*”.
5. Bavarsad S.H., Zandi-Sohani N., Rajabpour A.  
“Fumigant toxicity of some essential oils against the eggs of cowpea weevil, *Callosobruchus maculatus* F. (Col.: Bruchidae)”.
6. Bachrouch O., Hamdi S.H., Sritib J., Hamamib M., Boushah E., Abderraba M., Limam F., Médiouni-Ben Jemâad J.  
“Fumigant potential of Tunisian *Mentha pulegium* L. essential oil against *Tribolium castaneum* (Herbst) and impact on flour quality in storage period”.
7. Singh P., Dall’Ara P., Martinez-Sañudo I., Sella L., Mori N.  
“Efficacy evaluation of *Mentha piperita* essential oil against *Rhyzopertha dominica* and *Sitophilus zeamais* adults”.
8. Prvulović D., Milić B., Tarlanović J., Peić Tukuljac M., Milašinović N., Babić F.  
“Sour cherry postharvest quality as affected by biopolymer and wild oregano essential oil”
9. Aulicky R., Jonas A., Hnatek J., Stejskal V.  
“The efficacy of HCN and ethanedinitrile on stored product and phytoquarantine pests and their penetration through thick wooden blocks”.

10. Acheuk F., Baouche N., Bellazouz H., Lakhdari W., Belaid M., Dahliz A.  
"Valorization of the crude plant extract of the Saharan plant *Cotula cinerea* in the biocontrol of the red tribolium of the flour *Tribolium castaneum*"
11. Marques A., Magro A., Siteo M., Silva E., Barros G.  
"Botanical insecticides against *Sitophilus zeamais* (Motschulsky)"
12. Goudougou J.W., Tofel K.H., Gangué T., Suh C., Nukenine E.N.  
"Comparative toxicity of *Clinopodium ambrosoides* and *Tephrosia vogelii* leaf powder against *Acanthoscelides obtectus* (Chrysomelidae: Bruchinae)".
13. Hedjal-Chebheb M., Médiouni-Ben J.J., Taleb-Toudert K., Soumaya H., Kellouche A.  
"Fumigant and repellent effects of *Eucalyptus cinerea* and *Eucalyptus maidenii* essential oils on *Callosobruchus maculatus* F. 1775 (Coleoptera: Bruchidae) and *Sitophilus oryzae* L. 1763 (Coleoptera: Curculionidae).
14. Sabbour M.M.A.  
"Effect of some essential oils and their nano formulations against red flour beetle, *Tribolium castaneum* and confused flour beetle, *Tribolium confusum* (Coleoptera: Tenebrionidae) under laboratory and store conditions"
15. Sabbour M.M.A.  
"Toxicity of the three essential oils against *Sitophilus granarius* under laboratory and store conditions"
16. Tofel H.K., Nkwain L., Atanga J.M. Nukenine E.N, Adler C.  
"Effects of orange peel powder and cypress ash on *Phaseolus vulgaris* germination and *Acanthoscelides obtectus* infestation"
17. Di Domenico D., Blaiotta G., Rubechini A.  
"Development of an IPM program in the Vatican Secret Archives"
18. Sinitsyna E., Staneva E.  
"The monitoring of quarantine pest - cowpea weevil *Callosobruchus maculatus* Fabricius under storage conditions by using the synthetic sex pheromone"
19. Pimentel M.A.G., Mendes S.M., de Meneses C.B., Fernandes D.K.S., de Oliveira I.R., Cota R.A.  
"Insecticidal efficacy of commercial formulations of diatomaceous earth and neem oil against *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae) on stored sorghum"
20. Gómez Benalcázar E., Bedini S., Echeverria M.C., Chiriboga Ortega R., Acrizzi R., Flamini G., Conti B.  
"Endemic Andean plants against food-stuff insect pest"

## **SESSION 1**

### **Physical, chemical and other techniques for stored product pest control**



## Phosphine tolerance/resistance in Europe: what do we know so far?

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Between 2013 and 2018, a screening has been carried out, initially from Greece and then from many other European countries, to investigate the potential presence and spread of tolerance/resistance to phosphine, for various stored product insect species. Overall, this work evaluated several hundreds of populations that had been sampled from different countries; this evaluation was carried out in both laboratory and field studies. The results so far indicate that there are remarkable differences in the susceptibility to phosphine among different populations, but none of the populations found was able to survive at extremely high phosphine concentrations. Moreover, this work underlined the need for developing further a standardized evaluation test that: a) should be utilized as a quick diagnostic, and b) can be adopted by various research groups to obtain comparable results. Field tests with populations that have different susceptibility levels to phosphine showed that all populations could be controlled effectively when fumigations were based on good management practices (e.g. realistic exposures and concentrations). Simultaneous tests with additional methods, such as heat, nitrogen and contact insecticides, showed that there is no cross-resistance with phosphine and thus, some of these techniques can be used in a rotation basis to mitigate resistance development. Overall, this surveillance underlines the need for designing IPM-based strategies in stored-product protection that should include regular sampling protocols for resistance evaluation.

**Key words:** phosphine, Europe, tolerance, resistance, evaluation diagnostics

## **Monitoring Rice Storability Using Carbon Dioxide Sensors in Gastight Storage**

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Storage of agricultural commodities in industrial settings and in food reserves is a major challenge. Losses are common and add up to 10% annually in weight loss, while qualitative losses are much higher. Hermetic storage in flexible gas tight containers has proven to be efficient in maintaining the quality of commodity during storage. Paddy, milled rice, rice seeds and rice bran can be stored safely in self-generated atmospheres of low O<sub>2</sub> and elevated CO<sub>2</sub> as published in numerous publications on the subject. Monitoring of the modified atmosphere in the hermetic containers was with the help of portable O<sub>2</sub> analyzers requiring operators to collect readings on a regular basis. Recently GrainPro developed its EcoWise™ remote sensing system, which enables collection of data on temperature, humidity and CO<sub>2</sub> in regular intervals varying from 5 minutes to 24 hrs. With the help of scientific data that have been collected over the years on the performance of hermetic storage, an “algorithm” of storage can be developed which is verified with the data generated from the field, thus being able to not only monitor the stored grain, but also predict its conditions. Data collected from scientific publications on stored paddy and rice, can be matched with data from EcoWise and contribute to the development of a predictive storage model. Ability to monitor and predict storage performance will have major impact on the financing of agricultural commodities and their ability to serve as collateral.

**Key words:** hermetic storage, carbon dioxide, monitoring, wireless sensor, predictive storage

## **Pressurized Pest Control with Carbon Dioxide for Biological Stock Protection**

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The Pressurized Pest Control system is applied to grains, cereals, dried fruits, dried vegetables, confectionery, nuts, tea, cocoa, coffee, tobacco, medicinal plants and rice which are infected by harmful insects as well as by their larvae or eggs. The material to be processed is inserted in bags in specially constructed pest disinfection chambers. These chambers are designed customer individually and consist of 1 to 3 pressure chambers, made for pressures up to 30 bars and usually a diameter between 2,1 to 2,4 m and a length up to 13m horizontal or vertical (Silo). Carbon dioxide is a nontoxic gas common in the food industry with no dangerous effects on humans and environment. It has no changing impact on the treated product. In Germany and Austria, the CARBO carbon dioxide is approved as plant production product. Only the combination of CO<sub>2</sub> and pressure allows the treatment to work time efficient in a short period of exposure. The benefits of using carbon dioxide and pressure in this method are three effects to achieve 100% mortality of insects, larvae and eggs within a short exposure time: 1. hyperacidity of the cell sap and haemolymph of the insects, 2. pressure effect (diving paralysis) 3. Oxygen removal. The advantage of the pressurized pest control can be demonstrated even more efficiently in the example of the grain weevil. While conventional, pressure-free gas flushing takes approx. 28 days, only a few hours are required in a pressurized pest control system in order to achieve the same result. The CO<sub>2</sub> which is be used comes from natural sources, chemical, or biological processes. There will be no extra production of CO<sub>2</sub> for the pressurized pest control. The CO<sub>2</sub> is already there.

**Key words:** Pressurized Pest Control, CO<sub>2</sub> store protection

## **Deltamethrin Emulsion Activity in Grain Warehouses**

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Spraying insecticides disinfest insect population on warehouses' structure surface and prevent rapid infestation on new stored produce. However, insecticides efficacy varies on different sprayed surfaces. Deltamethrin is a synthetic pyrethroid, used in Israel with KESHET 2.5% EC (ADAMA Ltd.) product, for warehouse spraying. KESHET efficiency against stored product pests has been tested, by commercial spraying, in warehouse. Rice weevil (*Sitophilus oryzae* L.) adults were exposed to the treated surface, and their mortality was recorded after 24 hours' exposure. On iron surface, the mortality was complete. On concrete surface, the mortality ranged between 20% to 100%, depending on the location in the warehouse. In a non-treated warehouse, which served as control, mortality was 0-20%. In laboratory conditions, by spraying KESHET with same dosage on a fresh concrete surface, no mortality was recorded. The results show that the efficiency of spraying on concrete varies between laboratory conditions and commercial spraying in warehouse. Furthermore, we have examined a number of factors that may affect the efficiency of KESHET on concrete in laboratory conditions: concrete age, grain dust stuck to concrete, and air temperature during the treatment. The results of this study indicate that KESHET activity is affected by a combination of all the factors together. Understanding the main factors that increase the success of insecticides is pivotal in grain storage management.

**Key words:** Deltamethrin, emulsion, stored product pests, concrete, warehouse

## **Efficacy of novel, reduced-risk insecticides for inducing mortality and sublethal changes in behavior for the post-harvest beetles, *Prostephanus truncatus* and *Sitophilus zeamais* after exposure on concrete surfaces**

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Every year, 10-30% of cereal crops such as maize, are lost to insects after harvest. In Africa, where maize is of particular importance for human consumption, the two major stored products pests are the larger grain borer (*Prostephanus truncatus*) and the maize weevil (*Sitophilus zeamais*). The estimated weight loss in grain due to infestations of *P. truncatus* and *S. zeamais* is about 34 – 40% and 10 – 20%, respectively. These losses may be due to several factors, including inadequate storage equipment or structures and a lack of appropriate chemical control tools. In light of the importance of this global staple crop, it is therefore imperative to develop and utilize new management tools to protect the commodity from post-harvest insect pests. In this study, we investigated the efficacy of a new insecticide, the insect growth regulator (IGR) combined with the pyrethroid deltamethrin and the synergist piperonyl butoxide (Central Life Science, Schaumburg, IL, USA), at inducing mortality and causing sublethal changes in movement for adult *P. truncatus* and *S. zeamais* exposed on a treated concrete surface. We were able to induce significant mortality and reduced movement for individuals exposed to the new compound compared to controls. Overall, these results suggest that this new insecticide combination is a very promising tool for controlling these insects in warehouses where bagged maize is stored, and could be incorporated in integrated pest management programs to protect stored maize.

**Key words:** maize, Larger grain borer, Maize weevil, insecticides, food security

## **Evaluation of Sulfuryl Fluoride (ProFume® gas fumigant) for control of the Flat Grain Beetle (*Cryptolestes pusillus* (Schönherr)) and Maize Weevil (*Sitophilus zeamais* (Motschulsky))**

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ProFume® fumigant (99.8% sulfuryl fluoride) is a broad spectrum, non-ozone depleting fumigant, manufactured by Douglas Products, for the control of rodent, insect and other invertebrate pests. ProFume is used to treat a wide range of stored products and structures which transport, store, and process commodities. Douglas Products has been working to expand registrations for ProFume into new geographies. As a result, the list of pests included in the Fumiguide™, program, a calculator used for determining the effective dose and dosage based on specific pest and environmental parameters, will need to be expanded. In 2019, lab studies were undertaken as a first step to include both flat grain beetle (*Cryptolestes pusillus*) and maize weevil (*Sitophilus zeamais*) in the Fumiguide program's pest list. The methodology used and results of these studies will be reviewed in the presentation.

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**Key words:** sulfuryl fluoride, *Cryptolestes pusillus*, *Stiophilus zeamais*, efficacy

## Using linked-reads to generate whole genome assemblies of stored product insects

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Invasive and emerging insect pests can cause significant agricultural losses post-harvest. Historically, genome and transcriptome sequencing of insect species have provided tremendous insights into their metabolic and physiological capabilities, facilitated the development of molecular barcodes for taxonomic classification, and led to the identification of mutations associated with pesticide and fumigant resistance and genetic factors that allow insects to exploit new ecological niches. Despite the utility of genome sequences in understanding the biology insects and facilitating management decisions, insect genome assemblies have been hampered by a number of challenges. 10X Chromium libraries coupled with HiSeqX sequencing largely overcomes these challenges and has led to the assembly of high quality draft genomes for several stored product insects of global important, including kharpa beetle, larger grain borer, and warehouse beetle. Recovery of conserved single copy orthologs (BUSCOs) exceeded 92% and >80% of the total assembly length was present in >1000 scaffolds in the majority of assemblies. Overall, these assemblies exceeded the contiguity of several previously published insect genomes, suggesting that 10X Chromium libraries represent a viable approach for obtaining fast and reliable assemblies for insect genomes. Additionally, long-read sequencing on PacBio is becoming more cost-effectively and lower inputs of DNA are required, which will also expedite sequencing and assembly of other stored product genomes in the future.

**Key words:** Khapra beetle, Indianmeal moth, Dermestidae, 10X, PacBio

## **Residual contact toxicity of spinetoram against granary weevil (*Sitophilus granarius* L.) and confused flour beetle (*Tribolium confusum* Du Val.)**

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In present study, residual contact toxicity of Spinetoram suspension applied to wheat grains against *S. granarius* and *T. confusum* adults were investigated under laboratory conditions. In laboratory bioassays, *S. granarius* and *T. confusum* adults were exposed to wheat grains sprayed with Spinetoram suspension at 0.5, 1, 2.5, 5 and 10 ppm (mg active ingredient/kg commodity) at 26±1 °C temperature, 65±5 % relative humidity and completely dark condition. Knockdown and mortality of the adults were recorded after 1, 3, 5 and 7 day of exposure and 35-40 day later the wheat was examined for progeny production. The suspension treatments at all concentrations after 1 day of exposure resulted in low mortality of *S. granarius* and *T. confusum* adults. Mortality of *S. granarius* and *T. confusum* adults increased after 1 day of exposure period. Spinetoram treatment at 1 ppm and above concentrations after 3 day of exposure resulted in almost 100 % knockdown or mortality of *S. granarius* and *T. confusum* adults and completely hindered their progeny production. On the other hand, 100 % knockdown or mortality of *T. confusum* adults were obtained at 10 ppm concentration of Spinetoram treatment after 3 day of exposure. The results obtained from biological tests indicated that *T. confusum* adults generally were more tolerant to Spinetoram treatments particularly at low concentrations and exposure times than *S. granarius* adults. In conclusion, this study indicated that Spinetoram suspension treatment on commodity would be potential to be used for control of *S. granarius* and *T. confusum*.

**Key words:** Spinetoram, *Sitophilus granarius*, *Tribolium confusum*, wheat, residual contact toxicity

## **Adaptation to non-lethal cold stress in *Trogoderma variabile* shows cross-tolerances for chronic cold stress and body size**

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Physical methods of insect control such as thermal stress have been used against a variety of stored product pests and the use of extreme cold is generally safe for durable commodities. Understanding how temperature and time influences effective control of insect pests and their ability to evolve resistance to cold is critical for implementation of this technique. *Trogoderma variabile* has high tolerance to cold treatments, such as short exposures at extreme temperatures or longer exposures at milder temperatures, but if they can adapt or develop resistance to cold stress over time is not known. Here we select *T. variabile* response to a non-lethal cold stress over 7 generations. We found significant differences between populations selected for quick and slow recovery to cold and body size is significantly reduced in populations selected for 5-hour versus 3-hour exposure to cold. Survival to a 48-hour cold exposure also increases for populations selected for quick recovery at a 3-hour exposure at a mild temperature. These results show that selection for short-term cold exposure is tied to chronic cold tolerance and reproductive capacity and cold stress may be used in tandem with other management techniques to target all life stages of the insect. *T. variabile* can also adapt to cold and this needs to be taken into account in the application of cold as a management strategy as far as temperatures and exposure times that are suggested to control this species.

**Key words:** chill coma recovery, artificial selection, Dermestids, cross-tolerance, warehouse beetle

## Phosphine Discriminating Doses for Four Store-Product Psocid ('Psocoptera' – Psocodea: Liposcelididae)

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Psocids are now recognized as stored-product pests of substance. Studies on phosphine (PH<sub>3</sub>) resistance in psocid pest species collected in Oklahoma only commenced in 2015. In the present study we estimated discriminating doses of PH<sub>3</sub> for adults of four psocid ('Psocoptera'--- Psocodea: Liposcelididae) species at 20- and 72-hour exposure periods. The species comprised *Liposcelis bostrychophila*, *L. paeta*, *L. entomophila*, and *L. decolor*. Dose-response experiments were conducted by exposing adults of the four species to different concentrations of PH<sub>3</sub> for 20 and 72 h. Mortality was assessed 7 days after exposure. In the 20-hour exposure, the upper limits of the 95% confidence intervals of LC<sub>99</sub> for *L. bostrychophila*, *L. paeta*, *L. entomophila*, and *L. decolor* were 97.1, 310.4, 697.3, and 1011.6 ppm, respectively. In the 72-hour exposure, these values were 49.1, 39.6, 157.1, and 195.50 ppm respectively. These data show that the four *Liposcelis* species responded differently to PH<sub>3</sub> and that discriminating doses of the four species are higher than those of stored-product beetle pests. Data on discriminating doses of eggs of the four species will be presented and discussed.

**Key words:** phosphine, fumigation, discriminating dose, psocids, psocodea

# The effectiveness of high-temperature treatments against *Dermanyssus gallinae* in layer poultry farms with a commercial eggs production, and an evaluation of its secondary effects to Total Bacterial Load (TBL) and Enterobacteriaceae

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The use of high temperatures in the field of disinfestation and in pest control is widespread within the urban and food sectors as an alternative solution to pesticides and toxic gases, especially in mills and pasta factories. We have extended this methodology also to layer poultry farms commercially producing eggs as food. Following a description of the sector itself, this study aims to show the effectiveness of high-temperature treatments carried out between 2014 and 2019 against all life stages of *Dermanyssus gallinae*. Electric thermofan, where positioned inside several poultry farms (ranging between 8,000 and 35,000 m<sup>3</sup>) during the “empty period”. Reaching temperatures >55°C and <65°C and humidity reduction rate between 5% and 10%, with exposure times of 38-48 hours. All the treatments showed 100% effectiveness on biological tests conducted in test-tubes containing *D. gallinae* adults with an unspecified number of eggs. The authors also carried out preliminary data of side-effects caused by heat on total bacterial contamination and Enterobacteriaceae contamination (CFU/cm<sup>2</sup>). The high-temperature treatment represents a feasible, effective method for *D. gallinae* control as well as an interest way for some disinfection protocol system.

**Key words:** heat treatment, sustainable disinfestation, *Dermanyssus gallinae*, poultry farm

## Small particle size of flour limits efficacy of carbon dioxide-high pressure-treatment

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In the last two decades the treatment of goods with carbon dioxide (CO<sub>2</sub>) at pressures of 15 to 30 bar has gained importance in Europe and elsewhere. This is partly due to the acceptability for organic production and short treatment times (e.g. three hours at 20 bar). In a systematic study, whole wheat grains and milled grist particles from coarse to fine (> 710 µm, 500-710 µm, 400-500 µm, 300-400 µm, 200-300 µm, 100-200 µm, <100 µm) were exposed to pressure treatments in PVC drainage tubes of 500 mm length and 75 mm diameter (volume approx. 2.1 L). 50 adult granary weevils in a wire mesh cage with some wheat kernels were placed into the centre of the tubes prior to treatment. The treatment was carried out in a large commercial triple high-pressure chamber that was evacuated prior to flooding with CO<sub>2</sub>. Only the smallest particle size of <100 µm led to the survival of adult granary weevils while in particles >100 µm all weevils died. This indicates that fine flours may be compressed from the outside keeping a pocket of air in their centre and thus cannot be pressure-treated with CO<sub>2</sub>. For pest control, fine flours should rather be sifted or sent through an impact mill.

**Key words:** carbon dioxide, high pressure, flour, insect, pest control

## Potential of Flavocide™ as a new grain protectant to manage major resistant stored grain pests: an Australian case study

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In Australia, approximately 30% of the postharvest grain is treated with contact insecticides for their protection from a range of pests during long-term storage. Over the years, several pests have developed resistance to a range of registered grain protectants. For example, currently, resistance to organophosphates (OPs, e.g., fenitrothion, malathion, chlorpyrifos-methyl and pirimiphos-methyl), synthetic pyrethroids (SP, e.g., deltamethrin, bioresmethrin) and the insect growth regulator (IGR) methoprene is common in *Rhyzopertha dominica* (F.). Although *Oryzaephilus surinamensis* (L.) developed resistance to OPs, they can control other key pest species including *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst). To achieve broad spectrum control of these pests, industry currently depends on binary applications that involve combinations of OPs with either deltamethrin or spinosad and an IGR. The current study involves the evaluation of Flavocide™ 500EW for its potential as a grain protectant. It contains 500g/L of flavesone, a natural-identical  $\beta$ -triketone molecule produced by synthetic means that exhibits broad-spectrum activity against a range of insect pest species and operates by a novel mode of action. After the initial range finding tests, Flavocide at 60 ppm flavesone was found to adequately control both adults and progeny of resistant *R. dominica*, but failed to provide complete control of *T. castaneum* and *S. oryzae*. Flavocide at 60 ppm, when applied in a binary combination with chlorpyrifos-methyl at 10 ppm, however, successfully controlled progeny production in all of the above pest species (as well as *Cryptolestes ferrugineus*), a major criterion for ultimate control of these pests. Currently, we have extended the research to evaluate the long-term residual efficacy of Flavocide™ at higher rates of 60, 90 and 120 ppm against resistant *R. dominica* populations. After 3 months storage of both commercially treated grain stored in the field as well as grain treated in the laboratory at all three rates have yielded complete progeny reduction in these pests. These results confirm that Flavocide™ in binary combination with chlorpyrifos-methyl can potentially be used as part of an integrated strategy to control all major pests of stored grain in Australia.

