**Session 1: Recent advances in IPSP and post-harvest IPM current trends**

**Recent advances and future directions in Integrated Stored-Product Insect Management Programs for the food industry**  
*Campbell, J.*  ................................................................. 1-6  
**Abstract:** Stored-product insect management at food facilities such as mills, processing plants, warehouses and retail stores increasingly relies on integrated approaches, and as a result there is increasing need for research that provides ‘real world’ solutions. Because of the spatial distribution and movement patterns of the pest insects and the structural complexity and operational constraints of food facilities it is challenging to transfer tactics from the lab to the field. Recent research approaches that attempt to assess treatment effectiveness under conditions found in food facilities are summarized. Finally, some critical data gaps are discussed that would be fruitful areas of future research are discussed. This brief summary of where stored-product pest management research is and where it needs to go to improve the management of insects in food facilities will hopefully stimulate additional research in this important area.

**Metal silos have been turned into safe keeping grain facilities**  
*Zakladnoy, G., Dogadinssi, A., Abdiushev, M., Soskin, M., Markov, Y.*  ......................... 7  
**Abstract only**

**Carifend™: an alternative method to protect stored tobacco,**  
demonstrated by laboratory trials and semi-commercial test systems  
under diverse climatic conditions  
**Abstract only**

**Field efficacy of *Beauveria bassiana*, diatomaceous earth and imidacloprid against two major stored grain insect pests**  
*Wakil, W., Schmitt, T.*  ................................................................. 9  
**Abstract only**
Facilitating safe fumigation with QuickPHlo-R phosphine generators
Asher, P. .................................................................................................................. 10
Abstract only

Integration of Isaria fumosorosea with enhanced diatomaceous earth DEBBM
for the control of Rhyzopertha dominica
Wakil, W., Riasat, T. .................................................................................................. 11
Abstract only

The combination of the parasitoid Bracon hebetor Say and gamma radiation
as an IPM efficient strategy for controlling Ephestia cautella (Walker)
Al-Taweel, A. A., Muhsen, A., Hamad, B. Sh., Mahmood, E. A. ................................. 12
Abstract only

Using the parasitoid Trichogramma evanescens in date palm orchards alone
and with pheromone traps in date warehouses to control Ephestia spp.
in three provinces in Iraq
Al-Taweel, A. A. ....................................................................................................... 13
Abstract only

Session 2: Stored-product pests and pathogens biology and ecology
in relation with IPSP
Tools for detecting pest contamination in stored raw materials
Riudavets, J. ........................................................................................................... 17
Abstract only

Corks damaged by Nemapogon granellus (L.) in Tuscan wine cellars (Italy)
Trematerra, P., Canovai, R., Lucchi, A. ................................................................. 19-26
Abstract: European grain moth, Nemapogon granellus (L.), is cosmopolitan in the temperate
regions of the world and includes indoor and outdoor populations. Larvae feed on cereals,
soybeans, almonds, hazelnuts, walnuts, peanuts, brans, grass seeds, clovers, flax, ergot, dry fruits,
chocolate, mushrooms, seeds, moldy cheese, prunes, chestnuts, garlic, decayed wood, lichens,
tobacco and pharmaceutical products. Some authors have stressed the importance of N. granellus
as a pest in wine cellars where larvae feed on, and tunnel into, the corks of wine bottles. This
causes aesthetic damage to the corks, which must be replaced before delivery to consumers.
When tunnels ultimately connect both ends of the cork, the wine itself is affected and bottles
rejected due to alteration in the organoleptic properties of the wine. During 2011, heavy
infestations of European grain moth occurred in some Italian wine cellars in Tuscany (Italy),
causing serious damage on exposed wine-bottle corks. The infestation occurred on red wine
bottles (approximately 9,000) stored for aging for over 20 years. Integrated Pest Management
(IPM) strategy was adopted, monitoring N. granellus adults with pheromone traps, accompanied
by careful cleaning of the rooms, shelves and machinery, alternated to localized treatments using
fogs with pyrethrum, and by the replacement of the infested corks. In addition, application of
cellar sanitation procedures reduced the sources of pests as well as the possibility of insect
reproduction, particularly in the areas of corks storage.

Stored-product insects and their natural enemies in Germany: a species-inventory
Schöller, M., Prozell, S. ......................................................................................... 27-34
Abstract: Native