**Key words:** Flavocide™, stored grain, protectant, long-term efficacy

**Insecticidal efficacy of three commercial diatomaceous earths, Detech<sup>®</sup>, Demite<sup>®</sup> and Silicosec<sup>®</sup> against cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae: Bruchninae)**

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In present study, insecticidal efficacy of three commercial diatomaceous earths, Detech<sup>®</sup>, Demite<sup>®</sup> and Silicosec<sup>®</sup> were tested against cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae: Bruchninae) at three different concentrations (500,750 and 1000 ppm) on chickpea. Detech<sup>®</sup> and Demite<sup>®</sup> were new diatomaceous earth formulations developed in Turkey. Due to the short life span of *C. maculatus* adults, mortality of the adults was assessed after 1, 3, 5 and 7 days of DE exposure. Progeny (F1) production on treated chickpeas was recorded 42 days after DE treatments. Biological tests were carried out under laboratory conditions at 25±1 °C, 55±5 % R.H. in the dark. All tested commercial DEs showed similar toxicity against *C. maculatus* adults. After 1 day of DE exposure, the most effective DE treatments were found at 1000 ppm concentration by 75% mortality rate. After 5 days exposure, all DE products resulted in 100% mortality of *C. maculatus* adults. DE treatments resulted in the reductions of the progeny (F1) production ranging from 77% to 85 % at 1000 ppm concentration. Generally, increasing DE concentration lowered the progeny production. In conclusion, this study indicated that the new Turkish commercial DE formulations showed the higher mortality of *C. maculatus* adults compared to other commercial DE product, Silicosec and can be used in the management of *C. maculatus* of stored chickpea.

**Key words:** Turkish diatomaceous earth, *Callosobruchus maculatus*, Silicosec<sup>®</sup>, Detech<sup>®</sup>, Demite<sup>®</sup>

## **Residual efficacy of novaluron applied on grain commodities for the control of sawtoothed grain beetle (*Oryzaephilus surinamensis*) and red flour beetle (*Tribolium castaneum*)**

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Stored-product insects are serious pests of dried, stored, durable agricultural commodities, and of many value-added food products worldwide. The residual efficacy of novaluron, an insect growth regulator, was assessed by exposing last instar larvae of *O. surinamensis* and *T. castaneum* to the treated commodities (wheat, maize, rice and oats) at concentrations of 1, 2 and 4 ppm under laboratory conditions. Six bioassays were conducted by releasing the insects on treated commodities after different post treatment periods (0, 2, 4, 8, 12 and 16 weeks). Adult emergence of the insect species was greatly reduced at tested concentrations in all the treated commodities. Overall results of all bioassays show that residual efficacy of novaluron was reduced with the increase of post treatment period. At 4 ppm, the adult emergence did not exceed 24% in both tested species for the first 12 weeks of the test period in oats. Results show that novaluron can be a potential product for pest management in mills, warehouses and food storage facilities.

**Key words:** insect growth regulator, grain commodities, stored grain insects, residual efficacy, adult emergence

## Insecticidal efficacy of six new pyrrole derivatives against four stored-product pests

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The insecticidal efficacy of six novel pyrrole derivatives, under the trivial names 2a-*syn*, 2a-*anti*, 2f-*syn*, 2f-*anti*, 3e and 0665 was evaluated on wheat, against *Sitophilus oryzae*, *Rhyzopertha dominica*, *Tribolium confusum* and *Ephestia kuehniella*, at different doses (0.1, 1 and 10 ppm) and exposure intervals (7, 14 and 21 days). For *S. oryzae*, the highest mortality was noted at 10 ppm of 2a-*syn* (36.7%) followed by 2f-*syn* (32.2%) and 2f-*anti* (27.8%) after 21 days of exposure. Mortality of *R. dominica* reached 50 % testing 10 ppm of 2f-*syn*, followed by 2a-*syn* (46.7%), 2f-*anti* (41.1%) and 2a-*anti* (33.3%) after 21 days. Mortality of *T. confusum* adults was very low, ranging from 0.0 to 16.7 % after 21 days. For *T. confusum* larvae, after 21 days of exposure, mortality reached 62.2 % at 10 ppm of 3e followed by 0665 (55.6%) and 2a-*anti* (42.2%). For *E. kuehniella* larvae, mortality reached 57.8 % at 10 ppm of 2a-*syn*, followed by 2f-*anti* (43.3 %) after 21 days. Overall, according to our results the efficacy of pyrrole derivatives is chiefly regulated by the exposure interval, tested dose and the treated insect species and developmental instar. The tested pyrrole derivatives are slow-acting compounds exerting relevant toxicity on key stored product pests over time. They can be considered further for testing in selected blends aiming to develop novel control tools against stored product pests in real-world conditions.

**Key words:** pyrrole derivatives, pyrrole insecticides; stored-product protection, stored-product insects

## Evaluation of repellency effect of diatomaceous Earth formulation (Detech®) on three coleopteran stored grain insects

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In this study, repellent effect of diatomaceous earth formulation (Detech®) against *Sitophilus oryzae* (L.), *Tribolium confusum* du Val. and *Rhyzopertha dominica* (F.) adults were determined. For repellency tests, two-choice tests on single-layered wheat and in deep cups were carried out in a climate chamber at  $25 \pm 1$  °C temperature,  $65 \pm 5\%$  relative humidity and in completely dark condition. In repellency tests, 500 and 1000 ppm concentrations of DE were used. In both two-choice tests carried out on single-layer wheat and in deep cups, there were significant differences among the insect numbers and percentages of the insects for *S. oryzae* and *T. confusum* in arenas with DE-treated and untreated wheat at almost all exposure periods at both concentrations of 6 diatomaceous earth formulation (500 and 1000 ppm). However, there were significant differences among the insect numbers and percentages of the insects for *R. dominica* in arenas with DE-treated and untreated wheat at all exposure periods. The results of two-choice tests indicated that *S. oryzae* and *T. confusum* adults preferred mostly arenas with untreated wheat and thus, tested DE formulation had a high repellent effect on *S. oryzae* and *T. confusum* adults. Conversely, no repellent effect of DE formulation on *R. dominica* adults, which have low mobility in the grains was determined.

**Key words:** diatomaceous earth, repellency effect, stored grain insects, two-choice tests



## **SESSION 2**

### **Pest management in the food industry**

## **Pest Management in a Changing World: Challenges and Triumphs in the Food Industry**

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The direction of pest management in the food industry has changed over the past few years. These changes include reduced reliance on pesticides within the food processing and storage areas, integration of more biologically safe, ecologically sound, environmentally benign and residue free pest management tactics along with greater professionalism through training and education of members of the pest management industry. Elimination of key pesticides from the chemical registry, development of insect resistance to pesticides, along with diverse array of behavioral traits enabling stored product insects to successfully survive in man-made environments, posed challenges in the food industry. A holistic approach incorporating systemic tactics to regulate pests not only by integrating various management techniques but also employing proactive measures to eliminate pests by using effective design features in structures, processing equipment and packaging seem more appropriate for the current food industry. Monitoring & sampling, insecticides, biological control, physical control, semiochemicals and modified atmosphere are some of the tools that are available for the food industry to successfully manage pests. This talk summarizes all possible management tactics that can be used in the food industry, but emphasizing physical control and semiochemicals, provided with relevant data.

**Key words:** food industry, heat treatment, insect management, mating disruption, ozone

## ***Alphitobius diaperinus*: the potential role in the transmission of human pathogenic bacteria**

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The lesser mealworm, *Alphitobius diaperinus* (Panzer), is a scavenger, mould feeders and minor pest of a wide range of cereals and cereal product, especially if damp. It is considered as a major problem worldwide in poultry industry, being found in high density in the litter where it feeds from feed, faeces, and dead birds. The insect can host and potentially transmit several microorganisms, including human pathogenic bacteria such as *Escherichia coli*, *Salmonella* spp., *Campylobacter* spp., and *Staphylococcus aureus*. Few studies concerning the role of *A. diaperinus* in the transmission of human pathogens have been carried out. Indeed, this is the first study conducted in Italy to evaluate the carriage of *E. coli*, *Salmonella* spp., *Campylobacter* spp., and *S. aureus* in adult *A. diaperinus* in a poultry farm, by detecting their presence in the external surface, faecal and internal content of the beetles. The detection of these pathogens was also performed for broilers, and administered feed and water. During July and September 2017, three samplings of adult *A. diaperinus* were performed in a poultry farm located in Abruzzo region (Central Italy); each sampling aimed at the collection of 90 beetles, 10 rectal swabs from broilers, one sample each of administered feed and water. Detection of microorganisms was firstly carried out through conventional microbial culture, using pathogens specific and selective growth media. The suspected positive colonies were tested with biochemical analyses. Results were further confirmed through PCR assays on DNA extracts, using specie-specific genes. Our results allow to support the available evidences on the role of *A. diaperinus* in the spread within the farm environment of bacteria as *Salmonella* spp. and *E. coli*, which are responsible of human foodborne diseases. Conversely, *S. aureus* was not detected, while other *Staphylococcus* species never reported before in these beetles were found. The study findings do not allow confirming the role of the insect in the spread of *Campylobacter* spp., but additional analyses are needed to better elucidate the potential function of *A. diaperinus* in the transmission of pathogenic bacteria, including further samplings, and the use of culture independent assays and next-generation sequencing methodologies targeting the 16S bacterial gene.

**Key words:** *Alphitobius diaperinus*, transmission, pathogenic bacteria

## Research with Dermestid Larvae: Pitfalls and Cautions

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Insects in the family Dermestidae are often overlooked as a pest of stored products. However, in the USA and other parts of the world, they are receiving increased importance as an emerging pest in mills, processing plants, and food warehouses. Although adults are short lived and generally susceptible to insecticides used to control other stored product beetles, larvae are much more difficult to kill, and there are differences in susceptibility between larval age stages and between individual species. Also, larvae will enter diapause and bias results of insecticide studies. Recent research with several members of the genus *Trogoderma* will be discussed in relation to susceptibility to contact residual treatments, aerosols, and packaging treatments.

**Key words:** storage, management, control, Dermestids, insecticides

## The growth dynamics of *Plodia interpunctella* (Lepidoptera: Pyralidae) larvae on dried fruits and nuts

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The larvae of *Plodia interpunctella* (Hübner) are the most important pests of stored dried fruits and nuts. Precise estimation of developmental time of its larval instars could help in targeting the life stages which are the most susceptible to control methods. The objective of this study was to determine the growth dynamics of *P. interpunctella* larvae depending on the nutritive contents of nine tested dried fruits and three nuts. The natural logarithmic regression based on every week head capsule width measurement expressed the dynamics of larval development. The PCA analysis identified the influence of qualitative and quantitative content of macronutrients and secondary metabolites on the larval development. The contents of proteins and fats were strongly negatively correlated with the larval developmental dynamics. Among the tested substrates, the fastest larval growth was registered on figs, goji berries, and walnuts, the richest in proteins, while the slowest development was in prunes, rich in carbohydrates. The contents of total phenolics, flavonoids and tannins were in strong positive correlation with the larval developmental dynamics (the slowest larval growth was on prunes, apple chips, and chokeberry). The results of this study could provide a contribution to the knowledge necessary for modelling the growth and population dynamics of *P. interpunctella* and other stored-products pests, important for evaluating the timing of management practices.

**Key words:** Indianmeal moth, larval development, macronutrients, secondary metabolites, PCA

## **The practical application of mating disruption to population reductions of *Ephestia elutella* (Hb.) and *Plodia interpunctella* (Hb.) in the chocolate and dried fruit processing industries and the reduction of disinfestation activities using biocidal products**

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Mating disruption is one of the methods adopted to control lepidoptera infesting foodstuffs and food industries in alternative to chemical products. This practical application describes tests performed, in two different food plants respectively with chocolate and dried fruit processing. The authors described an accurate monitoring programme carried out prior (12 months), and during (24 months), the introduction of the mating disruption technique for the population control of *Ephestia elutella* (Hübner) and *Plodia interpunctella* (Hübner). With the same structural and management of the food factories, as the same settings, number and location of traps used for the monitoring activities and the same dosage of pheromones used for the mating disruption technique, the authors showed the results of the mating disruption leading to a significant reduction of the pest population by *E. elutella* in the chocolate processing plant and *P. interpunctella* in the dried fruit processing plant. In this latter case, implications were also observed concerning a reduction of the disinfestation treatments to be carried out using biocidal products.

**Key words:** mating disruption, sustainable control, *Ephestia elutella* and *Plodia interpunctella* in chocolate and dried fruit

## Estimating the release rate of pheromone dispensers of stored product pests with the use of Solid Phase Micro-Extraction

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The use of pheromones in the management of stored product pests is receiving great attention due to the increasing public demand for healthy and pest-free food products and the limitation on the use of pesticides. The pheromones efficacy over time is linked with their emission rate, which is determined by intrinsic (dispenser type used) and extrinsic (environmental) factors. In this study the role of releaser type and temperature in the pheromone emission over time, was evaluated using the method of the solid phase micro extraction (SPME). This technique is as an easy, reliable and rapid alternative to the conventional solvent-extraction methods. In the specific, experiments were carried out to estimate the pheromone emission from: 1) two different pheromone releaser types for monitoring *Lasioderma serricorne* (Coleoptera: Anobidae) and *Tineola bisselliella* (Lepidoptera: Tineidae) and 2) a same releaser used for mating disruption of *Plodia interpunctella* (Lepidoptera: Pyralidae) kept at two different temperatures. Samplings were carried out in static air, using different times of collection in dependence of the pheromone characteristics. Overall this work validated the use of SPME for monitoring the pheromone emission. The results indicated that the releaser type strongly influence the pheromone release in terms of total emission and duration, and moreover that the increasing temperature determines a higher emission rate of the pheromone.

**Key words:** SPME, emission rate, dispenser, temperature, chemical analysis

## Impact of geographical origin on male mating success and behavioral asymmetries in the lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae) – implications for IPM

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The effect of geographical origin on the male mating success and related functional asymmetries in different strains of the lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae) (i.e., a Greek strain, a Romanian strain and a Turkish strain) was investigated. Males of the Romanian and Turkish strains exhibited right-biased approach and copulation attempts, resulting in higher mating success over left-biased males. In the case of the Greek strain, despite the fact that the most males showed left-biased approach, males that performed right-biased copulation attempts achieved the highest proportion of successful copulations. Right-biased asymmetries in copulation attempts led to significant differences in the duration of precopula and copula, regardless of the tested strain; the duration of precopula was lower while the duration of copula was higher than that of males which performed left-biased or backside copulation attempts. Overall, the findings of the present study shed light on the mating behavior of *R. dominica*. Moreover, knowledge about factors routing male mating success may be helpful for optimizing mass-rearing techniques of this important stored-product pest that are necessary to large-scale laboratory or semi-field experiments, and to contribute to the development of behavior-based control tools such as reducing specie's population growth and fecundity.

**Key words:** behavioural asymmetries, laterality, male mating success, Integrated Pest Management, stored-product insect pests

## **Assessment of different diet mediums for development of stored grain pest *Oryzaephilus surinamensis* (Coleoptera: Silvanidae)**

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*Oryzaephilus surinamensis* is a common pest found in stored grain and stored cereal commodities and also infests tobacco, chocolate and drugs. The study was conducted to evaluate different diet mediums for development of *O. surinamensis*. Mixed insect populations were collected from storages and grain markets of Faisalabad, Pakistan. Test insect was separated and homogenized for bioassays. Different diet mediums (maize bran, wheat bran, wheat and rice) were used. Ten pairs of adults were released and allowed to lay eggs on each diet medium and replicated four times under controlled environmental conditions. After three days adults were removed, and diet mediums were preserved for filial F<sub>1</sub> development. Data was collected for larval, pupal and adult emergence. Number of larvae, pupae, adults and their developmental duration was also recorded. Results suggested that wheat bran is most preferable for the development of *O. surinamensis*.

**Key words:** saw tooth beetle, bran, flour, progeny development, stored grain pest

## **Long-time storage of grain**

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As the market regulating agency within the European Union the Federal Office of Agriculture and Food (BLE) is concerned with EU-market measures but commissioned by the Federal Ministry of Food and Agriculture the BLE is responsible for food storages for emergency cases, too. For about 10 years our storekeepers have to keep the foods healthy and at any time available. Especially moths need attention during storage. The presentation shows some important requirements for the long-time storage from the quality of grain, building requirements, care of the stored grain, insect monitoring to methods of pest control.

**Key words:** long-time storage of grain

## Stored-product insects as nutrient source: challenges and perspectives

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With a continuously growing human population, the need for alternative nutrient sources for animal feed, as well as for human consumption, is increasingly prominent. The last years there has been an increasing interest on the exploitation of insects as a source of nutrients for animal feed and human food. Insects appear to be a promising, sustainable solution to the upcoming protein shortage, as they have high nutritional value, can be easily produced using low-cost raw materials and their production has low ecological footprint. Among the insect species that have been tested so far as food and feed resources are two stored-product insects: the yellow mealworm, *Tenebrio molitor* L., and the lesser mealworm, *Alphitobius diaperinus* (Panzer). Both tenebrionids are listed among the seven insect species that can be included since 2017 as feed ingredient in aquaculture fish feeds in EU. However, the exploitation of these insect species as nutrient source and their mass-production in large scale have still several challenges to face. In the present study, issues such as the optimization of the diet for the mass-rearing of *T. molitor* and *A. diaperinus*, the use of cheap agricultural by-products as insect feeding substrates, as well as the susceptibility of insect-based feeds to insect infestations during storage will be addressed.

**Key words:** *Tenebrio molitor*, *Alphitobius diaperinus*, insect mass-rearing, insect protein, nutrient source

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## Control of *Rhyzopertha dominica* (Coleoptera: Bostrichidae) in chickpeas with CO<sub>2</sub> modified atmosphere packaging

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*Rhyzopertha dominica* is a chickpea pest. Their larvae and pupae develop inside the grains of this legume causing loss in weight and contamination of the product. It is controlled with few and very toxic pesticide treatments, which implies to have a high risk of developing resistant populations. An alternative control measure is packaging chickpeas with CO<sub>2</sub> modified atmospheres (AM). Three MAs have been tested (50%, 70% and 90% CO<sub>2</sub>) on the different developmental stages of *R. dominica*, using chickpeas packed in flexible bags in which there was an excess of CO<sub>2</sub>. The exposure time for 50% mortality (LT<sub>50</sub>) ranged from 7 hours for larvae with 90% CO<sub>2</sub> to 2 days for pupae with 50% CO<sub>2</sub>. These exposure times (LT<sub>50</sub>) were tested in semi-rigid containers filled up to their 96% capacity with chickpeas, and with a relatively lower amount of CO<sub>2</sub>. The aim was to evaluate the possible AM loss of effect due to the sorption of the gas by the chickpeas, which was calculated to be between 18% and 29%. Our results indicate that while larvae and pupae remained susceptible to the gas concentrations tested, eggs and adults were tolerant. Therefore, procedures to compensate for this loss of gas in the package must be resolved in order to maintain the effectiveness of the MAs and optimize their commercial application.

**Key words:** weevils, carbon dioxide, legumes, stored products, gas available

## **Diapause, desiccation and cold tolerance in khapra beetle, *Trogoderma granarium***

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Khapra beetle, *Trogoderma granarium* Everts (Coleoptera: Dermestidae), is unusual in two key respects. First, it is among the most cold-hardy of stored-product insect pests even though they originate in hot and dry regions of the Indian sub-continent. Second, their larvae can enter into a diapause state to survive harsh environmental conditions. In the current study, we examined whether these two phenomena might be related; i.e., cross-tolerance. Cross-tolerance is the tolerance to one ecological stress when induced by a separate stress. To investigate this, khapra beetle larvae were reared at different relative humidities (3, 28, 49 and 79%) either in non-diapausing or diapausing conditions. Then the cold-tolerance of larvae was estimated by measuring mortality after different durations at  $-10^{\circ}\text{C}$ . For non-diapausing larvae, relative humidity had little effect on cold tolerance with the lethal time to 50% mortality (LT50) occurring between 2-4 days. For diapausing larvae, cold tolerance increased with greater desiccation stress with LT50's of 5, 7, 10 and 18 days at 79, 49, 28 and 3% RH respectively. This suggests that the physiological mechanisms that protect diapausing larvae from desiccation may also increase cold-tolerance, even though these insects may rarely be exposed to low temperatures.

**Key words:** canola, development, Brassicaceae, Dermestidae

## **Efficacy of heat treatment on phosphine resistant and susceptible populations of stored product insects**

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In this study we evaluated the efficacy of heat treatment on phosphine resistant and susceptible populations of stored product insects at twenty-three different commercial facilities in Greece. Heat treatments were carried out by using special equipment, such as Therminate, TempAir and ThermoNox, applied alone or in combination. The overall temperature range was between 33 and 55 °C and the duration of the heat treatments was between 20 and 39 h. Adults of the lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae), and the sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae), were used in the experiments. The field populations were collected from different storage facilities in Greece and were characterized as resistant populations by using the Detia Degesch Phosphine Tolerance Test Kit. Insect mortality was measured at the termination of each trial. Then, the vials were kept in incubator chambers at 25 °C and 65% relative humidity and 65 d later the progeny production was measured in the treated substrate. In light of our findings, in the vast majority of the cases, complete control was observed for both resistant and susceptible populations at all facilities. In general, in the few cases where survival and progeny production were recorded, there was no specific trend towards specific species or population. Overall, based on the current results, heat treatment can be used by the industry as an alternative method for the control of phosphine-resistant adults of *R. dominica* and *O. surinamensis*.

**Key words:** heat treatment, stored product insects, phosphine resistance, non-chemical control

## **SafeGrains: project to evaluate the contamination by insects and fungi on grains and derivatives in Portugal**

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The contamination of stored grains by insects and mycotoxin producing fungi is an important problem worldwide. *SafeGrains* project intends to study different aspects of two major pests of stored grain. *Trogoderma granarium*, one of the most destructive stored product insects worldwide and a quarantine species in several countries. This species was recorded in some European countries and is established in some parts of the eastern Mediterranean area. The main objective is to develop a sampling protocol together in consortia countries (Portugal, Spain, Italy and Greece) using specific traps, to evaluate its presence and distribution. Preliminary studies have been conducted in ports and warehouses in Portugal, where khapra beetle was not recorded. However, more studies will be developed in the next 3 years. A report will be prepared and distributed to the authorities and stakeholders and also submitted to EPPO and EFSA, in order to point to the presence of this species in Southern Europe. *Tribolium castaneum*, is one of the key pests of milled grain. Adults produce benzoquinones, used as defenses against noxious agents, and may also confer resistance to insecticides. The aim is to understand the interaction between *T. castaneum* and biotic factors on grain and derivatives. Preliminary trials evaluating the nutritional value of *T. Castaneum larvae* showed a content of 21.4% protein, 9.1% lipids, 8.8% fiber, eight essential amino acids, manganese and copper. Because nutritional value of these insects, tolerable threshold of infestation of wheat flours contaminated by *T. castaneum* will be evaluated towards their influence in flours rheological properties. Also biodegraded packages will be tested comparing the traditional packs used for grains and derivatives. Decision support oriented models will also be developed and validated based on collected biotic and environmental data, being latter translated into risk management procedures. The final inferences may be an important step for more sustainable decision-making, and a valuable contribution to public health policies.

**Keywords:** stored grains, *Trogoderma granarium*, *Tribolium castaneum*, benzoquinones, nutritional value

## **Application of modified Silicium Dioxide in Grain storages pest control. Practical application, Industrial treatment results**

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Detailed report on practical researches and applications of modified Silicium Dioxide of natural origin in grain storages pest control. Industrial treatment of 100 tons of grain (15 pcs of insects per 1 Kg of grain). Treatment of empty grain storages against the insects. Deep laboratory tests on 10 species. Report is accompanied with HD video materials and description of treatment methods.

**Key words:** Silicium Dioxide, organic farming, non-toxic alternatives, practical applications, industrial size treatment

## **SESSION 3**

### **Prevention of microflora infection and development of mycotoxins**

## Field application of beneficial fungi to prevent postharvest mycotoxin contamination

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In the last years there is an increasing pressure leading to the development of alternative strategies to guarantee food security, with the continuous pursuit of food quality, the need to feed an increasing global population and to satisfy the legislative requirements (especially at EU level) to reduce the chemical input in the environment and in agriculture. According to a recent report by FAO, 15 crop plants provide 90% of the world's food energy intake, with cereals such as rice, corn and wheat representing the most important staple foods. Cereals are very often a target for mycotoxigenic fungi, which can cause severe crop losses in the field and quality reduction in harvested crops due to the accumulation of mycotoxins. Despite mycotoxin production occurs after harvest, thanks to the growth of the inoculum present in caryopses and improper storage conditions, infection by mycotoxigenic fungi starts in the field at a preharvest stage. Within the wide scenario of plant pathogens, controlling mycotoxigenic fungi is critical. Beneficial fungi, both filamentous and yeasts, are well-known potential biocontrol agents for use in crop protection, as part of integrated or biological strategies, and represent one of the possible solutions to manage mycotoxigenic fungi. This contribution will present an overview of the possible applications of beneficial fungi, at a preharvest stage, on cereals such as corn and wheat in order to control the attack of *Aspergillus* and *Fusarium*, respectively, and to reduce the risk of mycotoxin contamination (aflatoxins and trichothecenes) at a postharvest stage and in the resulting food and feed commodities.

**Key words:** mycotoxins, cereals, preharvest, postharvest, beneficial fungi

## ***Aureobasidium* spp. as potent biocontrol yeasts for tackling fungal storage diseases**

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The yeast-like fungus *Aureobasidium pullulans* (de Bary) Arnaud (order Dothideales, Ascomycota) inhabit various, including extreme, environments and is frequently found on leaves and fruits of numerous plants without causing diseases. The species is characteristic for its high tolerance to variety of environmental stresses (hypersaline, acidic, basic, cold and oligotrophic conditions) and shows substantial biotechnological potential as a producer of several biomolecules and as a biocontrol agent used in prevention of pre- and postharvest plant diseases. A rich repertoire of strains of *Aureobasidium* spp. from extreme environments stored in the Ex Culture Collection (Infrastructural centre Mycosmo, MRIC UL, Slovenia) were screened for their antagonistic activity against the three postharvest fungal pathogens, namely *Botrytis cinerea*, *Penicillium expansum* and *Colletotrichum acutatum* by *in vitro* and *in situ* tests on apple fruits. Additionally, the physiological and genomic characteristics were analysed, and numerous traits involved in their antagonistic activity were identified. This study further confirms the suitability of use of *A. pullulans* and uncovers new species *A. subglaciale* applicable in postharvest biocontrol of plant pathogens.

**Key words:** biocontrol agent, biopesticide, grey mold, blue mold, bitter rot

## Maize Biodegradation Control using Essential Oils from Bamenda

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Successful storage of harvest is a matter of utmost importance in the Western Highlands agro-ecological zone of Cameroon due to long rainy seasons and high relative humidity. Poor and rudimentary drying/storage methods, as well as inaccessibility to the chemical pesticides leave stored maize at the mercy of insect and fungal attack. Biodegradation of stored maize is the effect of these attacks. Insect attack favours secondary attack by fungi; both leading to a fall in the nutritional, sanitary and organoleptic qualities of the stored maize. Thus, poor peasant farmers are left with the choice of locally available botanicals as alternatives to chemical pesticides. It is against this backdrop that this study seeks to determine the insecticidal efficacy of essential oils from the leaves of *Chenopodium ambrosioides* and *Cupressus sempervirens* together with their 50/50 binary combination against the maize weevil, *Sitophilus zeamais*, and the fungi: *Rhizopus stolonifer* and *Aspergillus flavus* on stored maize. Insect mortality and progeny inhibition and the inhibition of fungal invasion were evaluated. Pesticidal activities of both essential oils increased with ascending dose of application. 200 µL/kg of *C. ambrosioides* caused 100% mortality within 3 days and it completely inhibited progeny production in the weevil. The mixture of the two oils showed additive effects against the weevils and fungi. The two essential oils in isolation significantly inhibited fungal spore invasion in 21 days of storage although *A. flavus* was less susceptible than *R. stolonifer*. Therefore, both plants could provide active botanical pesticides against *S. zeamais* and fungal pests in stored maize.

**Key words:** Botanical, essential oil, fungal spore, stored maize pests, food security

## **Prevention of condensation in shipping containers containing bagged stored products**

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There is an increasing trend in the handling and transportation of many agricultural commodities in shipping containers. Although, at time of loading the commodities are stored at their safe moisture content, after several weeks of voyage the commodities arrive with water damage, even when precautions are made with desiccants and dry bags. Condensation is greater especially when transporting from warm climates to cooler ones. Once the commodity exceeds the equilibrium relative humidity of 65% molds are activated and further enhanced. The resulting effect of this phenomenon is detrimental to the transported commodity that disqualifies them of being suitable for consumption as food or feed. In the present communication the reason for such condensation was investigated on bagged groundnuts and a solution to reduce the risk was detailed. Calcium chloride was applied to in-shell groundnuts, at 8.5% moisture content (mc). In addition, condensation in containers handling cocoa beans was elaborated. To prevent mold development, cocoa beans mc should be at 6.8 %. In some countries, mc of 8.5% is common and this places quality preservation of the beans at great risk of increased mold damage and corresponding increase in free fatty acids. Although, placing desiccants in the container to absorb the condensed water is common, the process of condensation is a continuous one, and water extracted from the cargo continues to be extracted by the convection currents, causing the absorbing agents to be saturated easily and thus create water damage to the commodity. To reduce such risk, use of a container size large bag named TransSafeLiner (TSL) was proposed. The purpose of using a TSL is double: it reduces the chances of condensation and reduces infestation.

**Key words:** prevention, condensation, containers, groundnuts, cocoa beans



## **SESSION 4**

### **Quarantine and regulatory issues**

## **Regulations related to storing of agricultural products and other goods**

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Pursuant to the Regulation 178/2002 EP and Council food is meant as any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans, whereas excluded are plants before harvest and tobacco. This means that stored agricultural products are within mentioned groups. Since stored products such as wheat, barley, maize and others are infested by different pests there is need to look at links with two regulations that determine placing on the market pesticides used for their control. Regulation 1107/2009 provides the registration procedure for pesticides used for the protection of plant products against harmful organisms, and thus for the control of storage pests on goods, in premises and on surfaces. Since the product/ a. s. is directly in contact with food, beside effectiveness on pests and other requests, it is important to investigate residues so as to have no effect on the consumer's health. Regulation 528/2012 on biocides determines that insecticides classified within Group 18 are commonly used to control various arthropods, most commonly they are cockroaches and flies, but a. s. are also effective on some stored product pests. Biocides mustn't be applied directly to the goods but are used on surfaces or to treat air. Commodities are stored under different conditions in various types of warehouses and transported in various vehicles and infection by insects can come in all these places. Accordingly, it is necessary to find appropriate measures to protect the goods and the ways of control. It should also be emphasized that the technology of storing of the same goods can be different and these must be considered in the registration process. Due to the control measures insects may remain in treated food and missing are prescripts of pest particles in food.

**Key words:** regulation, stored products, food, pests, pesticides

## Development of postharvest quarantine treatment against the western flower thrips *Frankliniella occidentalis* in pepper fruit

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The western flower thrips (WFT) *Franklidentella occidentalis* (Pergande) is a quarantine insect pest. In Israel, the WFT infestation is one of the limited factors for pepper fruit export, a very important part of the Israeli agricultural export. The preharvest treatments do not allow the zero WFT infestation, the strictly importers requirement. Therefore, there is an urgent need to develop the postharvest treatment in the pepper fruit, which will fit the quarantine requirements. Fumigation is common quarantine treatment against insect pests in various agricultural commodities. However, the accepted fumigation treatment against the WFT in pepper fruits is absent. We evaluated some possibilities for effective WFT control in pepper fruits. Essential oils. In the laboratory experiments, some of essential oils were tested. The pepper fruits were infested by adults/nymphs of the WFT and were treated in the glass chambers of 1.5 liter. The various concentrations and exposure period time were tested at least in tree replications. The best results were obtained by use of the mint essential oil at the concentration of 20  $\mu\text{L/L}$  for 24 h exposure period. Ethyl formate. This compound was tested in the laboratory experiments similar to the essential oils. The total mortality of the WFT was obtained at the concentration of 10  $\mu\text{L/L}$  for 24 h. Phosphine. The experiments were conducted in the fumigation room of 15- $\text{m}^3$  volume. The pepper fruits were fumigated by Degesch-plates. Total WFT mortality was obtained at the rate of 2g/ $\text{m}^3$  for 24 h. The concentration of phosphine was about 1000 ppm. All mentioned treatments did not cause phytotoxic effects and may be used as a postharvest treatment against the WFT in the pepper fruits.

**Key words:** Western flower thrips, pepper fruits, essential oils, ethyl formate, phosphine

## Phosphine sorption at low temperature fumigation of pot plants

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A fumigation technology was developed using phosphine to replace methyl bromide. Commercial scale tests were carried out for fresh plants to control insect pests such as: *Thrips*, *Aphid* spp., *Bemisia tabaci*, *Liriomyza trifolii* and *Tetranychus urticae*. Most plants had no quality deterioration due to the treatment even after 14 d of storage. To implement the technology, a quick phosphine release generator was developed to control fresh plant pests at low temperatures within 24 h at a gas concentration of 1,100 ppm to 1450 ppm. The generator is connected to a gastight rigid fumigation chamber which must hold a pressure decay test of at least 5 minutes. This technology has been commercially available to control QPS treatments of cut flowers, seedlings and cuttings in Israel by generating phosphine gas in a short time. Since exposure time is 24 h, target concentration must be maintained in order to control quarantine pests. Authors have observed decrease in gas concentrations in some cases. It was not clear whether the decrease was due to leaks in the fumigation chamber or due to sorption. After elimination of leaks from the chamber, the effect of sorption due to volume taken by pot plants inside the fumigation chamber was evaluated. The effect of a wet mixture of 10% peat with 90% tuff was tested in the lab at 25°C and at 6°C. Based on this information the expected decrease in concentration after 24 h of exposure time was established and compared with the actual gas concentration of 1450 ppm in commercial fumigations. In addition, remote PH<sub>3</sub> sensors were placed in the fumigation chamber to evaluate the gas concentration decay pattern. The established correlation enabled to estimate the gas decay according to the number of pot plants in the chamber.

**Key words:** phosphine sorption, QPS treatment, pot plants, fumigation, methyl bromide alternatives.

## Dates disinfestation by Radio Frequency treatments

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Quarantine and phytosanitary treatments of stored dates are important to prevent the damage caused by insects feeding on these fruits. Radio frequency (RF) heating has been proposed as one of the most effective and efficient disinfestation methods for postharvest treatment of agricultural products. RF applications have been evaluated to experimentally develop treatment protocol for disinfesting dates. All the experiments were performed in a pilot-scale RF heating system with a 3.5 kW nominal maximum power and a frequency of 27.12 MHz. Siwi or Deglet Nour dates, infested by *Carpophilus hemipterus* (Coleoptera Nitidulidae) have been used in different trials. The authors first assessed the possibility of using RF for the disinfestation of Siwi dates artificially infested with larvae, pupae and adults of *C. hemipterus*. Dates exposed for 6 minutes to 5000V RF treatments were evidenced to be effective in killing larvae, pupae and adults of the pest. During experiments, was observed an insect's emigration from the fruits. Therefore, authors also focused on the application of RF treatments to induce the emigration of *C. hemipterus* adults from the fruits. In the same pilot-scale RF heating system, infested dates were exposed to different RF voltage (V) – time (s) combinations (RF 5000 V – 180 seconds; RF 5000 V – 300 seconds; RF 3500 V – 210 seconds; RF 3000 V – 330 seconds; RF 3000 V – 390 seconds; RF 2500 V – 450 s; RF 2500 V – 600 s). Results showed that the application of 2500 V RF for 8–10. minutes to infested dates resulted in nearly 100% of adults escaping from fruits, with a low or no mortality inside the dates, thus achieving a good disinfestation procedure.

**Key words:** *Carpophilus hemipterus*, dates, RF treatments, disinfestation, emigration phenomenon



## **SESSION 5**

### **Biological control of stored product pests**

## Entomophagous insects as biocontrol agents of stored food pests

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Several reviews on biological control of stored-product pests have been published during the last 30 years reporting advantages and disadvantages of this approach for the management of different stored food pests. A brief summarization on the potential and practical application of the main predators [i.e. *Xylocoris flavipes* (Reuter)] and parasitoids [i.e. *Anisopteromalus calandrae* (Howard), *Habrobracon hebetor* (Say), *Holepyris sylvanidis* (Brèthes)] of some stored food pests, is herein presented and discussed.

**Key words:** integrated control, natural enemies, wheat

## Biologically-based control of *Tribolium confusum* using parasitoids and semiochemicals: from basic research to semifield application

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Natural enemies of pest organisms such as parasitoids are nowadays frequently used as biological control agents in agricultural systems and to some extent also for the protection of post-harvest products. Nevertheless, the high potential of these beneficial insects to alternatively protect stored goods is far from exhausted. This is partly due to the limited knowledge about the biology and behaviour of many parasitoid species, and more importantly to the lack of information on the semiochemicals involved in the host search. Also, results of field applications or efficacy measurements are rather the exception. Therefore, in behavioural, electrophysiological and analytical studies, we investigated the odour-mediated host location and host recognition process of the bethylid wasp *Holepyris sylvanidis* Brethes. This larval ectoparasitoid of stored-product pest beetles has been shown to use faecal volatiles from *Tribolium* spp. larvae, the preferred host, in combination with habitat substrate odours (i.a. wheat grist) for host finding from a distance. Moreover, host larval cuticular hydrocarbons demonstrated to elicit trail following behaviour as well as to mediate host recognition in the parasitoid. In semi-field experiments using flight cages, we measured the effectiveness of *H. sylvanidis* to control the confused flour beetle *T. confusum* in the presence (or absence) of additional, specifically host-associated volatiles.

**Key words:** biorational pest control, GC-MS analysis, *Holepyris sylvanidis*, host location, olfactometer bioassays

## Control of *Callosobruchus maculatus* (Coleoptera: Bruchidae) with natural enemies in chickpeas

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*Callosobruchus maculatus* is the main pest of the stored chickpeas. Their larvae develop inside the grain producing a loss of mass, of the germination? viability as well as contaminating the product for the consumer. A limited number of highly toxic pesticides are repeatedly used for its control during the storage period. This leads to residue problems in the grain and the appearance of resistant populations, which is why it is necessary to develop alternative control methods. The use of natural enemies is a possible alternative that can be very effective in legume warehouses. In this study, two egg predatory mites and two larval parasitoids were evaluated in the laboratory for the control of this weevil. The two predatory mites, *Blattisocius tarsalis* and *Amblyseius swirskii*, were able to survive in the low humidity conditions of a warehouse. But the number of eggs that they preyed was not very high. However, the parasitoids *Anisopteromalus calandrae* and *Lariophagus distinguendus* were very effective, causing mortalities greater than 90% of the weevil population. These parasitoids were able to effectively parasitize the host at depths of up to one and a half meters in 20 cm diameter tubes filled with chickpeas, that simulated the depth at which parasitoids would have to penetrate within a pile. Thus, both parasitoids can be an effective alternative for the control of this weevil.

**Key words:** predatory mites, parasitoids, weevils, legumes, stored products

## Studies on developmental compatibility and botanical management of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) on different cultivars of *Vigna radiata* (L.) Wilczek

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The study was initiated with the objective to bring on record the comparative life history of *Callosobruchus maculatus* (F.) on sixteen different cultivars of *Vigna radiata* to unveil the susceptibility and resistance along with developmental compatibility of the pest on different legume commodities and management of the pest species by a locally available botanical species. Females laid an average of  $65.25 \pm 2.30$  eggs and produced  $60.25 \pm 1.10$  offsprings on land races of *V. radiata*. All genotypes of *V. radiata* were preferred by *C. maculatus* with varying degree of 55 to 79 eggs per female. The highest numbers of eggs were laid on large sized and smooth coat seed surface of genotype, MH125 (basanti) ( $79.75 \pm 2.63$ ) and least on PLU 1050 ( $55.25 \pm 2.22$ ). The highest adult emergence was recorded in genotype, IPM99-125 (52.19%) and least in IPM205-7 (15.68%). Larvae grew and moulted inside the host seed and adult bruchid emerged out after cutting circular window in testa of seed. Total development was completed in 42-46 days during favourable period but life cycle prolonged during unfavourable periods. In botanical management the use of natural plant products is an important alternative of chemical pesticides to keep the pest population below the economic injury level. Acetone and methanol extracts of *Viburnum cotinifolium* D. Don. (Adoxaceae: Dipsacales) leaves were prepared and employed at concentrations of 5, 10 and 20% with three replicas each. Efficacy of these extracts was observed on adult mortality, fecundity and F1 adult emergence. 100% adult mortality was observed on 10<sup>th</sup> day of treatment at 20% concentration of acetone extract, whereas methanol leaves extract showed 100% mortality on 3<sup>th</sup> day of treatment at the same concentration. Results revealed that methanol leaves extract of *V. cotinifolium* was most effective in reducing life span, fecundity and adult emergence of *C. maculatus* among all the treatments.

**Key words:** Life history, pest, legumes, bruchid, botanical

## **Influence of temperature on the functional response of *Anisopteromalus calandrae* (Hym.: Pteromalidae) to different population densities of *Callosobruchus maculatus* (Col.: Bruchidae)**

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Functional response is defined as the behavior of parasitoids in response to an increasing host density which is thought to be related with parasitoid success. *Anisopteromalus calandrae* (Howard) is a cosmopolitan solitary ectoparasitoid of immature stages of many coleopteran species, such as *Callosobruchus maculatus* (Fabricius). In this study the functional response of *A. calandrae* to different densities of 2,4,8,16,30,40, and 50 of forth instar larvae of *C. maculatus* was investigated under laboratory condition of  $65\pm 5\%$  R.H., in dark condition and three different temperatures of 25, 30 and 35°C. Various densities of host were exposed to newly emerged mated female parasitoids for 24h. Logistic regression revealed Type II functional response for *A. calandrae* at all temperatures. The searching efficiencies ( $a$ ) and handling times ( $T_h$ ) were  $0.0327h^{-1}$  and 3.1486h at 25°C,  $0.0531h^{-1}$  and 2.3546h at 30°C, and  $0.0514h^{-1}$  and 2.4998h at 35°C, respectively. The maximum attack rates ( $T/T_h$ ) of parasitoid were calculated to be 7.62, 10.19 and 9.60 larvae at 25, 30, and 35°C, respectively. These results indicate that *A. calandrae* is able to find and parasitize *C. maculatus* over a broad range of temperatures and it is probably more effective parasitoid at 30°C.

**Key words:** biological control, cowpea weevil, host density, parasitoid, searching efficiency

## **Possibilities for the biological control of the bean weevils *Acanthoscelides obtectus* and *Zabrotes subfasciatus* (Coleoptera: Bruchidae)**

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*Acanthoscelides obtectus* and *Zabrotes subfasciatus* are two important pests of stored beans. While the cosmopolitan *A. obtectus* is present in Europe, *Z. subfasciatus* is not, with a tropical and subtropical distribution in America, Africa and Asia. Their control is commonly done with few available insecticides that, other than leaving toxic residues in the grain, may enhance the appearance of resistant populations. Therefore, it is necessary to develop alternative strategies for its control, among which the use of natural enemies stands out. The effectiveness of four egg predatory mites and two larval parasitoids in the control of these two weevils has been evaluated in the laboratory. Two mites' species, *Amblyseius cucumeris* and *Hypoaspis miles*, have difficulty in surviving at the humidity conditions of a storehouse, while the other two species, *Blattisocius tarsalis* and *Amblyseius swirskii*, would be more adapted to this dry environment. When tested individually, the mites *B. tarsalis* and *A. swirskii*, and the parasitoids *Anisopteromalus calandrae* and *Lariophagus distinguendus*, were not very effective in the control of *A. obtectus*, causing mortalities below 20% of the weevil population. However, when a predatory mite and a parasitoid were combined, their effectiveness increased considerably. In the case of *Z. subfasciatus* any species had enough efficiency, individually or combined, to be consider as possible candidates for its biological control.

**Key words:** weevils, predators, parasitoids, legumes, stored products

## Preferential infectivity of entomopathogenic nematodes in an envenomed *Plodia interpunctella* larvae

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Entomopathogenic nematodes and parasitoid wasps are used as biological control agents for management of insect pests like the Indianmeal moth, *Plodia interpunctella*. The parasitoid wasp *Habrobracon hebetor* injects a paralytic venom into *P. interpunctella* larvae before laying eggs. A previous study reported that the entomopathogenic nematode *Heterorhabditis indica* preferentially infects *P. interpunctella* that have been envenomed by *H. hebetor* while results in this study showed a similar preference by the entomopathogenic nematode, *Steinernema glaseri*. We therefore tested four hypotheses for why nematode infection rates are higher in envenomed hosts: 1) elevated CO<sub>2</sub> emission from envenomed hosts attracts nematodes, 2) paralysis prevents hosts from escaping nematodes, 3) volatile chemicals emitted from envenomed hosts attract nematodes and increases infection, and 4) reduced immune in envenomed hosts increases nematode survival. Results showed that envenomed *P. interpunctella* larvae emitted lower amounts of CO<sub>2</sub> than non-envenomed larvae. Physical immobilization of *P. interpunctella* larvae did not increase infection rates by *S. glaseri* but did increase infection rates by *H. indica*. Emissions from envenomed hosts were collected and analysed by thermal desorption gas chromatography/mass spectrometry. The most abundant compound, 3-methyl-3-buten-1-ol (*3-methyl-3-buten-1-ol*) was found to be an effective cue for *S. glaseri* attraction and infection but was not an effective stimulus for *H. indica*. Envenomed *P. interpunctella* exhibited a stronger immune response toward nematodes than non-envenomed hosts. Altogether, we conclude that different mechanisms underlie preferential infection in the two nematode species: host immobilization for *H. indica* and chemical cues for *S. glaseri*.

**Key words:** entomopathogenic nematode, Hymenoptera, infection, parasitoid

## **SESSION 6**

### **Methods of pest prevention during storage, transportation and handling of stored products**

## **Prevention of stored product insect infestations through management of the outdoor landscape**

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Preventing stored product insects from entering food facilities such as mills, processing plants, and warehouses is the first line of defense and the foundation of a successful integrated pest management program. In this presentation, will summarize research into how stored product insects exploit outside spillage accumulations, how dispersal from these sources can contribute to interior infestations, and how management tactics targeted at these sources and blocking movement can improve pest management programs inside food facilities.

**Key words:** Integrated Pest Management, prevention, spillage, dispersal, rice, wheat

## Long-lasting insecticide netting is effective at preventing dispersal to novel food patches against multiple stored product species and life stages

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Post-harvest insects cause billions of US dollars in damage globally. To satisfy consumer demand for low-insecticide products throughout the supply chain, and to preserve the efficacy of remaining fumigants, it is important to diversify integrated pest management programs by developing alternative tactics. One alternative tactic is the use of long-lasting, insecticide-incorporated netting (LLIN), which has historically been used to control vectors of arthropod-borne diseases. More recently, our team has been assessing this tool for control of stored product insects for deployment in and around facilities. The goal of this study was to evaluate whether LLIN is effective against multiple species of stored product insects and whether efficacy varied by life stage. To assess this, we tracked sublethal changes in movement after exposure to LLIN or control netting for 1, 5, or 10 min either immediately after exposure, 24, 48, 72, or 168 h later. This was done by using video tracking coupled with Ethovision software. To understand whether these sublethal changes in movement had implications for dispersal capacity of the pests to novel food patches, we used a dispersal assay. Our findings indicated that there were multiple-fold decreases in movement for a range of species and life stages, which were immediate and long-lasting even after brief exposures. This resulted in impairment of stored product insects to disperse to novel food patches. Overall, our results suggest that LLIN is an incredibly promising tool for diversifying IPM programs for food facilities.

**Key words:** Integrated Pest Management, behavior, chemical control, *Tribolium castaneum*, sublethal effects

## **Lower temperature thresholds for development, locomotion, flight, respiration and sound production of stored product insects and mites**

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Low temperatures limit development and activity of all arthropods and therefore belong among primary nonchemical pest control method. The species-specific knowledge regarding lower temperature thresholds for flight and locomotion is important in order to establish limits of any trap-based pest monitoring program. We compared published data on more than 100 species of storage arthropod pests and found that the low temperature thresholds for their development differed substantially not only among species, but also among orders. The low average development threshold (LDT) was reported for Acari (6.8°C), followed by Lepidoptera (11.3°C), Psocoptera (13.8°C), and Coleoptera (14°C). Temperature thresholds were scaled from the lowest to highest temperature as follows: the the trap capture threshold, the lower development threshold, lower population threshold, and the lower trap capture threshold for flying pests.

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**Key words:** low temperature, thresholds, activity, development, monitoring, sound production

## Quality of maize stored in hermetic bags by smallholder farmers in the Northern highlands of Tanzania: impact of farmer practices and agro-location

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We investigated how harvesting, handling and storage practices affected quality of maize stored in hermetic bags by smallholders in contrasting agro-locations. Different forms of grain damage were assessed at the time of storage and monitored over the storage period. The overall damage levels were 11–22%. Late harvest increased moldy/rotten/diseased (MRD) grain two-fold. Handling practices increased MRD grain of early harvest maize by factor of 2–3. Insect populations were >10 times higher in the cooler location, and handling practices increased the counts by factor of 2–10. Interaction of practice x location was significant for levels of rodent damage ( $P < 0.001$ ), insect damage ( $P = 0.038$ ), impurities ( $P = 0.049$ ), and broken ( $P = 0.020$ ) and discolored grains ( $P = 0.012$ ). Potential pre-storage losses averaged 3.6–11.2% in form of grade-outs, and the interaction of location x harvesting/handling practice was significant ( $P = 0.040$ ). During storage, interaction of harvesting/handling practice x location x storage duration influenced grain quality ( $P = 0.012$ ) in hermetic bags. Better quality was achieved in the warmer location and was improved in the cooler location when crop was harvested early, and husked cobs dried on improved tarpaulins. However, high levels of grade-outs (6–7% losses) arising from poor grain condition suggest pre-storage sorting is essential for quality improvement. The sorting losses can be minimized by choice of varieties with superior maturing and post-harvest traits. Our findings show that integrated education and training on choice of variety, and best handling practices should be implemented to improve storage protection of grains in air-tight containers by rural small holder farmers.

**Key words:** farmer practices, maize, post-harvest, quality, storage

## Evaluation of long-lasting insecticide treated netting against a suite of stored product insects

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Commercially available long-lasting insecticide treated nets (LLIN, impregnated with pyrethroid, were initially developed to kill mosquitos and offer long-term protection. The use of LLIN has since been expanded outside the scope of mosquitos into agricultural pests. Recently, this technology has begun to be evaluated against stored product insects. First, we evaluated the efficacy of LLIN against a suite of adult stored product insects over a range of exposure periods up to 60 minutes. Second, we evaluated the time to 100% affected adults after exposure to LLIN. Third we evaluated the longevity of the LLIN when exposed to outdoor an indoor ambient condition over a 12-month period. Results have demonstrated stored product insects vary in susceptibly, even within the same genus. After 7 d post LLIN exposure of 60 min, 47% of *Tribolium confusum* adult were alive compared to 57% of *Tribolium castaneum*. *Rhyzopertha dominica*'s time to 100% affected after a 15 min exposure to LLIN was <30 min and resulted in 100% of adults affected or dead at 7 d post exposure. LLIN exposed to outdoor and indoor conditions have shown to be highly effective against *R. dominica* and *T. castaneum* adults over exposure periods of 10 and 15 minutes respectively. Our results demonstrate a novel technology that is highly effective against stored product insects and could be incorporated into existing pest prevention programs, storage and coverage strategies, or possibly attract-and-kill technologies.

**Key words:** long-lasting insecticide treated netting, efficacy, pest prevention, stored product insect

## **Protecting the Quality of Grain during storage through cool conservation**

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Grain cooling is a natural process for conservation cooling of grain, maize, rice, paddy and oilseeds. The grain would be cooled down to a desired temperature, effectively preventing insect infestation, mould formation and mycotoxins. The cooling unit therefore also contributes significantly to assuring the harvest quality.

**Key words:** grain cooling, natural grain conservation



## **SESSION 7**

### **Natural products**

## **Role of natural products in management of stored product pests: challenges and opportunities**

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In theory, the best approach to control stored product insect pests is to integrate physical, chemical, biological and hygiene methods. In practice, however, industry relies heavily on chemical treatments belonging to two major groups: fumigants as disinfestants and residual treatments for long term protection of stored commodities. Heavy reliance on chemical treatments has led to widespread resistance in a range of pests to major groups of chemicals including fumigant phosphine and organophosphates, pyrethroids and insect growth regulators. Another negative aspect of chemical treatments is the ever-growing public concerns about their impact on environment and residues on food commodities. In this context, many researchers have been investigating the use of natural products to control pests, while addressing the environment, public health and resistance issues. There is a rich literature available on the efficacy of several natural products, predominantly plant extracts and diatomaceous earth products against a range of stored product pests, both in terms of their toxicity and repellency activities. Unfortunately, most of this research has been confined to limited laboratory studies, typically using simple testing methods, and only few natural products have successfully progressed through the registration process for industry use. These include plant-derived pyrethrum and neem products, a few diatomaceous earth products and more recently, spinosad, the fermentation product of a naturally occurring bacterium. This talk is a discussion on challenges and opportunities associated with natural products, particularly in terms of their practical utility in management of stored product pests.

**Key words:** pyrethrum, spinosad, diatomaceous earth, plant extracts, grain protectant

## **Efficacy of *Alstonia boonei* De Wild essential oil as entomocides in the management of cowpea bruchid, *Callosobruchus maculatus* Fab.**

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Essential oil prepared from *Alstonia boonei* De Wild were tested as entomocide in the management of cowpea bruchid, *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae). Three levels of concentrations were tested vis 1, 2, 3 and 4%. The oil of *A. boonei* stem bark had the highest mortality of 100% after 4 days of application at all level of concentrations tested. The survival of the cowpea bruchid from egg to adult when treated with the plant oils showed significantly higher mortality. Oils of the tested plant were toxic to adult bruchid and also prevented adult emergence of *C. maculatus*. The phytochemicals present in the petroleum ether extracts of *A. boonei* leaf, stem bark and root were similar. Flavonoid was absent in *A. boonei* leaf and root but present in *A. boonei* stem bark and this might be responsible for its high insecticidal activity. The efficacy of the plant oil could be arranged in the following order: stem bark oil > leaf oil > root oil.

**Key words:** *Callosobruchus maculatus*, adult emergence, entomocide; *Alstonia boonei*, phytochemicals

## The potential of *Ajuga* species as sunflower grain protectants against *Plodia interpunctella* Hübner

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Higher plants represent a rich source of bioactive compounds and can be used to develop environmentally safe means for insect control. *Ajuga* species are well known by their antimicrobial activity, while only a few reports indicate repellent and insecticidal activity towards stored product pests. This work aimed to assess the potential of *A. pyramidalis* and *A. reptans* ethanol extracts (0.5, 1 and 2%), as protectants of sunflower seeds against *Plodia interpunctella*. The biochemical analyses of extracts determined levels of secondary metabolites (phenols, tannins, antocians), while antioxidative stress parameters were analyzed in sunflower seedlings. In “no choice” test we monitored larval mortality (24, 48, 72 h and 7 days of exposure), larval development, mean developmental duration, adult emergence and fecundity. The allelopathic effect was evaluated based on germination energy (GE) and germination (G) of seeds. Significant mortality (45%) of larvae was caused only by 2% extract of *A. pyramidalis*, after 7 days. In other treatments monitored parameters were at the same level of significance with the control. *A. pyramidalis* (0.5, 1 and 2%) inhibited GE of sunflowers seeds, while G was not affected. *A. reptans* did not express any activity on *P. interpunctella*, but 1% extract significantly reduced GE and 2% extract inhibited both GE and G of sunflower seeds. The antioxidative tests detected significant stress in seedlings when seed was treated with *Ajuga* extracts, regardless on the concentration.

**Key words:** *Ajuga* species, sunflower, *Plodia interpunctella*, alleopathy, grain protectant

## Susceptibility and Termiticidal activity of oil-seeds of *Jatropha curcas* and Neem tree on the management of wood termites

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In Nigeria, termite infestation is common to the wood industry and the use of synthetic insecticide has caused economic and environmental harms. The termiticidal effects of oils of *Jatropha curcas* and *Azadiracta indica* seeds on the management of wood termites was evaluated in Cross State of Nigeria. Field bioassays were conducted using seven different wood species. *Antaris toxicera*, *Gmelina arborea*, *Baphia nitida*, *Parkia biglobosa*, *Pycnanthus angolensis*, *Terminalia superba* and *Ceiba pentandra*, were subjected to natural infestation by the termites. Thereafter, the wood materials arranged in a randomized complete block design with four replications, while 0.0, 1.0 and 1.5 mls of the oils were applied to 1 kg of each material. Data on susceptibility of the wood species to termite activities and mortality of the wood termites at 12-hrs intervals were recorded and terminated at 120-hrs after application of the oils. Results showed that *C. pentandra*, *P. biglobosa* were significantly infested by wood termites followed by *P. angolensis* and *A. toxicera*. The result also indicated that *J. curcas* oil significantly increased mortality at all levels of application compared with *A. indica* and the untreated. The toxicity of the oils increased with increase in time of exposure. *J. curcas* recorded 100% mortality at 48 a 60 hrs of exposure for 1.0 and 1.5 mls while *A. indica* recorded 100% mortality at 84 and 96 hrs of 1.0 and 1.5 ml respectively. In conclusion, *J. curcas* oil could be used as an alternative to synthetic insecticide which are not environmentally friendly.

**Key words:** *Jatropha curcas* oil, *Azadiracta indica* oil, mortality, toxicity, time of exposure

## **Effect of some essential oils against *Rhyzopertha dominica* (Coleoptera: Bostrichidae) under laboratory and store conditions**

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The lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae) is a very harmful insect pests to cereal grains including wheat. The essential oils (EOs) of thyme, frankincense and turmeric were tested against the pests, under laboratory and store conditions. Results showed that the cumulative mortality percentage gradually increased after increasing the period of exposure to the foam treated with the three EOs. Nano-formulated EOs showed a highest cumulative mortality of 99.0%, 89%, and 87% when the insects were treated with thyme, frankincense and turmeric EOs respectively. The reduction of the eggs laid per female was 99.3% after treatments with nano-thyme. Under store conditions the percentage of infestations significantly decreased to 2%, 7% and 10% after treating the stocks sacs with thyme, frankincense and turmeric, as compared to 99% in the untreated stock sacs (control)

**Key words:** *Rhyzopertha dominica*, thyme, frankincense, turmeric, essential oils

## **Bio insecticidal effect of *Jatropha curcas* oil of Tunisian origin on *Rhizopertha dominica***

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An analysis of the composition of the oil extracted by gas chromatography from three lots of Tunisian *Jatropha curcas* seeds revealed its richness in oleic and linoleic acids. This oil was used for a patch test on *Rhizopertha dominica*, and the results showed a significant biocidal effect towards the pest; it reduced significantly the lifespan of the exposed insects to 24 hours. The mortality rate of the treated insects increases with oil doses and exposure time.

**Key words:** *Rhizopertha dominica*, *Jatropha curcas*, oil

## Behavioral effects of naturally extracted fatty acid on *Trogoderma* larvae

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Khapra beetle (KB), *Trogoderma granarium*, larvae often enter diapause and are observed assembled in clusters on non-food sources. Older literature describes profiles of cuticular hydrocarbons extracted from adults and larvae, but not any behavioral effects of compounds extracted from surfaces. Investigations were made concerning the effects of such chemical extracts on KB movement. Parallel studies were performed using two related species, the warehouse beetle (WB), *Trogoderma variable*, and larger cabinet beetle (LCB), *Trogoderma inclusum*. The KB extracts had hydrocarbon profiles similar to what was reported in the previous literature. However, all three species had a highly variable amount of one particular fatty acid. In petri dish arenas two choice experiments were performed. Extracts (5 larval equivalents) were presented versus blank controls. The trials were repeated for all three species. In some cases, we used extracts with no detectable amounts of the fatty acid, and in others they made up more than 50% of the extract. For all the species, when the fatty acid component was high, there was a repulsion of the larvae toward the other side of the arena for all three species. Otherwise there was no effect. For KB we also performed the assay using increasing doses of a commercial source of the fatty acid. At very low doses the compound was mildly attractive but became strongly repellent at high doses. Further research is needed to assess potential management applications.

**Key words:** attractant, behavior, repellent, semiochemical, *Trogoderma*

## Effectiveness of propolis' extracts for storage mites' control

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The propolis' properties are described as antibacterial, antifungal and antiviral; furthermore, it is shown its activity against various organisms (*i.e.* bee's parasites). In this study, it was evaluated the toxic effect of two extracts of propolis (Propolis Mother Tincture 80° and Propolis Hydroglyceric extract) on two astigmatid storage mites: *Glycyphagus domesticus* and *Lepidoglyphus destructor*. In laboratory, the mites were treated by <1min. immersion with the two Propolis extracts, 80° alcohol, water; tests were performed at two different temperatures (6°C and 16°C) and 85±5% RH. On the whole, by different treatments and temperatures, toxicity of propolis extracts was detected; *L. destructor* showed higher susceptibility than *G. domesticus*. The tested mites were also processed to have a broad indication of the effect of the substances on microbial communities associated to the storage mites.

**Key words:** *Glycyphagus domesticus*, *Lepidoglyphus destructor*, microbial community, toxic effect, propolis

## **The potential for integration of insecticidal botanical products with other control methods for stored grain protection against insect infestation and damage in Nigeria**

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Food grains, mainly cereals and legumes, are major dietary staples in Nigeria, but are often greatly damaged by insects during storage. Traditional use of botanicals for stored products protection against insect damage is common but not very effective. Research studies conducted in Nigeria involving combining insecticidal botanical products with other controls especially non-chemical methods for increased efficacy in insect control in stored grain are therefore reviewed. Admixtures of botanicals and combinations of botanicals with grain resistance, heat and solarisation, diatomaceous earths, modified atmospheres, and pathogens and other bio-insecticides, conventional insecticides and insect growth regulators were considered. It is suggested that use of cocktails of insecticidal botanicals or their combination with other non-chemical methods in three-tiered or more systems may greatly improve their efficacy against stored products insect pests.

**Key words:** insecticidal botanicals, integrated control, insect pests, stored grain

## **Insecticidal Bioactivity of Extract of Basil Plant (*Ocimum basilicum*) in Combination with *Metarhizium anisopliae* against saw toothed beetle *Oryzaephilus surinamensis* (Coleoptera: Silvanidae)**

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The present investigation was carried out to evaluate the insecticidal bioactivity of leaf and flower extract of *Ocimum basilicum* alone and in combination with *Metarhizium anisopliae* against *Oryzaephilus surinamensis*. Three doses (10, 20 and 30%) of both leaves and flowers extracts and three concentrations (60, 120 and 180 mg) of *M. anisopliae* were tested using three replications following completely randomized design. Toxic and repellent effect of extracts of basal plants were evaluated whereas in case of *M. anisopliae*, only toxic effect was evaluated. In case of plant extracts, the data of percent mortality bioassay were observed after 24, 48 and 72 hrs while in bioassay of entomopathogenic fungus mortality was observed after 7, 14 and 21 days. All collected data were analyzed for analysis of variance using Statistica-8 software. The means of significant treatments were compared using Tuckey-HSD test at  $\alpha = 0.05$ . The results show significant effect of both extract and fungus on mortality of *O. surinamensis*. The results reveal that highest mortality by leaf extract of *O. basilicum* was 52.87% at 30% concentration followed by 39.65 and 28.08% with 20 and 10% dose rates. In case of flower extract highest mortality was 41.61% with 30% concentration followed by 32.50 and 16.67% caused by 20 and 10% flower extract respectively. While in case of entomopathogenic fungus, 48.11% was the maximum mortality caused by 180 mg dose rate of fungus followed by 35.84% with 120 mg and 31.88% with 60 mg concentration of *M. anisopliae*. In combination bioassay, 88.85% mortality was achieved using 30% concentration of flower and leaf extract and 180 mg of fungus followed by 67.48% by flower extract + fungus, 51.10% by leaf extract + fungus and 47.45% by leaf + flower. In repellency bioassay leaf extract showed significant effect by causing 80% repellency to adult beetle with 30% concentration after 72 hours followed by 40.00 with 20% after 72 hours and 26.67% with 10% after 72 hours. While in case of flower extract 40.00% repellency was achieved with 10% concentration followed by 36.67% with 30% and 28.89% with 20% concentration. The conclusion of the study is that basil plant and fungus in combination gives better results to control the saw toothed beetle *Oryzaephilus surinamensis* rather they are used separately.

**Key words:** biopesticides, entomopathogenic, plant extract, microbial, repellency, toxicity

## **Efficacy of plant extracts against *Tribolium castaneum* (Herbst) in two types of flours**

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*Tribolium castaneum* is a serious pest of stored grains and their by-products which severely deteriorate the quality of products. Current research was designed to check the lethal effect of *Nerium oleander* and *Azadirachta indica* extract against *T. castaneum*. Three concentrations of each plant extract were prepared and applied to wheat and corn flour which were used as food medium during bioassays. Mortality of test insect was counted after time interval of 5, 10 and 15 days. Findings of the trial divulge that effect of different diet medium regarding mortality of *T. castaneum* by application of plant extracts was non-significant. However, increase of concentration and exposure interval significantly affect the mortality of *T. castaneum*. Maximum mean mortality (56.55%) was noticed after 15 days with the application of *A. indica* at highest concentration on corn flour, while lowest mortality of (12.33%) was counted with lowest concentration of *N. oleander* after exposure interval of 5 days on wheat flour. These results suggest that *N. oleander* and *A. indica* could be used as a safe alternative to chemicals in IPM of stored grains.

**Key words:** *Nerium oleander*, *Azadirachta indica*, stored grains, Mortality, pest

## Essential oils loaded in Nano-delivery systems: a developing technique for the control of the date moth *Ectomyelois ceratoniae* under storage conditions

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Plant essential oils have proved their insecticidal potential against various insect species. They were successfully implemented mainly against stored product pests. However, constraints relating to their volatility, potential for oxidation and poor water solubility, need to be addressed before they can be considered for industrial use. Consequently, encapsulation in nanometric particles is an alternative for overcoming these problems, to modulate the release, guarantee protection of essential oils compounds against degradation or evaporation, decrease the volatility, enhance the bioactivity and reduce the toxicity. In this work, we assess the fumigant toxicity of *Rosmarinus officinalis* (L.) essential oils in comparison with a powdered cyclodextrin (CD)/1,8-cineole inclusion complex, a powdered Conventional Liposomes (CL)/1,8-cineole inclusion complex and free 1,8-cineole (oils major compound) against last instars developing inside fruit and adults of *Ectomyelois ceratoniae* (Zeller). *E. ceratoniae* is the most important and destructive insect pest attacking dates in Tunisia. It caused loss of weight and downgrading of the commercial value of dates. Results revealed the performance of the nanometric particles in terms of insect mortality and toxicity persistence. Results emphasized the benefit of essential oils encapsulation either in cyclodextrin or in liposomes for the postharvest control the date moth *E. ceratoniae*.

**Key words:** *Ectomyelois ceratoniae*, essential oil, encapsulation, nanoparticles

## Effectiveness of new developed natural and safe insecticide formulations against stored product insects

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The insecticidal effect of new developed insecticide formulations labelled as Natural P, Inert Natural P and Py EC on *Sitophilus oryzae* (L.), *Rhyzopertha dominica* (F.) and *Tribolium castaneum* (Herbst) have been evaluated on wheat grains. Formulation Natural P contains diatomaceous earth (DE), amorphous silica gel (3%), pyrethrin, flax oil, lavandin essential oil (EO) and un-activated yeast. Formulation Inert Natural P combines DE, amorphous silica gel, lavandin EO and food grade bait whereas formulation Py EC contains pyrethrin, piperonyl butoxide (PBO), flax oil, polysorbate, methyl oleate and amorphous silica gel (5%). DE Celatom<sup>®</sup> MN-51 was used as a standard insecticide. Inert Natural P and Natural P were applied as dust at four different doses, while Py EC was mixed with water in 4 dilutions containing 0.5, 1.0, 1.5 and 2.0 ppm of pyrethrin a.i. and applied as emulsions on grain by spraying. The LD<sub>50</sub> and LD<sub>90</sub> values of Inert Natural P were 48.72 and 163.73 ppm respectively for *S. oryzae*, 15.18 and 177.96 ppm for *R. dominica* and 115.20 and 171.30 ppm for *T. castaneum*. The LD<sub>50</sub> and LD<sub>90</sub> values of Natural P were 53.56 and 97.94 ppm respectively for *S. oryzae*, 19.47 and 53.05 ppm for *R. dominica* and 75.40 and 105.60 ppm for *T. castaneum*. While the LD<sub>50</sub> and LD<sub>90</sub> values of DE Celatom<sup>®</sup> MN-51 were 188.55 and 352.79 ppm respectively for *S. oryzae*, 39.86 and 405.420 ppm for *R. dominica* and 358.10 and 716.87 ppm for *T. castaneum*. Comparing with DE Celatom<sup>®</sup> MN-51 two powder formulations applied at effective concentrations had lower impact on wheat test weight reduction. Applied Py EC at concentration of 2.0 ppm a.i. pyrethrin exhibited 100 % mortality after 2 days of *S. oryzae* and *T. castaneum* and after 6 days of *R. dominica*. In addition, all three formulations caused significant reduction of F1 adults compared to control, providing promising approach of integrated pest management strategy.

**Key words:** stored product insects, natural substances, diatomaceous earth, essential oil, pyrethrin

## Response of saw-toothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus, 1758) (Coleoptera: Silvanidae), to *Piper guineense*-based biopesticides infesting melon

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The response of saw-toothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus, 1758), to four *Piper guineense*-based biopestidal powder (*Piper guineense*, *P. guineense* + *Securidaca longipendiculata*, *P. guineense* + *Zanthoxylum xanthoxyloides*, *P. guineense* + spinosad) and two synthetic insecticides (spinosad and imidacloprid) was evaluated in the laboratory. Toxicity was dose-dependent and progressed with the exposure period for all *P. guineense*-based formulations and ranged from 19.30% to 63.60%. At 14 days after treatment, Spinosad-based formulations and imidacloprid caused significantly higher mortality (90%) than 70.33% and 66.67% observed in *P. guineense* and *P. guineense* + *Z. xanthoxyloides*, respectively. All formulations inhibited *O. surinamensis* progeny emergence (0.00-1.30) compared with the untreated control (9.53). Steroids (1716.7 mg/100g), terpenoids (1235.0 mg/100g) and alkaloids (491.69 mg/100g) in *P. guineense* were significantly highest than the values observed in *S. longipendiculata* and *Z. xanthoxyloides*. It was concluded that *Piper guineense*-based biopesticides can be explored for protection of melon against the infestation of *Oryzaephilus surinamensis*.

**Key words:** *Oryzaephilus surinamensis*, *Piper guineense*, progeny inhibition, *Securidaca longipendiculata*, toxicity, *Zanthoxylum xanthoxyloides*

## Habituation of the lesser grain borer, *Rhyzoperta dominica*, to essential oil-based repellents

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Repeated exposure to deterrents may result in their increased acceptability to some insects. Several essential oils (EOs) were reported to be repellent for stored product beetles, but few data are available on habituation. Habituation is defined as a behavioral response decrement caused by repeated stimulations. Habituation responds to a series of characteristics which are needed to demonstrate that insect behaviours are not affected by sensory adaptation/fatigue or motor fatigue. Here, potential habituation of the lesser grain borer, *Rhyzoperta dominica*, toward EO-based repellents in presence of food was tested under laboratory conditions. Petri dish trials were set up to determine the repellence of EO-based formulation, as well as to compare residence durations between treatments. *Rhyzoperta dominica* adults were trained at different training intervals to assess frequency-dependent decline and recovery onset. Results indicated that habituation can occur at the shorter training intervals, even if insects did not reach the asymptotic level. Furthermore, *R. dominica* adults recovered their responses just after 24hs from the training sessions, suggesting that the habituation for EO-based repellents was moderate. This can be important to understand natural strategies of food selection and their evolutionary changes, and to improve the efficiency of repellents for stored product pest control.

**Key words:** stored product beetles, habituation, essential oil, avoidance, repellence

## **Biopesticide granules based on essential oils for the protection of wheat grain during storage**

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Biopesticide granules based in cereal by-products and essential oils were developed for wheat protection during storage. The elaboration process of the granules was performed by extrusion, allowing the modulation of the retention and release of the essential oils, but also taking into account specific mechanical properties. The essential oils used were selected from their known insecticidal and fungicidal activity. Insecticidal tests using the biopesticide granules have been conducted against *Rhyzopertha dominica* and *Sitophilus oryzae* in contact with wheat grain simulating storage conditions. The insecticidal effect was evaluated after 24, 48 and 336 hours. The mortality of both species was dependent on the nature, concentration, and release rate of the essential oil. The highest mortality reached was of 78% for a high load of insects (100 insects/Kg of wheat grain). In addition, fungicide essays were carried out against *Aspergillus westerdijkiae* and *Penicillium verrucosum*. The germination and growth of the microorganisms and ochratoxin A production were evaluated. The results were strongly dependent on the essential oil nature released by the biopesticide granules. The findings suggest that the obtained biopesticide granules could be an alternative solution for the control of infestations in stored crops.

**Key words:** essential oils, controlled release, insecticide, fungicide, wheat

## **Repellence and attractiveness: the double effect of essential oils on insect pests**

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Essential oils (EOs) are complex mixtures of volatile compounds extracted from aromatic plants belonging to a few families. They have a wide range of biological activities and they have been largely used for the protection of human, food, and crops from the attack of insects. Their activities against insect have been mainly reported as insecticide, antifeedant, or repellent. In particular, in the last 30 years, a large number of reports showed the repellent effect of the EOs extracted from plants of all continents and against most of the main insect pests. Nevertheless, even if the majority of the reports indicate the EOs as repellents, some EOs have been reported as attractive and some EOs exerted opposite effects on different insect species. In this work, we hypothesized that the attractiveness or repellence of EOs may be due not only to the insect species and to the EO but also to the dose of the EO. For that, we performed an experiment using a two-way static olfactometer and we tested six EOs against the main stored food insect pest *Sitophilus zeamais* (Coleoptera: Curculionidae). The results indicated that most of the EOs tested can exert both attractive and repellent activity depending on the dose. Since EOs contains volatile substances whose concentration vary in time after the application, the implication of these results will be discussed in relation to their possible use as insect repellents or as lures for trapping.

**Key words:** maize weevil, essential oils, bioactivity, insect repellents, lures

## Control effect of an almond and black cumin seed oil mixture towards four stored product pests

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The efficiency of essential oils from the mixture of Almond (*Prinus dulcis*) and black cummin seed oil (*Nigella* spp.) combined with other phytochemicals (garlic, onion, chilli pepper) was tested to assess their enhanced toxicity against the 1-7 days old adults of four stored product pest, *Plodia interpunctella*, *Tribolium confusum*, *Stegobium paniceum* and *Sitophilus granarius*. The plant essential oils were mixed in two combinations (Mix1 and Mix2) were applied in 1ml, 2ml and 5ml on the filter papers inside the jar glasses. 30 adults were placed with approximately 20 ml grain substrate in the 250 ml jar glasses with plastic screw cap. The saturated filter papers were fixed on the screw cap. Mix1 and Mix2 with 30 insect adults placed in climatic chambers for an exposure time of 24h, 48h, 72h, 96h and 120h under two different climatic conditions, 20°C and 25°C. Each concentration was replicated 3 times. It was shown that the toxicity effect of essential oils mixtures was increased against stored product pests. According to the results obtained from present study insects mortality increased with increasing concentration levels and exposure times. *S. granarius* and *S. paniceum* were more sufficient than *P. interpunctella* and *T. confusum* after 120h exposure time. The highest mortality was achieved with 5ml of Mix1 and Mix2 after 120h at all species (>80%). The present study suggests that essential oils mixtures in combinations with other phytochemicals have the potential to apply as alternative to synthetic toxic chemicals in stored product protection.

**Key words:** phytochemicals, oil, almond, cumin, stored, toxic



## **SESSION 8**

### **Wood-boring, urban and museum pests**

## Uninvited Guests in Museums – Management of Wood Worms and Clothes Moths

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Furniture beetle (*Anobium punctatum*) and clothes moths (*Tineola bisselliella* and *Tinea pellionella*) are economically most important pests on wooden artefact or textiles in museums. Their management is essential to protect cultural ethnological heritage and natural history collections for future generations. Pest management strategies have changed over time. Today, intensive knowledge on material science and overall pest biology are key cornerstones in IPM concepts - also for the museum environment. Early detection and identification of pathways of infestation are important first steps for sustainable pest management. Followed by physical and biological means of control, which have gained more importance than applying biocides. This keynote presentation will summarize current concepts of pest life cycle intervention by following good quarantine, general physical and very specific biological measures. The lessons learned from recent faunistic surveys and behavioral studies on predators and parasitoids of wood worms and clothes moths may soon supplement the pest management toolbox.

**Key words:** *Anobium punctatum*, *Tineola bisselliella*, *Corynetes caeruleus*, *Apanteles carpatus*, *Baryscapus tineivorus*, museum pests

## Coating technology to preserve bread-made museum collections against *Sitophilus granarius*

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Italian cultural heritage includes a huge number of local creations that reflect the tradition of a specific territory. Bread-made artifacts are the products of an ancient creative tradition in some parts of Sardinia (Italy). The cultural heritage linked to these objects is endangered by several stored product pests including *Sitophilus granarius* (L.). The aim of this work was to evaluate the potential for the coating technology to protect bread-made artifacts from insect attack. A nanocomposite coating and an active coating were prepared, and the coated objects were characterized in terms of optical, mechanical, and insect-resistant properties. Laboratory tests showed that the nanocomposite coating was the most effective for preventing the *S. granarius* attack, with no damages detected on the samples. The approach proposed here could be successfully extended to other art objects (e.g., museum collections) susceptible to insect damages.

**Key words:** active coating, cultural heritage protection, stored-product pests, granary weevil, bread-made artefact

## Biological control of wood destroying beetles with *Spathius exarator*

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Biological control using beneficial organisms is known in agriculture for decades and now getting more important in Integrated Pest Management. An efficient strategy in fighting the furniture beetle *Anobium punctatum* is based on the parasitoid *Spathius exarator*. This wasp parasitizes the beetle larvae by piercing its ovipositor through the wood followed by oviposition. After devouring and killing the host, the wasp pupates and hatches as adult through a self-gnawed 0.5mm-hole. Thus, each new *S. exarator* hole is equivalent to one killed beetle larva. As the wasp holes clearly can be distinguished from the 2mm-hole of *A. punctatum*, we are able to observe the treatment success. Until now, we successfully released *S. exarator* into more than 110 *A. punctatum* infested objects. At least twelve treatments within three years were performed. On exactly defined areas, new exit holes of *A. punctatum* and *S. exarator* were counted and parasitism rate was calculated. We present pooled data of 50 *A. punctatum* infested buildings, treated and monitored up to six years. In these objects, parasitism rate increased significantly, thus declining hatching success of *A. punctatum*. Laboratory experiments showed that *S. exarator* also parasitizes larvae of the powderpost beetle *Lyctus brunneus* and small larvae of the house longhorn beetle *Hylotrupes bajulus*. Hence, *S. exarator* might be a candidate to control these wood pests as well.

**Key words:** biological control, cultural heritage, furniture beetle, parasitic wasp.

## Tropical woods and the West Indian drywood termite *Cryptotermes brevis*

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The importance and impact of invasive species are usually considered based on their economic implications, particularly the direct damage that they cause. The West Indian drywood termite *Cryptotermes brevis* (Walker) is an example and is a concern in structural lumber, furniture, and other wood products. Despite its importance, its tropical wood preferences and the wood physical and chemical characteristics contributing to resistance were little studied. Here, we developed wood testing units to allow the X-ray recording of termite colonization and then subsequently tested tropical wood resistance to the termite through free-choice and no-choice bioassays using these wood testing units. The relevance of wood chemical characteristics, and wood density and hardness as determinants of such resistance was also tested, as was termite mandible wear. The wood testing units used allowed the assessment of the termite infestation and wood area loss, enabling subsequent choice bioassays to be performed. While pine (*Pinus* sp.), jequitiba (*Cariniana* sp.) and angelim (*Hymenolobium petraenum*) exhibited the heaviest losses and highest infestations; cumaru (*Dipteryx odorata*), guariuba (*Clarisia racemosa*), and purpleheart (*Peltogyne* sp.) showed the lowest losses and infestations; courbaril (*Hymenaea courbaril*), eucalyptus (*Eucalyptus* sp.), and tatajuba (*Bagassa guianensis*) exhibited intermediary results. Wood hardness and in particular wood density were key determinants of wood resistance to the termites, which exhibited lower infestations associated with greater mandible wear when infesting harder high-density wood.

**Key words:** wood preference, wood resistance, mandible wear, termite choice, invasive species



## **POSTERS**

**SESSION 1: Physical, chemical and other techniques for  
stored product pest control**

**SESSION 2: Pest management in the food industry**

## Effect of barley and buckwheat grain processing on the development and feeding of the confused flour beetle

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The consequences of pearling and cutting (barley *Hordeum vulgare* L.), and roasting and cutting (buckwheat *Fagopyrum esculentum* Möench) on the development and food consumption of the confused flour beetle *Tribolium confusum* J. du Val. were studied. The factors affecting the increase in the *T. confusum* population, and food consumption effectiveness (the proportion of wasted food in the whole amount of the used product) were different in barley and buckwheat. The best barley product for *T. confusum* was the flour. The population number, the proportion of imagines, and the effectiveness of food consumption were relatively high for cut groats, compared to whole barley. The toughness of the whole groats was most likely the cause of the lowest suitability of this product for the confused flour beetle. Neither the size of the cut groats nor the pearling of barley had any effect on *T. confusum* development and food consumption effectiveness. The best buckwheat product for *T. confusum* was the whole hulled non-processed groats. In these groats, the total population number, the proportion of imagines, and the effectiveness of food consumption were relatively high compared to cut groats. The total population number was the lowest in the steamed groats. The decrease in nutrients and B vitamins due to the removal of the embryo and aleurone layer during the breaking process of buckwheat, was possibly the main factor affecting *T. confusum* development and food consumption in buckwheat.

**Key words:** *Fagopyrum esculentum*, *Hordeum vulgare*, *Tribolium confusum*, storage

## **Insecticidal efficacy of commercial formulations of diatomaceous earth and neem oil against *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae) on stored sorghum**

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Residual insecticides are widely used to protect stored grain in Brazil against insect pests. On-farm and in large storage units, increases the frequency of control failures and, consequently, increases the demand for protection alternatives, especially for sorghum, due to few insecticides' registries. The objective of this work was to evaluate the efficacy of formulated products based on the neem oil and diatomaceous earth (DE) on *Sitophilus zeamais*, relative to the efficacy of residual insecticides, and estimated the losses by infestation. Adults of *S. zeamais* were expose to sorghum grains sprayed with nine different insecticides at different doses and mixed with DE on two doses for 10, 30 and 110 storage days. The pirimiphos-methyl on both doses and mixture with bifenthrin had 100% mortality in the three storage periods. DE was efficient in the control of *S. zeamais*, with mortality higher than 94% after 10 days of storage on both doses. Neem oil formulated products had 51% maximum mortality at 10 days and decline to 110 days of storage. The maximum percentage of grain loss was 21.7% after 100 days of storage on grains treated with neem oil formulated product, while the lowest grain loss was in the grains treated with pirimiphos-methyl. Treatments with higher percentages of losses showed lower mortality with poor protection of sorghum grains. Application of a DE product is an alternative to residual insecticides in the management of stored grain pests in sorghum storage.

**Key words:** maize weevil, inert dusts, botanic oils, chemical control, grain storage

## The development of *Ephestia cautella* (Lepidoptera: Pyralidae) under different temperature regimes

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Almond moth, *Ephestia cautella* Walker (Lepidoptera: Pyralidae) is a serious pest of date fruits in store houses responsible for economic losses. The deleterious impacts of insecticides on environment and human health led researchers to search for the alternative *E. cautella* control methods. The use of modified atmospheric conditions to control the infestations of *E. cautella* in date fruits storage structures is a logical potential alternative. In this study, we evaluated the impact of different temperatures such as 20, 25, 28, 30, 32, and 35 °C on the larval development of *E. cautella* in order to find suitable temperature that can protect date fruits from almond moth infestations. Our results showed that different temperatures exhibited different times to complete larval development. We recorded 106, 104, 80, 61, 92 days to complete until fifth instar larvae at 20, 25, 28, 30 and 32 °C, respectively. However, the highest temperature (35 °C) used in the current study greatly disturbed the larval growth resulting the death of all larvae during their second instar. In conclusion, the high temperature tremendously disturbed the larval growth and might be effectively used to control *E. cautella* infestations in storage structures of date fruits.

**Key words:** abiotic factors, date palm pest, eco-friendly, storage, temperatures

## The tolerance of external (*Plodia interpunctella*) and internal (*Sitophilus oryzae* and *S. zeamais*) grain feeders to high temperatures

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One of the most promising biorational pest management practices for seed protection is the application of high temperatures (heat treatments). It is a hundred-year-old technology, effective for disinfesting stored commodities from insects, primarily in bins and grain-processing facilities. The aim of this work was to determine the heat tolerance of three most important polyphagous seed pests, external grain feeder - larvae of *Plodia interpunctella* Hübner, and internal grain feeders – adults of *Sitophilus oryzae* L. and *S. zeamais* Motschulsky. The insects were subjected to high temperatures (35, 40, 45, 50, 55, 60 °C) in different exposure periods (0.5, 1, 2, 3 and 6 h), both in seeds and without seeds. 34% mortality of *P. interpunctella* larvae was achieved at 40 °C after 6 h, when exposed without seeds while at 45 °C, total mortality was registered after 30 min. Significant mortality (80%) of *S. oryzae* in maize seeds was achieved after 30 min at 45 °C, while the total mortality (100%) at this temperature was reached after 1 h. Without seeds, the mortality of *S. oryzae* at 40 °C was 31% after 3 h, while at 45 °C it ranged from 79% up to 100% (after 1 h and 3 h, respectively). At 50 °C, 30 min exposure caused total mortality. Temperature of 45 °C caused paralysis of 53% and mortality of 7% of tested *S. zeamais* population in seeds, at short exposure (up to 1 h), while after 2h, 93% mortality was recorded. At 50 °C, all weevils died after 30 min. Without seeds, at 45 °C after 30 min the mortality was 40%, while 38% of *S. zeamais* weevils were paralyzed and all died after 1 h. Our results indicate that for treating empty storages, shorter exposure is sufficient, while for treating seed bulks, higher temperature or longer exposure is needed. *S. oryzae* was more tolerant to high temperatures.

**Key words:** high temperatures, heat tolerance, *Plodia interpunctella*, *Sitophilus oryzae*, *Sitophilus zeamais*

## Effective light device for trapping stored products pyralid moths

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Although laboratory studies have demonstrated that UV-LED attracts Indian meal moth *Plodia interpunctella* and tobacco moth *Ephestia elutella*, they are seldom caught by commercial light traps equipped with a black light fluorescent tube (BL). Our study was conducted to eliminate this inconsistency and to support trap device improvement. The predominant wavelengths emitted by BL and UV-LED are almost equal, i.e., 360-370 nm, but the directivity of light emitted from each device differs greatly: the light from BL disperses in all directions, whereas the light from LED is highly directional; and the LED intensity decreases sharply according to the distance from the axial center. First, we confirmed that UV-LED effects as a trap lure. Both moth species were caught effectively at intensity of  $10 \times 10^{-3} \text{ W/m}^2$  (15 cm distant from LED at the axial center), but the number of catches decreased significantly above that irradiance level. Then the moth behaviors under light exposure were observed. When UV light at intensity of  $10 \times 10^{-3} \text{ W/m}^2$  was irradiated to the active moths for 10 s under dark conditions, the locomotive or flight activities ceased within a minute. These results suggest that UV light induces attraction and interferes with moth locomotion, depending on irradiance. When UV-irradiance on the prospected flight paths to the sticky surface of a trap is kept below approximately  $10 \times 10^{-3} \text{ W/m}^2$ , these pyralid moths can be caught using a light trap.

**Key words:** *Plodia interpunctella*, *Ephestia elutella*, light trap, UV-LED, irradiance

## Ozone efficiency in insect suppression

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Insect infestation within stored product facilities is a major concern to the animal and human food industry. Insect infestation in storage systems can result in economic losses of up to 9 till 20%. Furthermore, the presence of insects and their remains in grain and stored food may pose a health risk to humans and livestock. At present, pests in commercial storages are managed by a combination of different methods ranging from cleaning and cooling to treatment of the stored material with contact insecticides or fumigation. The available pesticides for treatment of grain and other stored products are decreasing owing in some cases to environmental and safety concerns among consumers and society, thus emphasising the need for alternative pest control methods. One of the potential methods is the use of ozone. Although the mechanism of action of ozone on insects is not completely known, the insect's respiratory system is a likely target. The main goal of our investigation was to determine efficacy of ozone in suppression of different insect pests. The investigation has been conducted on seven different insect species which were in different growing stages (adults: *Sitophilus granarius*, *Blatta lateralis*, *Blaptica dubia*, *Gryllus campestris*; larvae: *Pachnoda sinuata flaviventris*, *Tenebrio molitor* and *Zophobas morio*). Variants in the experiment were different durations of ozone exposure. In addition of ozone toxicity, the waking response and speed of *Sitophilus granarius* were investigated. The results shown the harmful effects of ozone on insects. The maximum efficiency of ozonation was found in insects where adults have been treated and a very small and no efficacy was found in the treated larvae. In addition to mortality ozone has negative effect on the mobility and insect speed as well. Ozone efficiency increases with increasing ozone exposure. The results of this investigation suggest that ozone has the potential to become a realistic choice in suppressing harmful insects in storage systems for human and animal nutrition, either alone or as a complement to other methods.

**Key words:** storage pests, ozone, ozonation, mortality, efficiency

## The effects of grain cleaning on the development of *Sitophilus oryzae* infestation

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It is known that grain cleaning makes it possible to fight against secondary pests. Indeed, at the same time as impurities are removed, aspiration and screening of the cleaner are helpful to remove insects from grain. However, immature stages of primary pests like *Sitophilus oryzae* hide inside kernels so they can't be separated from the grain this way. Previous studies have shown that mechanical disturbance of infested grain may prevent immature stages from developing successfully, especially when the physical stress is carried out regularly. That's why we have studied the effects of grain cleaning on *S. oryzae* depending on the cleaning frequency applied during an 8-week treatment. We have monitored adult densities in mini storage silos filled with 290 kg of infested soft wheat and cleaned once every two weeks, once or twice a week, three times a week or never cleaned. A regular sampling has also been done and grain samples have been incubated during 6 weeks in order to measure the emergence rate in each silo. The results demonstrate that a grain cleaning carried out twice or three times a week prevents a dramatic growth of adult beetles in the silo and it reduces emergence of *S. oryzae* by more than 90%. One cleaning per week shows an intermediary efficacy with a 70% decrease of emergence compared to uncleaned silos. Only one cleaning every two weeks nevertheless seems insufficient to control pest development under the ambient conditions of this study which were favourable for insects.

**Key words:** *Sitophilus oryzae*, rice weevil, grain cleaning, mechanical disturbance, insect mortality

## The effect of time's exposure and thickness of material on efficacy of microwave energy in some different stages for some storage insects

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Dates artificially infested with eggs and larvae of *Ephestia cautella* and corn seed artificially afflicted with *Sitotroga cerealella* have been exposed to Microwave 1000 Watt at different exposure time (0, 20, 25, 30, 35, 40, 45 seconds). The results have indicated that the Microwave has high capacity on killing eggs and larvae of *E. cautella* and *S. cerealella*; besides this effect gets increased by increasing the exposure time. Ratio of killing eggs reached to 92% and 100% during time of exposure 40, 45 seconds consequently, in comparison with 23%, 38% at exposure time 20, 25 seconds. The results have not indicated the spiritual differences in ratios of killing when dates arranged with one layer or two layers when being exposed to ray. In respect to larvae processing, the percentage of killing reached to 93%, 97% during exposure time 40, 45 secs consequently in comparison with 20%, 35% at exposure time 20, 25 secs. In treatment of the larvae, results indicated that mortality was 93%, 97% at 40, 45 secs exposure time compared with 20%, 35% at 20, 25 secs exposure time. In respect to corn seeds, mortality of larvae of *S. cerealella* was 97% at 45 secs exposure time compared with 34%-36% at 20 secs exposure time. Results have not indicated to any effects on germination of corn seeds. Results have explained that the efficacy of microwave on controlling *E. cautella* that afflicted stored dates played as an alternative method for Methyl Bromide in stored corn seeds.

**Key words:** microwave, control, dates, *Ephestia cautella*, *Sitotroga cerealella*

## **Insect laser - optical detection and control of stored product insects pests with laser beams**

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Stored product insects may be found in a given premise for different reasons they can come with infested materials; they could have developed in unattended areas of the building or may have entered from the outside. In any case it is worth while to determine the cause why insects can be found inside a storage or food processing facility in order to reduce the frequency of insects as potential contaminants of food. In a project, we test a mobile camera system, scanning surfaces in storage warehouses or food processing industry storages. If insects are detected by the camera system, they are compared with morphological background data to decide if the detected insect is a target pest. In case a target pest is determined with high probability, a laser beam is then directed to the target to eliminate the insect by heat. The concept was to develop a system that is able to learn and identify more and more different species over time. First aims of the project were to improve reliability of species detection and identification in contrast to the grain and other surfaces. Tests were done with two insect model species, the grain weevil *Sitophilus granarius* (Col., Curculionidae) and Indianmeal moth *Plodia interpunctella* (Lepid., Pyralidae). Further the project investigated two laser beam wavelengths in different intensities, not damaging surfaces and surrounding elements. This system could be utilized in the future, to support IPM in well-sealed structures for storage or processing of food and feed stuffs.

**Key words:** camera, insect surveillance, light, laser, *Sitophilus*, *Plodia*

## Preliminary tests of spinosad for grain treatment against stored product pests in Russia

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Results of laboratory bioassays with spinosad formulation Spintor 240, SC for pre-stored treatment of wheat grain, *Triticum aestivum* L., against adults of grain weevil, *Sitophilus granarius* L., rice weevil, *Sitophilus oryzae* L., and confused flour beetle, *Tribolium confusum* J. du Val. are presented. Spinosad was applied at the rates 1 and 10 ppm. Untreated grain was used as a control. The experiment was carried out in triplicate. Mortality was assessed after 1, 3, 7, 9, 14 days (d) post exposure. Spinosad at the rate 1 ppm caused 17% mortality of *S. oryzae* and 40% mortality of *S. granarius* after 14 d. Spinosad at the rate 10 ppm achieved total mortality of *S. granarius* and *S. oryzae* after 7 d. Adults of *T. confusum* were found more resistance to spinosad. The highest mortality (20%) of *T. confusum* was recorded after 9 d at the rate 10 ppm. Spinosad at the rate 1 ppm did not lead to any mortality of *T. confusum* after 14 d.

**Key words:** spinosad, grain, *Sitophilus granarius*, *Sitophilus oryzae*, *Tribolium confusum*

## **Controlled atmospheres to control an internally feeding stored product pests *Sitophilus granarius* and *Callosobruchus chinensis***

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Currently there is a globally increasing pest resistance to the fumigants containing phosphine as an active ingredient. Modified and controlled atmospheres are considered to be vital alternatives to this type of pesticides. This work presents laboratory data on efficacy of nitrogen atmosphere on two Coleoptera species pests, internally developing inside either cereal or legumes grains. Tests were conducted in thermostatically controlled N<sub>2</sub> device that consisted of series of small plastic boxes (Lock and Lock HPL834, 2600 ml) in which tested pests and their developmental stages were exposed. These boxes were connected by transparent plastic (PVC) hoses. Nitrogen (i.e. atmosphere with almost 100% N<sub>2</sub>) was delivered from a pressurized metal cylinder (Linde Gas a.s.; Czech) using a C200/2B-3SS outlet valve (Linde Gas a.s.). The results of biological efficacy of differential exposures (i.e. different periods of time) to pure nitrogen on various developmental stages *Sitophilus granarius* and *Callosobruchus chinensis* will be presented.

*The work supported from Project No. MZE - RO0418.*

**Key words:** stored products, pests, nonchemical control, modified atmospheres, nitrogen

## Average cooling availability for grain aeration in France over the last 20 years

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Grain aeration with ambient air is the primary method used in France to maintain grain quality during a long storage period. Its success depends on the number of hours where ambient air is suitable to cool grain. Fan aeration is usually processed in three steps, from the harvest (July) to the early winter (January). Using temperature measurements made on 369 French weather stations between 1997 and 2016, we calculated the number of grain bins where can be properly achieved the three successive temperature targets: 20°C, 12°C and 5°C. We assumed that specific doses were respectively 1000 m<sup>3</sup> air/m<sup>3</sup> grain for the first aeration stage, 1400 m<sup>3</sup> air/m<sup>3</sup> grain for the second one and 1800 m<sup>3</sup> air/m<sup>3</sup> grain for the third one. Calculations have been made using four specific flow rates (4, 8, 12 et 16 m<sup>3</sup>.h- 1.m-3), assumed to be representative of the equipment in French silos. Results have been mapped by interpolation between the 369 weather stations. Maps reveal that the first temperature target (20°C) is achieved before the 15/09 everywhere in France including for the lowest specific flow rate, except in the extreme South. For the second and third temperature targets (respectively 12°C and 5°C), an East-West gradient is observed. For instance, with a 4 m<sup>3</sup>.h-1.m-3 flow rate, the 5°C target can't be achieved before the 15/01 in a broad area from Brittany to South-West of France. By contrast, in the North-East area of France cooling grain with ambient air is easier, even with low flow rate.

**Key words:** grain aeration, climate, map, aeration strategy, simulation

## Is Indian meal moth good at playing “oviposition-darts” when searching for holes in fruit bar packages?

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This work evaluated the effect of package perforations or micro-injury on the consequent infestation of cereal-fruit bars by the eggs of *Plodia interpunctella*. It was measured the “targeting” of oviposition by individual moth females on the (1) unpackaged bars, (2) empty packages, (3) bars in packages and (4) bars in perforated packages in laboratory experiments. Almost 100% of the laid eggs were laid directly on the bars when they were placed in the enclosure without packaging while few of the eggs were laid on either the empty or non-perforated polypropylene foil packages. However, 5 mm package perforations enabled *P. interpunctella* efficiently located and infested the bars with eggs. The most important practical conclusions of this study are that even small perforations enable the moth to precisely target egg oviposition to the damaged fruit bar.

*The work supported from TACR - TH02030215.*

**Key words:** food, stored products, risk assessment, infestation, moths, oviposition.

## Assessment of different traps and attractants in three processing facilities in Central Greece

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In this study, we evaluated all combinations of different trap types and attractants in three processing facilities in Central of Greece, on the capture of stored product insects. Trapping was carried out from June to December of 2018. The traps used in our experiments were Dome Trap (Trécé Inc.), Wall Trap (Trécé Inc.) and Box Trap (Insects Limited Ltd.) in all facilities. The attractants that were used in our experiments were: a) 0.13 g of PantryPatrol gel (Insects Limited Inc.), b) oil-based kairomone food attractant (Storgard Oil, Trécé Inc.), c) 0.13 g of wheat germ (Honeyville), d) 0.13 g of Dermestid tablet attractant (Insects Limited Inc.) and e) “control”, without any attractant. In the Facility 1, the traps were replicated two times, whereas in the Facilities 2 and 3 the traps were replicated three times for each trap-attractant combination. All samples were transferred to the Laboratory of Entomology and Agricultural Zoology for identification and counting. In total, 11,732 insects were collected in all three facilities, with 227, 203 and 148 trap-checks for Facilities 1, 2 and 3, respectively. In Facility 1, the most abundant species were *Plodia interpunctella*, *Rhyzopertha dominica*, *Sitophilus granarius*, in Facility 2 it was *Lasioderma serricorne*, *Tribolium confusum* and *S. granarius* and while in Facility 3 it was *T. confusum*, *Latheticus oryzae* and *L. serricorne*. Furthermore, *Trogoderma* spp. was reported in all facilities at certain trapping periods. Our data show that there were trap and attractant combinations that were superior to others, but this changed according to the target species. This study will be continued in 2019 in order to better understand specific trap and attractant combinations that can be adopted for multi-species capture in a wide range of storage facilities and microclimates.

**Key words:** storage facilities, traps, attractants, stored-product insects, Greece

## **Efficacy of modified atmospheres on *Trogoderma granarium* and *Sitophilus zeamais***

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We investigated the efficacy of two types of modified atmospheres (MA) against adults of the khapra beetle, *Trogoderma granarium* Everts (Coleoptera: Dermestidae) and the maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) under laboratory conditions. Adults of the above species were exposed to a carbon dioxide (CO<sub>2</sub>) concentration of 70% or a low oxygen (O<sub>2</sub>) concentration of 0.1% for durations of 0.67 (16 h), 1, 2, 4 and 6d and stored in an environmental chamber set at 28 ± 2°C, 70 ± 5% RH and 16:8 light:dark photoperiod. After each exposure interval, immediate mortality and knockdown were recorded and the surviving or knocked down individuals were transferred to normal atmospheres and returned to the environmental chamber, where survival was recorded 7d later. Additionally, after the immediate and delayed mortality counts, all adults were removed from the substrate, and the number of progeny produced was recorded 60d later. Both MA conditions totally controlled (100% mortality) the adults of *T. granarium* and *S. zeamais* immediately after 6d of exposure, or after a 4d exposure when delayed mortality was taken into account, showing the post-exposure effect of the MA. Moreover, high CO<sub>2</sub> was more effective than low O<sub>2</sub> for *S. zeamais*, while the reverse was true for *T. granarium*. The 4d exposure period was crucial for the production of progeny of both species, because after that period surviving insects did not produce offspring. Our results show that both MA conditions can be used with success to control these species.

**Key words:** modified atmospheres, khapra beetle, maize weevil, carbon dioxide, low oxygen

**Resistance test for different pasta packagings to the massive and repeated attack by *Plodia interpunctella* larvae (Lepidoptera: Pyralidae) and *Sitophilus oryzae* adults (Coleoptera: Dryophthoridae)**

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Pasta infestation discovered by the consumers is often caused by stored-grain pests that manage to enter in the packaged product on the shelves of the retail outlets, breaking through the package wall or passing through existing openings. In this study, 2 types of pasta packages by 3 different brands, with different characteristics in terms of construction material (cardboard, plastic and plastic-coated paper) and presence/absence of micropores, were exposed to the massive and repeated attack by *Plodia interpunctella* (Hbn.) larvae and *Sitophilus oryzae* (L.) adults, in order to evaluate their resistance to penetration. The results showed that packaging with micropores were on average more susceptible to the penetration of *P. interpunctella* and *S. oryzae* compared to those without. The cardboard cases resulted more resistant than the others, while the more susceptible material was plastic-coated paper.

**Key words:** pasta, packaging, stored-food pests, micropores, shelf-life

## **Agricultural Production, distribution and the demands for pesticides in Nigeria**

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The demands of agricultural inputs such as the seedlings, fertilizers, pesticides are all over the world increasing, and our environment is being polluted, one way or the other, while the usage are very important for the Agricultural production and food security of our land, but there must be a guided agricultural policies related to the usage, supply, regulation and policy frame work, so that it can benefit the farmers, our environment, agricultural players at large. While some farmers in the Northern part of Nigeria are into different Agricultural production and which they are facing a lot of problems in respect to preservation, processing, storage facilities and control of pest in some of the harvested crop products and field problems of different diseases. There was a bumper harvest of onion, which was recorded in Sokoto State of Nigeria at this year and farmers does not have enough technology of processing adding value, to meet the demands of the populace. Through our oral interview, pictures taken and field trip with extensive studies. We are able to read some of the daily newspapers to get some information and we also try to find out whether there are guided policy for the usage and we explain too details how Onion's and Bambara are being preserve, processed in the Northern part of Nigeria, which make the farmers to make profit and preserve their Agricultural Produce. Looking at the needs to explore the use of the pesticides in preservation, storage systems for Onions and other Agricultural crops. The key findings show that some of the farmers are using different agrochemicals which are based on the individuals' purposes in storage, preservation and there is no guiding policy to the effect. While Bambara nut were stored either in special coated sacks or pesticide's treated normal sacks, some weevils like those that destroy beans also attack Bambara nut, so to store effectively someone have to be carefully so that the seeds will not damage, which is a seasonally, many people are engaged in the local processing of Bambara nuts. Girls are all involved in the processing, distribution and selling, it is being traded in almost every weekly market in the North. Meanwhile the onion farmers in Nigeria and dealers have made passionate appeals for provision of Morden storage facilities and request for more support from government in the form of soft loans and others such as fertilizer's, pumping machines and pesticides. This paper therefore recommends for simple technology of Onion's and Bambara preservation, processing and suggest that there should be a guided principles, policy for all form of Agro Chemical Inputs usage for economically factors, safety of production, distribution systems, food quality and security, understanding the agronomical principles, social ecological factors towards sustainable agricultural production.

**Key words:** Nigeria, demands, pesticides

## **Microwave technology: post harvest effectiveness on bruchid pests and mites on legumes**

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Attention to food safety has increased with increasingly stringent regulations aimed at reducing the risk of chemical, biological and microbiological contamination of food. A microwave system has been tested to verify their efficiency in the control of some species of insects and mites in the legumes' post-harvesting. The following organisms were treated with different RF powers and exposure times in experimental microwave reverberation chambers: adults and pre-imaginal phases of two common species of stored legumes' insects, *Acanthoscelides obtectus* (Say) and *Callosobruchus maculatus* (Fabricius) (Coleoptera, Bruchidae); eggs and adults of food mites, *Glycyphagus domesticus* (De Geer), *Lepidoglyphus destructor* (Schrank), which grow on bean seeds and chickpea. The control of the matrices after the treatments showed no alteration of their quality. For insects and mites, a mortality rates between 50 and 100% were recorded; this parameter was always higher than 90% by applying the power of 1 kW for 135 sec. In the case of mite treatments, the power of 1 kW for one minute determined the complete mortality of the adults of the two species tested and higher egg mortality on *G. domesticus*, on bean. Furthermore, on the specimens of the mites tested, a preliminary screening was carried on to evaluate the effect of the treatment on the presence of fungal and bacterial colonies.

**Key words:** *Acanthoscelides obtectus*, *Callosobruchus maculatus*, *Glycyphagus domesticus*, *Lepidoglyphus destructor*, microorganisms

## **Carbon nanotube based gas sensors for application in stored product protection**

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The ability to reliably monitor the concentration of gases such as phosphine is essential for safe and economic fumigation operation.

To assess the quality of stored products the analysis of VOCs emerging from the goods give an indication of its condition. To address these measurement requirements, we develop and implement gas sensors based on functionalized carbon nanotubes.

Single-walled semiconducting carbon nanotubes (CNTs) have emerged as a promising active material for highly efficient gas sensors due to their remarkable properties like ultimately high surface-to-volume ratio, quasi-one-dimensional structure, chemical stability and the possibility of doping or functionalization according to a specific application. The very low power consumption of these sensors in the micro-Watt range enable the deployments in mobile and long-term applications. Our sensors can potentially be used as a platform for sensitive and selective gas measurements in many industrial application - including stored product protection.

**Key words:** PH<sub>3</sub>, monitoring, CNT, sensor, VOC

## Assessment of flour beetle *Tribolium confusum* Duv. infestation risk to compound animal feed

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The importance of commercial and small-scale manufactured compound animal feed composition and structure on development and food consumption by the flour beetle *Tribolium Confusum* J. du Val. was investigated. The following feed were examined: commercial feed (for pigs of various ages, goats, cows, and poultry), small-scale manufactured (for pigs) and following meal types: pellets, small grain (< 0.2mm), and flour. Considering the qualitative value of the feed, the feed types prepared for pigs were the most preferred by *T. confusum*. The highest parameters of food consumption and development occurred on small grain and flour kinds of the meal. The highest number of offspring occurred in small-scale manufactured small-grain meals for older pigs and the lowest number occurred in commercial meals for older pigs and poultry. The longest developmental time and the lowest reproduction occurred in *T. confusum* in commercial feed for poultry. However, a significant, ten-fold, increase in food consumption and reproduction occurred when the flour beetle fed upon flour meals instead of pellet meals, independent of their composition.

**Key words:** animal feed, feeding preferences, meal grain size, development

## **Experimental investigations on infestation of grains and seeds recently introduced into Italy by stored product insects**

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The growing demand for healthy foods has recently brought new kinds of products to the Italian market to meet consumers' needs. Currently, quinoa, teff and hemp seeds can be found quite easily in most stores, as whole or broken grains or flour. These products can be susceptible to pest attacks in different stages of the production process: from storage as whole seeds through the transformation phases to the final products ready for consumption. The aim of this work is to verify susceptibility to infestations, even if only temporary, for these recently introduced products, by two of northern Italy's most common stored product pests, known for their high polyphagy: *Tenebrio molitor* L. (Coleoptera Tenebrionidae) and *Plodia interpunctella* (Hübner) (Lepidoptera Pyralidae). Artificial infestation assays were carried out to evaluate the mating and development possibilities for such pests on these grains. The growth rate of larvae, life cycle length and number of individuals which reached the adult stage were also assessed. Insects were obtained from colonies maintained under constant conditions in a climatic chamber (23±1°C and 65±5% R.H.) at the Di.Pro.Ve.S. laboratory. These environmental conditions were maintained throughout all the assays. Insect colonies were fed on commercially available grains. Significant differences as regards the bionomical traits investigated under the above climatic conditions were observed for each species and the different grains.

**Key words:** quinoa, teff, hemp seeds, *Tenebrio molitor*, *Plodia interpunctella*

## **Susceptibility of dried mushrooms (*Boletus edulis*, *Cantharellus cibarius* and *Agaricus bisporus*) to the attack of some storage insect pests (preliminary results)**

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The ability of development of four economically important stored-product insect pests, one lepidopteran (*Plodia interpunctella*) and three coleopterans (*Sitophilus granarius*, *Rhyzopertha dominica* and *Tribolium confusum*) on dried slices of *Boletus edulis*, *Cantharellus cibarius* and *Agaricus bisporus* was observed in laboratory conditions. Into glass jar of 100 ml in volume, 10 g of specific dried mushrooms and 10 beetle adults of the known age or 10 *P. interpunctella* 3th stage larvae were added, in 36 replications per insect species, with 144 replications in total. The experiment lasted for 13 weeks. Every week, all jars were inspected in search for eggs, larvae, adults, feces and other traces of insect activity. Tested dried mushrooms were unsuitable food for *P. interpunctella*, *S. granarius*, and *R. dominica*, which did not complete their development. Our results confirm available literature data – tested mushrooms are highly resilient to the attack of the tested insect species, except to *T. confusum*. This insect survived on *B. edulis*, where the emergence of the 27 new adults was observed in seven out of 12 replicates. The pesticidal activity of *C. cibarius* against some storage insect species is already known. Further investigation of the mechanism(s) of resistance of the mushrooms to the infestation by storage insect pests, could be of significance giving us a potential to discover new sources of harmless natural agents for the protection of stored products.

**Key words:** *Tribolium confusum*, *Plodia interpunctella*, *Rhyzopertha dominica*, *Sitophilus granarius*, dried mushrooms, resistance to infestation

## Storage pests and pest control methods in Ukraine

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Storage pests represent a separate group of pests that causes problems in the whole world. There are as many as 116 species of organisms that damage the grain and its products during storage in Ukraine. The 32 species of them are most common ones, such as Coleoptera - 20, Lepidoptera - 7, Acari - 2, Rodentia - 3 species. There are few kinds of pesticides for control of storage pest that registered in Ukraine. Those are aluminium and magnesium phosphide preparations (phosphine PH<sub>3</sub> liberating) and pyrimiphos-methyl and deltamethrin based insecticides. The goal of our research was to compare the effectiveness of different pest control methods and to develop practical recommendations based on the results of studies, taking into account environmental safety and economic feasibility.

**Key words:** storage pests, grain, research, pesticides



## **POSTERS**

**SESSION 3: Prevention of microflora infection and  
development of mycotoxins**

**SESSION 4: Quarantine and regulatory issues**

**SESSION 5: Biological control of stored product pests**

## Antifungal activity of essential oils against post-harvest wheat pathogen of *Aspergillus sp.*

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The aim of this study is to evaluate the effectiveness of three essential oils of *Cedrus atlantica* M., *Pistacia lentiscus* L. and *Ammoides pusilla* Brot., against *Aspergillus sp.* under *in-vitro* conditions. This pathogen was isolated from durum wheat (var. *Boussalam*) in different culture middle of PDA, CDA and PDAac. Essential oils applied in 3 levels, included 0 (as control), 10 and 20  $\mu$ l. The antifungal activities of these essential oils were evaluated by disc diffusion method on PDA medium. The results showed that four species (*A. fumigatus*, *A. ochraceus*, *A. flavus* and *A. niger*) was identified. The contamination on PDA medium is dominated by the specie *A. flavus*, with  $4.56 \times 10^2$  UF/g, as well as on CDA and PDAac with  $2.93 \times 10^2$  UF/g and  $2.46 \times 10^2$  UF/g, respectively. Furthermore, the average extraction yields of essential oils of *C. atlantica* M., *P. lentiscus* L. and *A. pusilla* Brot., are 1.62%, 0.32% and 0.05%, respectively. The susceptibility of durum wheat pathogens showed that the essential oil of all plants affected the growth of *Aspergillus sp.* Thus, at the dose of 10  $\mu$ l, inhibition zones of *A. niger* and *A. flavus* vary between 17 and 37 mm, respectively; but the mycelial growth of two species, namely *A. fumigatus* and *A. ochraceus* was completely inhibited. However, at the dose of 20  $\mu$ l, we observed the increase of inhibition zones diameter in the other species, and *A. flavus* was totally inhibited. Thus, the MIC showed that *A. ochraceus* was the most sensitive to *A. pusilla* Brot., with 0.1  $\mu$ l/ml., As regards *C. atlantica* M. and *P. lentiscus* L., the antifungal activity was very weak against identified strains. The essential oil of *A. pusilla* Brot., showed a broad spectrum of inhibition and a remarkable antifungal efficacy on *Aspergillus sp.*

**Key words:** antifungal activity, essential oils, *Aspergillus sp.*, durum wheat, post-harvest

## Oviposition deterrent activity of essential oil-based gel formulations against *Plodia interpunctella*

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Essential oil (EO)-based insecticides are attracting the interest of researchers and consumers because these substances are considered not harmful to the environment and human health. Despite the large number of studies aimed to assess the repellent activity towards a series of stored product pests, few of them are addressed to develop new and effective EO delivery methods. EO-based gel formulations were developed and their oviposition repellent activity against the Indian meal moth, *Plodia interpunctella* Hübner was assessed. Three EOs (*Mentha piperita*, *Citrus sinensis* and *Pimpinella anisum*) were firstly GM-MS characterized and then formulated as nano-emulsions. These were used to produce the gel formulations made with Agar and Sodium Polyacrylate. Dual-choice trials were carried out to evaluate the oviposition deterrence under laboratory conditions. Newly mated females were released inside cages containing two oviposition substrates: one activated with the gel formulation and the other, untreated, used as a control. Differently aged gel formulations were tested. The results highlighted the potential of the developed formulation to deter the oviposition activity of *P. interpunctella*. The efficacy of the gel formulation was influenced by its age and the EO used. All the tested EOs are commonly used as food additives, so their integration in IPM programs is likely to be implemented.

**Key words:** indian meal moth, repellency, stored product pests, insecticide formulation, egg laying

## Biological control of *Callosobruchus maculatus* using the parasitoid wasp *Dinarmus basalis*: effects of host fitness

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Food safety is being challenged nowadays as a global concern. Thus, stored-product pest management strategies tend to emphasize the non-chemical aspects of pest control. Consequently, biological control with the use of parasitoids as natural enemies represents a good alternative. Unfortunately, for the correct implementation and success of this sustainable approach, higher management knowledge is required. In this context, the performance of parasitoids is directly related to the quality of the host. For this reason, our work investigated the relationship between *Dinarmus basalis* performances and the fitness of *Callosobruchus maculatus* forth larvae. Fitness was measured as the size and weight of *C. maculatus* forth larvae; while, longevity, parasitism rate, sex ratio and Mean Growth Rate were reported as *D. basalis* performances. Four Regression Equation Models were used. Results showed high positive correlation between *D. basalis* performances and larvae weight of the host *C. maculatus*. Heavy host bodies induced high parasitism rates and sex ratio shifted in favor of females. Moreover, *D. basalis* adults reared on heavy host bodies have a longer life span. Moreover, results showed that being small hosts does not prevent *D. basalis* to achieve acceptable performances. This work demonstrated the ability of *D. basalis* to control and limit *C. maculatus* populations with a parasitism rate reaching 86%.

**Key words:** *Dinarmus basalis*, *Callosobruchus maculatus*, parasitism, host fitness

## **Food Safety Standards positive contribution to Pest Management activities**

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Food Safety Standards like ISO 22000: 2018, BRC, IFS, are providing a general improvement of the quality of Pest Management services introducing a new concept of collaboration between Pest Management operators and client companies in recent years. This process of improvement is slowly going on, but surely the implementation of the UNI EN 16636:2015 Standard (Pest Management - Requirements and skills), a specific certification for Pest Control Companies (PCC), has helped to speed it up. InPEST LAB as a service and technical division of GEA is facing many examples of recent improvement of Pest Management services due to the new legislation. Firstly, a better communication between Food Industry and PCC is developing, at least to work out together the non-conformities that auditors report about Pest Control activities during their inspection visits. Moreover, there is an increasing demand for already certified PCC that hire higher profile operators. There is also a higher necessity of a better knowledge of pests' biology, as well as the toxicological and environmental aspects of biocides. This overall approach lets the PCC develop lower environmental

**Key words:** communication, food safety, improvement, pest management, UNI EN 16636:2015

# Population growth of the lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae) on amylaceous commodities

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The lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae) is a common pest in poultry farms and an often neglected secondary storage insect pest. In the present study, we investigated the population growth of *A. diaperinus* on various grains and relative amylaceous commodities. In a first series of bioassays, intact kernels of hard and soft wheat, barley, oats, rye, maize and rough rice were tested. In a second series of bioassays, we evaluated the influence of the percentage of cracked wheat (0, 5, 10, 25, 50 and 100% cracked soft wheat) on *A. diaperinus* progeny production, whereas in a third series of bioassays the population growth of *A. diaperinus* was assessed in different non-grain amylaceous commodities, i.e. semolina, flakes (rye, oat, barley), brans (wheat, oat) and flours (hard wheat, white soft wheat, whole meal, maize and rice). For all experiments, twenty *A. diaperinus* adults were placed separately in plastic cylindrical vials with 20 g of each commodity and were left at 30 °C and 55% relative humidity. After 30 d, progeny production was evaluated. *Alphitobius diaperinus* was able to reproduce and grow in most of the intact kernels tested. The highest progeny production was recorded in soft and hard wheat kernels and was significantly higher than the respective number of offspring in maize and rough rice kernels. When soft wheat intact kernels were mixed with cracked wheat, more larvae were produced in substrates with more than 25% cracked wheat compared to intact kernels, however, this increase was significant only in the case of 100% cracked wheat. Finally, *A. diaperinus* grew well in all the non-grain amylaceous commodities tested. The highest number of larvae was counted in maize and rice flour, as well as in oat and rye flakes, while the lowest number of offspring was recorded in semolina and white flour. Our findings add some interesting insight on the feeding preferences of *A. diaperinus* and its growth on a broad spectrum of amylaceous commodities.

**Key words:** amylaceous commodities, cracked wheat, food preferences, grains, population growth, lesser mealworm

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## **Food packages invasion by Silvanid and Laemophloeid stored pests: morphological adaptations and climbing abilities**

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*Oryzaephilus surinamensis* and *Cryptolestes ferrugineus* are serious secondary pests of various stored commodities and food products. Despite their general morphological similarity (flattened body shapes typical for invaders), the two species differ profoundly in their climbing abilities on smooth surfaces: *O. surinamensis* is a good climber, but *C. ferrugineus* is not. In our work we tested whether the difference in climbing ability is reflected in a difference in ability to infest packaged food through ventilation/pressure relief holes. To give a proximate explanation of the differences between the two species, we studied (based on scanning electron microscopy) tarsal morphology of the two species. The results of infestation potential and tarsal morphology will be presented.

**Key words:** technology, stored-grain, monitoring, sampling, detection, pests

### ***Acknowledgements***

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**Online identification guide for stored product pests:  
<https://pflanzenschutz.oekolandbau.de>**

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For organic farmers, especially in newly converted or diverse farms, assessing information concerning pest and disease identification and organic regulation options requires large efforts. A user-friendly diagnostic aid for relevant pest organisms in storage and other crops in organic farming is presented (pests diseases and weeds in arable and fruit crops, hop growing). Users can filter information image-based according to storage sites or systematics of pests. Predefined decision paths and microscopic features are avoided. In addition to characteristics of the organisms, it is also possible to filter for larval characteristics, infested products, and then determine them with high-quality images.

**Key words:** storage protection, organic farming, knowledge transfer, diagnosis, decision support tools

## Choosing a suitable sorghum hybrid helps control the maize weevil in the tropic region?

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Sorghum is the fifth most produced cereal in Brazil, with a total production of 1,919.6 thousand tons, in the 2018/19 crop. Widely used in animal feed, sorghum is stored for some months and damaged, especially by maize weevil, *Sitophilus zeamais*. The lack of data about susceptibility of modern hybrids of sorghum to maize weevil may underestimate the potential loss, especially in the tropics. The objective of this study was to identify sources of resistance to *S. zeamais* in sorghum hybrids during storage. The experiments were carried out using glass jars (1.7 L), with about 1.5 kg of 35 sorghum hybrids grains, characterized by water content and specific mass. The jars were infested with 70 adult insects and stored under ambient conditions (January-April). After 100 days of storage, the number of live insects, water content and specific mass were assessed. The weight loss was estimated by data of specific mass corrected by the water content. The experimental design was completely randomized with three replicates for each hybrid and the data subjected to analysis of variance followed by Waller-Duncan test ( $p < 0.05$ ), in addition to correlation analysis. Significant difference in the number of adult *S. zeamais* among the hybrids ( $F_{34,96} = 1.63$ ,  $P < 0.0482$ ) was observed, with hybrids CMSXS3002, 50A50, CMSXS3000 and 1527039, with lower number of live insects after storage. The hybrids with the highest number of live insects were AGN1806, XB6018, BRG37115 and BRS373. Significant and positive correlation was observed between weight loss and number of live insects. Some sorghum hybrids demonstrate greater tolerance to the development of *S. zeamais*, however, in the more susceptible ones, losses can occur over 11.6% in the period of 100 days of storage.

**Key words:** *Sitophilus zeamais*, varietal resistance, tropical regions, *Sorghum bicolor*, grain storage

## Surveying for stored product pests in the South Australian agricultural environment - insights into diversity, sampling design and methodology

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The grains industry in South Australia (SA) is worth \$4.5 billion and predominately export driven. The potential of exotic stored grain pests threatening the industries current market access is high, with several incursions of pests over the last few years. Government and industry funded surveillance programs, aimed at strengthening evidence of absence for exotic stored product pests, ran over two years (2016 to 2018). Over 1000 samples were collected from more than 100 locations throughout SA. This allowed for further examination of the diversity of stored product pests as well as the sampling methodology. Sampling methods included use of pheromone traps, grain sieves and vacuumed samples, sweepings and visual analysis. Sites varied in type and included on-farm storage facilities as well as commercial processors and wholesaler properties. Overall, the surveys were effective in collecting a range of insects, including dermestid beetles (family: Dermestidae); predominately *Anthrenocerus*, *Orphinus* and native *Trogoderma*. Curation of the dermestid specimens into a formal reference collection has led to the availability of a valuable diagnostic tool for researchers and industry. The most common insects found other than dermestid beetles were grain-related Coleoptera adults of *Tribolium*, *Oryzaephilus* and *Sitophilus* species. Results of the surveys are presented and insights into sampling in the outdoor agricultural environment discussed

**Key words:** exotic pest surveillance, market access, dermestids, grains biosecurity, sampling methodology

## **The influence of plant characters on the field infestation and resistance status of certain cowpea cultivars to the lima bean pod borer *Etiella zinckenella* Treitschke and the southern cowpea weevil *Callosobruchus maculatus* (Fabricius)**

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Ten locally produced and imported cowpea cultivars were evaluated to clear the influence of their characters on the infestation caused by *Etiella zinckenella* Treitschke in the field and *Callosobruchus maculatus* (Fabricius) in the store. Certain plant and/or pod characters influenced both infestation in the field and consequently in storage. Cultivars occupied small pods, small and colored seeds with high density plantations showed less infestation by the two pests. The lima bean pod borer *E. zinckenella*, levels of infestation showed a positive highly significant ( $r$ ) between infestation percentage and the yield loss. The resistant and relatively resistant cultivars to *E. zinckenella* were distinguished by the same above mentioned characters. Most of the tested cultivars infested by *C. maculatus* lost 100% of their seeds through 8-9 months post storage. However, the two common locally produced cultivars, Kaha 1 and Cream 7 which recorded low percentages of shattering pods and the lowest mean numbers of field introduced bruchid eggs did not suffer from any weevil's infestation.

**Key words:** *Etiella zinckenella*, *Callosobruchus maculatus*, susceptibility, plant characteristics



## **POSTERS**

**SESSION 6: Methods of pest prevention during storage,  
transportation and handling of stored products**

**SESSION 7: Natural products**

## **New machinery for rapid detection of pests of grain, rice and pulses during a loading process of a new commodity into a store**

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Under favorite conditions stored product pests are able to cause significant injuries and contamination of stored grain. It may result in reduction of grain quality grade which is associated either with penalization or commodity rejection by a customer. To prevent entrance commodity with pests, flour mills and grain elevators execute an initial inspection of each grain lot newly delivered into their facilities in trucks, rail carts, or ships. Although an effective and accurate sampling is the initial step in this inspection process, the grain store operators have limited time-capacity to sample and process (e.g. sieve) large amounts of grain. To speed the sampling process, automatic probes are used. However, it was documented that even the improved procedures, based on discrete sampling and sieving of limited amount of grain from each lot, still do not have high pest-detection sensitivity. Therefore, we proposed a new machinery (based on continuous sampling) for rapid detection of pests of grain, rice and pulses during a loading process into a store. The results of field tests on detection efficacy for different Coleoptera species (*Sitophilus* sp., *Oryzaephilus* sp., *Rhyzopertha* sp.) will be presented. It will be also described the effect of the various amounts of the loaded commodity per time unite on the pest detection sensitivity. The work was partially supported by MZE RO 0418.

**Key words:** technology, stored-grain, monitoring, sampling, detection, pests

## First results on potential insecticidal activity of plant powders of invasive alien plants against rice weevil under laboratory conditions

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In a laboratory experiment we investigated the potential insecticidal activity of powders of 8 invasive alien plants, namely Japanese knotweed (*Fallopia japonica*), Bohemian knotweed (*Fallopia x bohemica*), tree of heaven (*Ailanthus altissima*), Canada goldenrod (*Solidago canadensis*), giant goldenrod (*Solidago gigantea*), staghorn sumac (*Rhus typhina*), stinkwort (*Dittrichia graveolens*), and false indigo (*Amorpha fruticosa*), for controlling rice weevil adults (*Sitophilus oryzae*). For a positive control we used wood ash of Norway spruce (*Picea abies*), which showed high efficacy in controlling the same pest in our earlier experiments. Invasive alien plants were collected in 2018 in the territory of municipality Ljubljana, where they present undesirable plants in uncultivated areas. The first results of insecticidal activity of the leaves (all species), and flowers (Canada goldenrod, giant goldenrod, staghorn sumac) of invasive alien plants, which we test within a project ApPLAuSE (Alien PLAnt SpEcies - from harmful to useful with citizens' led activities), are not very promising.

**Key words:** plant powders, invasive alien plants, rice weevil, laboratory experiment, efficacy

## **Efficacy of *Elaeis guineensis* (Jacq) kernel oil against the bruchid pest, *Callosobruchus chinensis* (L.) (Coleoptera: Chrysomelidae) and two *Aspergillus* species: extraction methods and potency**

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Most farmers in developing countries rely on synthetic insecticides for control of stored products insect pests. Problems of consistent and haphazard use of insecticides: insect resistance; pest resurgence; insecticide residues in foods, hazard to consumers' health and environment have necessitated the search for eco-friendly substitutes globally. Essential oils of some plants had been reported toxic to insect pests and microorganisms. This study screened oil of palm, *Elaeis guineensis* kernel (PKO) extracted by dry-heating, and cold-press for toxicity to *Callosobruchus chinensis* (L.) at 0-1.5ml/25g seed. Viability tests were conducted on treated cowpea seeds to investigate possible phyto-toxic effect of the oils. Fungi-static potential of the oils against storage fungi, *Aspergillus niger* and *A. flavus* was also evaluated. Profiles of biochemical compounds in the oils were obtained using Solid Phase Micro Extraction (SPME) and Gas Chromatography–Mass Spectrophotometry (GC-MS) analyses. The two oils are toxic to adult *C. chinensis*. Toxicity was dose and exposure-period dependent. HPKO was a little more toxic ( $LD_{50} = 0.024$  ml/25g) to the insect than CPKO ( $LD_{50} = 0.03$  ml/25g), causing 100% mortality with 0.5ml at 96 h. HPKO did not inhibit seed germination unlike CPKO which adversely affected seed germination as dosages increased. Hence, HPKO-treated seeds consistently had higher growth qualities than seedlings of CPKO-treated seeds. Non-germinated seeds were covered with *A. flavus*. HPKO inhibited the growth of *A. niger* (0.93 cm) and *A. flavus* (1.27 cm) more than CPKO (0.20 cm and 1.13 cm respectively). Decanoic acid (Lauric acid), a confirmed anti-fungal, was the major component (71.33%) of the fifteen (15) compounds identified in HPKO. CPKO had thirty-seven (37) compounds with U- U-undecanone (34%) as the major constituent followed by decanoic acid (17.90%). The higher percentage of lauric acid in HPKO may accounts for its greater fungi-static potential hence, more effective at preserving viability of treated cowpea seeds than CPKO. The two oils would be useful in developing cheap biocontrol agents against storage insects and fungi thus enhancing safety of consumers.

**Key words:** Bruchid, *Elaeis guineensis*, fungi-static, insecticidal, phytoxicity

## **Bio-Pesticides potentialities of the Algerian Saharian plant *Euphorbia guyoniana* (Euphorbiaceae) against *Tribolium castaneum***

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Superior plants are a diverse source of potent bioactive agents, some of which have significantly contributed to the successful use of natural products in combating arthropod pests. In order to evaluate the bio-insecticidal potential of an Algerian desert plant: *Euphorbia guyoniana*, a study was conducted on *Tribolium castaneum*: red flour tribolium. A crude ethanolic extract was prepared and then tested in the laboratory on the adult stage. Five different doses were tested. The results of the phytochemical study showed that the plant is rich mainly in flavonoids, gallic tannins, alkaloids, saponosides and glucosides. The plant does not present anthocyanins, leuco-anthocyanins, catechins, coumarins and iridoids. For the insecticidal activity, the repulsivity of the extract at a dose of 700 µg / is low, it is 33.33 ± 23.09%. According to the percentages ranking of McDonald *et al.* (1970), the extract of this plant is classified in the 2nd class. The extract of this plant proved toxic against the adults of this insect, the mortality of 100% was reached after 48 h with the highest dose (700 µg / insect). The LD50 obtained at the shortest time (6 hours after treatment) is of the order of 169.82 µg / insect. The extract of this plant did not inhibit the AChE activity of the adultes tested, this result suggests that this plant does not have a neurotoxic effect on the *Tribolium*. The encouraging results obtained with the extract of this plant suggest the possibility of the use of metabolites of this plant for the formulation of plant bio-pesticides.

**Key words:** *Euphorbia guyoniana*, *Tribolium castaneum*, toxicity, crude extract

## **Fumigant toxicity of some essential oils against the eggs of cowpea weevil, *Callosobruchus maculatus* F. (Col.: Bruchidae)**

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The cowpea weevil, *Callosobruchus maculatus* F. (Col.: Bruchidae), is a major pest of stored grains in tropical and subtropical regions of the world. Application of chemical agents is the main method for protection of grains, but the environmental and health problems of chemical insecticides has led to search for alternatives for grain protection. In this study, fumigant toxicities of the essential oils extracted from *Pelargonium roseum* L., *Ferula gummosa* Boiss., *Cuminum cyminum* L., *Carum carvi* L. were assessed on eggs of *C. maculatus*. Ten mung beans each containing a one-day-old egg of *C. maculatus* were placed in a 27ml container with screw cap. Filter papers (1 cm diameter discs) were impregnated with various concentrations of oils. Then the discs were attached to the vial caps. Each dose was replicated five times. After 24h the filter papers were detached and the containers were maintained in laboratory condition (27±2°C, R.H.65±5% and dark condition) for 7 days. Then egg mortality was assessed by counting the number of unhatched eggs. All tested essential oils showed effective fumigant activities against eggs of *C. maculatus*. Calculated LC<sub>50</sub> values for eggs were 19.04, 5.56, 17.00, and 8.12 µL\*L<sup>-1</sup> air for *P. roseum*, *F. gummosa*, *C. cyminum*, and *C. carvi* essential oils, respectively. According to the results, essential oils of *F. gummosa* and *C. carvi* caused the most mortalities on the eggs of *C. maculatus*.

**Key words:** botanical insecticide, caraway, cowpea beetle, grain, mortality

## **Fumigant potential of Tunisian *Mentha pulegium* L. essential oil against *Tribolium castaneum* (Herbst) and impact on flour quality in storage period**

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In Tunisia, cereal grains are the most important basis of food and they constitute a major source of energy of high biological value, roughages and vitamins. Insect pests present a major threat for the food security. Worldwide, 10 to 20% of all grain produced is lost due to stored product pests before it attains the consumer. The control of these pests in storage mainly depends on synthetic fumigants. Nevertheless, they cause damage to human and environmental health. These problems have highlighted the need for the development of safer alternatives. Our study was conducted to determine insecticidal activity of essential oil from *Mentha pulegium* (L.) against *Tribolium castaneum* (Herbst) adults and impact on wheat flour quality in the flour mills conditions. Insect mortalities, occupation space conditions, and wheat flour quality were investigated after 1 and 2 months of storage period. The results of GC/MS analysis showed that p-Menthone (35.66%), Pulegone (39.15%) and Piperitone (3.55%) were the major compounds of the oil. Furthermore, the lethal concentration of *M. pulegium* essential oil used for the trial under industry scale was screened and corresponds to 196.6 µl/l air. In fact, results revealed that mortality depends on two parameters which are occupation space and storage duration. The strongest mortality rate corresponds to 50% of occupation space with 32.78% and 72.22% for one and two months of storage respectively. In addition, physicochemical characteristics were investigated on treated wheat flour on evaluate its quality. This study demonstrated that the optimizing of the occupation space and the storage period parameters could contribute to the success of *T. castaneum* management under mill environment.

**Key words:** *Tribolium castaneum*, *Mentha pulegium*, wheat, occupation, quality

## **Efficacy evaluation of *Mentha piperita* essential oil against *Rhyzopertha dominica* and *Sitophilus zeamais* adults**

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Pest infestation causes quantitative and nutritional loss to the stored commodity. *Rhyzopertha dominica* F. (Coleoptera, Bostrichidae) and *Sitophilus zeamais* Motschulsky (Coleoptera, Curculionidae), are notorious pests of maize and other cereals. The current pest management strategy relies on chemical pesticides. The indiscriminate and irrational use of chemicals in stored grains raises global food safety concerns. In a bid to find eco and human friendly alternatives to pesticides, plant essential oils have been tried against several storage pests at laboratory level. The present study is aimed at evaluation of insecticidal efficacy of *Mentha piperita* essential oil (EO) against *R. dominica* and *S. zeamais* adults. The comprehensive two-dimensional gas chromatography with flame ionization detector was employed to understand the chemical composition of *M. piperita* EO. The analysis revealed preponderance of menthol (38.5%) and menthone (18.2%) over other components. The mortality of two pests was monitored with EO concentration from 15 µg/cm<sup>2</sup> to 250 µg/cm<sup>2</sup> over 72 h. The EO was found to be toxic to model pests with LC<sub>50</sub> values of 48 µg/cm<sup>2</sup> and 92 µg/cm<sup>2</sup> at 72 h of exposure time for *R. dominica* and *S. zeamais* respectively. Investigation on the effects of EO applications on selected gene expression level is in progress. The research findings indicate the insecticidal potential of *M. piperita* EO to protect grains from *R. dominica* and *S. zeamais* infestation.

**Key words:** maize pests, stored grain protection, menthol, gas chromatography with flame ionization, contact toxicity

## Sour cherry postharvest quality as affected by biopolymer and wild oregano essential oil

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In order to preserve fruit quality of sour cherries (cv. Újfehértói Fürtös) for fresh consumption and prevent losses due to rots occurrence, fruits were post harvest treated with wild oregano (*Origanum vulgare* L.) essential oil (EO) in concentrations 0.05, 0.1 and 0.25% v/v. EO was applied either as water emulsion (EOW) or as an emulsion in edible biopolymer (EOBP) consisted of 1.0% (w/v) chitosan in water. Additionally, the amount of 1.0% and 5.0% (w/v) gelatin (type B) was added to initial polymer solution. Fruits were immersed in prepared emulsions followed by air drying, and cold stored either at 0 °C, relative humidity 90% for 14 days or at room temperature (21 ± 2°C) for 7 days. The untreated and fruits immersed in biopolymer only were used as control. Fruit analyses were performed at three points: after 14 days in cold storage (14 + 0), after the additional 7 days at room temperature (14 + 7) and after 7 days storage at room temperature only (0 + 7). Analyses included skin strength and elasticity, activity of enzyme superoxid dismutase (SOD) and intensity of lipid peroxidation. Both at 14 + 7 days in storage and 0 + 7 days at room temperature, weight loss was increased by EOW while reduced by EOBP treatments. The higher incidence of pitting, intensity of lipid peroxidation and SOD activity was detected in fruits treated with the EOW. Biopolymer itself decreased the incidence of pitting compared to the untreated control. In order to decrease fruit weight loss and pitting incidence in sour cherry fruits during storage biopolymer only could be effective solution.

*The research presented in this article is part of project No. TR-31038 supported by Ministry of Education, Science and Technological Development of the Republic of Serbia.*

**Key words:** chitosan, essential oils, oregano, quality, sour cherry

## **The efficacy of HCN and ethanedinitrile on stored product and phytoquarantine pests and their penetration through thick wooden blocks**

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There is a still continuing search for alternatives to methyl bromide for fumigation treatment of commodities and wooden packages during the international trade. Currently there are two candidate fumigating active ingredients (HCN; ethanedinitrile) and commercial preparations (EDN<sup>®</sup> and Bluefume<sup>®</sup>) produced in Czech Republic. The biological activity of the two fumigants on *Trogoderma granarium* and Cerambycid beetles will be presented. The penetration ability of EDN and HCN through thick wooden blocks will be described.

*The work supported from TACR - TH02030329.*

**Key words:** HCN, EDN, fumigation, wooden packages; commodities, phytoquarantine pests

## **Valorization of the crude plant extract of the Saharan plant *Cotula cinerea* in the biocontrol of the red tribolium of the flour *Tribolium castaneum***

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Recent research has identified chemical compounds with insecticidal and insect repellent activity derived from plant species based on an exhaustive literature review of 1965 references (from 1923 to 2010) and using scientific databases (Sciencedirect, Springerlink and Wiley, 2010), chemistry databases (Amicbase, 2010, Duke, 2010), botanical databases (Tropicos, 2010) and books. Identifying the synergies between different compounds, or natural constituents of plants, can lead to the development of powerful insect control agents (pest or vector). In order to evaluate the bio-insecticidal potential of an Algerian desert plant: *Cotula cinerea* a study was conducted on *Tribolium castaneum*: the red flour tribolium. A crude ethanolic extract was prepared and tested in the laboratory on adults of this species. Five different doses were tested (50, 100, 250, 500 and 700 µg/insect). The results of the phytochemical study showed that the plant is rich mainly in flavonoids, gallic tannins, alkaloids, saponosides and glucosides. The plant does not present anthocyanins, leuco-anthocyanins, catechins, coumarins and iridoids. For the insecticidal activity, the repulsivity of the extract at a dose of 500 µg /adult is low, it is  $26.66 \pm 11.54\%$ . According to the percentages ranking of McDonald *et al.* (1970), the extract of this plant is classified in the 2nd class. The extract of this plant proved, on the other hand, toxic for the adults of this insect, the mortality of 100% was reached after 48 h with the highest dose (500 µg / insect). The LD50 obtained at the shortest time (6 hours after treatment) is of the order of 107.15 µg / insect. The extract of this plant inhibited the activity of AChE in this model insect: *T. castaneum*. This result suggests that this plant has a neurotoxic effect on Tribolium. The encouraging results obtained with the extract of this plant suggest the possibility of using the extracts of this plant in integrated pest control in combination with other means of fight against insect pests of crops or stored commodities.

**Key words:** *Cotula cinerea*, *Tribolium castaneum*, Toxicity, Plant extract

## Botanical insecticides against *Sitophilus zeamais* (Motschulsky)

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Maize is one of the main staple foods in the world. *Sitophilus zeamais* Motschulsky (maize weevil) is an important insect storage pest that affects the maize grain on the field and during the storage causing significant losses under stored conditions. Common control strategies to manage stored product pests are mainly based on the use of synthetic insecticides and fumigants. Their intensive use may bring serious problems to human, animal and environmental health as well as the occurrence of resistance in the insects. There is a need to replace these chemicals with natural products such as essential oils and their main active components extracted from plants. This study aimed to evaluate the efficiency of the essential oils of pennyroyal (*Mentha pulegium* L.) and clove (*Syzygium aromaticum* (L.) Merrill & Perry) and of the main active components pulegone, eugenol and limonene against adults of *S. zeamais* in stored maize grains. The results showed that pennyroyal and pulegone had insecticidal action and the effectiveness of cloves oil and eugenol were not observed as insecticide.

**Key words:** insect pest, stored maize, essential oils, main active components, insecticide activity

## **Comparative toxicity of *Chenopodium ambrosioides* and *Tephrosia vogelii* leaf powder against *Acanthoscelides obtectus* (Chrysomelidae: Bruchinae)**

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*Acanthoscelides obtectus* is one of the most detrimental insect pests on stored bean. The infestation starts from the field and continues in storage. Many control methods are used to reduce the damage caused by this pest. The most used is synthetic residual chemical insecticides, however effective but caused many environmental problems. The search for environmentally friendly control methods become an imperative. In this issue *Chenopodium ambrosioides* and *Tephrosia vogelii* leaf powders were tested on *A. obtectus* regarding adult toxicity and F<sub>1</sub> progeny production. Four contents (4; 8; 16 and 32 g/kg) of each leaf plant powder were mixed with common beans (*Phaseolus vulgaris*). The mortality was recorded within 1, 4, 7 and 10 days post exposure. The two leaf powders induced significant adult mortality. Complete *A. obtectus* mortality was recorded with *C. ambrosioides* leaf powder (16 g/kg) 4-d post exposure. The same performance was observed with *T. vogelii* at its highest content (32 g/kg) within 10 days post-exposure. The LC<sub>50</sub> values within 10 days were 1.48 g/kg and 2.05g/kg respectively for *C. ambrosioides* and *T. vogelii*. The F<sub>1</sub> progeny production was considerably reduced by the two plants. The inhibition was complete with *C. ambrosioides* leaf powder at its highest content (32 g/kg). *T. vogelii* in the same condition induced 86.47% progeny reduction. Considering these results, the two plants can successful protect stored beans against damage caused by *A. obtectus*. These plant products could supersede the synthetic insecticides used by smallholders in grain storage.

**Key words:** *Acanthoscelides obtectus*, *Chenopodium ambrosioides*, *Tephrosia vogelii*, infestation, storage

**Fumigant and repellent effects of *Eucalyptus cinerea* and *Eucalyptus maidenii* essential oils on *Callosobruchus maculatus* F. (Coleoptera: Bruchidae) and *Sitophilus oryzae* L. (Coleoptera: Curculionidae)**

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The essential oil of *Eucalyptus maidenii* and *Eucalyptus cinerea* was extracted by the drive technique with water vapor and analyzed by means of gas chromatography coupled to mass spectrometry. The results reveal that the monoterpene compounds are the majority (57.69 and 51.28%) compared to sesquiterpenes (37.14 and 23.07%), and the 1.8-cineole is the most represented (70, 89 and 71.93%), respectively for *E. cinerea* and *E. maidenii*. In fumigation tests, after 24 hours of exposure, with a dose of 125µl/l, *E. cinerea* and *E. maidenii* caused 100% adult mortality in *Sitophilus oryzae*. The same mortality rate was achieved at a dose of 25µl/l, with adults of *Callosobruchus maculatus*. The adults of *S. oryzae* are more sensitive to *E. cinerea* and *E. maidenii* with respectively, LD50 = 8.45 µl/l and 8.95 µl/l, LD95 = 10.45µl/l and 11.62 µl/l, compared to *C. maculatus*, with LD50 = 11.75 µl/l and 12.35 µl/l, and LD95 = 26.90 µl/l and 19.07µl/l for, respectively, *E. cinerea* and *E. maidenii* essential oils.

**Key words:** essential oils, CGMS, *Sitophilus oryzae*, *Callosobruchus maculatus*, repellency

## **Effect of some essential oils and their nano formulations against red flour beetle, *Tribolium castaneum* and confused flour beetle, *Tribolium confusum* (Coleoptera: Tenebrionidae) under laboratory and store conditions**

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*Tribolium confusum* J. Du Val. and *Tribolium castaneum* (Herbst), are widespread species that attacks stored grains and foods in several commodities. The potential of natural essential oils (EOs) of rosemary, clove oil and ginger and their nano formulations were tested against the above species under laboratory and stored conditions. Results showed that, the percentage of larval mortality of both the insects increased with increase of concentrations. Larvae of *T. confusum* were more susceptible to the treatments than *T. castaneum* larvae. Nano formulated ginger EO was more effective than rosemary and Clove EOs. The fecundity of the tested insects was highly affected by both natural and nano-formulated EOs. The egg production was highly suppressed by nano-rosemary EO as well as by clove EO, and ginger under stored conditions. The mean number of laid eggs per female and the percentage of adult emergence (F1) were greatly affected by natural EOs and by the nano-formulated ones in comparison to untreated with highly significant differences. Nano-ginger EO strongly suppressed the number of laid eggs of *T. confusum* more than *T. castaneum* after 20, 90 and 120 storage interval days (1.8±1.1, 13.8±4.5, 16.6±3.5 eggs/female and 3.8±3.5, 17.8±7.5, 26.6±4.5 eggs/female respectively). The results of the tests carried out with the nano-EOs indicate a reduction of the oviposition, of the adult emergence (F1) and of the infestation percentages. Moreover, the results showed that ginger EO -nanoparticles could be used as a valuable tool in pest management programs of *T. confusum* and *T. castaneum*.

**Key words:** nano, rosemary, clove, ginger, essential oils, storage pests

## **Toxicity of the three essential oils against *Sitophilus granarius* under laboratory and store conditions**

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Almost all the insect pests of stored grains have a remarkably high rate of multiplication and within one season they may destroy 10-15% of the grains and contaminate the rest with undesirable odors and flavors. The present study aims to evaluate the toxicity of three essential oils (EOs) on *Sitophilus granarius* (Coleoptera Curculionidae).

*S. granarius* was reared on rice under laboratory conditions at  $28 \pm 2^\circ\text{C}$  and  $60 \pm 5\%$  R.H. Three essential oils were used for the toxicity bioassay: coriander, mint and sesame. Results, after the three EOs treatments show that the attack of the grain weevil to rice significantly decreased, and the percentage of larval mortality was 80.11, 30.10 and 2.21 after coriander EO treatments, at the concentrations of 5, 0.5 and 0.05%. The corresponding concentrations of mint, results in a larval mortality of 50.11, 21.22 and 6.41% while with sesame treatment of 39.61, 29.81 and 22.613%. The ovideterrent effect of the EOs of coriander, mint and sesame at the concentration of 3% is confirmed by the means number of eggs layed/female that is significantly lower ( $11.0 \pm 9.8$ ,  $27 \pm 7.1$  and  $25 \pm 6.8$  eggs/female respectively) when compared to the control ( $199 \pm 8.9$ ).

**Key words:** *Sitophilus granarius*, coriander, mint, sesame essential oils

## Effects of orange peel powder and cypress ash on *Phaseolus vulgaris* germination and *Acanthoscelides obtectus* infestation

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Common beans are highly attacked during storage by *Acanthoscelides obtectus*. Currently, small farmers are using mostly synthetic than botanicals to tackle damage caused by the pest. Due to the hazards of the synthetic chemicals to human health and the environment, there is a need to promote phytochemicals. In this effect, orange peel powder, cypress leaf ash and their mixture were used for the protection of the common bean weevil *A. obtectus* and to determine their influence on seed germination. Four concentrations (5, 10, 20 and 30 g/kg) of the botanicals were applied on beans. The results show that there is no significant difference among concentrations, days after treatment and products concerning seed viability. For each dosage at least 95% germination rate was recorded. For adult mortality, orange peel powder was less effective against *A. obtectus* with 12.5 % mortality at the content of 30 g/kg within 5 days post exposure. Cypress ash and the mixture of ash and peel recorded respectively of 98% and 86% mortality within the same period of time. The ash, powder and the mixture were effective in inhibiting the F1 progeny thereby leading to less grain damage and weight loss which showed no significant differences among the products dosages. Equally, there was no significant effect of insects' infestation on treated seed with regard on germination rate. As the cypress ash powder gave the similar result as with the mixture concerning germination rate, adult mortality and progeny reduction, it recommendable to use the powder alone as it is easy to wash the seeds treated with powders to remove residue of botanicals. Finally, cypress leaf ash could form a major component of the integrated storage protection package for beans against *A. obtectus* attacks.

**Key words:** Common beans, weevils, cypress ash, orange peels, toxicity

## Development of an IPM program in the Vatican Secret Archives

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Over time, the presence of different species of insects has been recorded in all the premises of the Vatican Secret Archive, almost everywhere, both as occasional guests and as real biodeteriogens. In this work, we describe the strategies implemented in the Vatican Secret Archives for the adoption of an IPM (Integrated Pest Management) project, based on a pest monitoring and on an evaluation program. Following the results of the monitoring, a series of corrective actions have been carried out on infested material and by sanitizing the infested areas. Insect damage occurs when the problem is underestimated and the environmental and sanitary conditions are neglected. Typical are the structural deficiencies in the premises or a lack of the system for promptly detecting the infestations. Fundamental is the training of the internal staff that handles the documents.

**Keywords:** cultural heritage, biodeteriogens, IPM, woodworm and termites

## The monitoring of quarantine pest - cowpea weevil *Callosobruchus maculatus* Fabricius under storage conditions by using the synthetic sex pheromone

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One of the most dangerous pests of the genus *Callosobruchus* spp. is a cowpea weevil *Callosobruchus maculatus* Fabricius that is widespread in many countries. In Russian Federation the cowpea weevil is quarantine pest that are mainly imported with foreign freight and could cause serious economic losses. The losses of crop such as cowpeas, mung beans and chickpeas during the storage period can reach 80-100%. At the same time, the germination of beans in the bulk infested by the cowpea weevil is reduced by 50-80%. In 2018 the storage trial was carried out with the aim to study the attractive effect of synthetic sex pheromones on catching insect males of cowpea weevil *C. maculatus*. The researched work was done in Bulgaria on the base of the Institute of soil, agricultural technology and plant protection named after Nikola Pushkarov. Synthesized in the All-Russian Plant Quarantine Center pheromones were tested with infested beans of the cowpea (*Vigna sinensis* L.) that were collected in the field. Different pheromone (the blend of five acids: 3-methylene-pentane, (Z)-3-methyl-3-heptene, (E)-3-methyl-3-heptene, (Z)-3-methyl-2-heptene, (E)-3-methyl-2-heptene) dosages (2 mg, 4 mg, 8 mg, 16 mg and 0 mg for control) were applied with two trap types: "delta trap" for wing-bearing insects and "book trap" for flightless forms. Comparison test showed that pheromone dosage of 16 mg and 8 mg applied with "delta" trap had non-significant difference between each other with average number of trapped individuals of 14 and 12, respectively. The trapped quantity of adults was higher in "delta trap" with a dosage of pheromone of 2 and 16 mg and an average of 23 and 14 individuals per trap, respectively. The use of "delta trap" showed a higher attractive effect than the "book trap" with average number of 7 individuals and 68 individuals per trap, respectively. Therefore, in warehouse conditions, the preferred type of trap is "delta". The obtained results of the biological attractiveness of the pheromones showed its effectiveness by using "delta trap" even in minimum commercial dosage of 2 mg. Evaluation of the pheromone attractiveness is the useful tool for monitoring and could be used in Integrated Pest Management. In addition, in some cases the use of different doses showed the possibility for pest disorientation in storage conditions as well as in the field.

**Key words:** *Callosobruchus maculatus*, pheromones, traps, monitoring

## Endemic Andean plants against food-stuff insect pest

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Tropical Andes, because of the exceptional number of endemic plants, have been classified as a hyper-hot spot for biodiversity and they represent an extraordinary source of yet undiscovered bioactive compounds. In fact, many of these plants are used in the local traditional medicine by the population, as well as to control fastidious insects. The properties of many of these plants, as well as their smell, are due to their essential oils, volatile substances produced either as a protection against phytophagous insects and to attract pollinators. Several studies have reported the toxicity and repellent activity of Andean plants essential oils against insects. However, to our knowledge, no information is available about their attractiveness. In this work, we analyzed the chemical composition and assessed the repellency and attractiveness of the essential oils of the Andean endemic plants *Aloysia citrodora* (Verbenaceae), *Bursera graveolens* (Bursedraceae), and *Buddleja globosa* (Scrophulariaceae) against the main food-stuff insect pests *Rhizopertha dominica* (Coleoptera: Bostrichidae) and *Tribolium confusum* (Coleoptera: Tenebrionidae) by area preference tests. The results showed that the tested essential oils have high repellency rates at high concentrations whilst, on the contrary, they are attractive to the insects at the lowest concentrations. Such results, beside confirming that tropical Andes plants are a valuable unexploited source of bioactive substances, indicate that the use of essential oils as repellent for the protection of the food should be evaluated carefully, also taking into account that both i) concentration changes in time due to their volatility and ii) their compositional variation due to volatilization can cause dramatic changes of bioactivity of the essential oils against insect pests.

**Key words:** Andean flora, essential oil, food-stuff insect pest, repellent, attractant



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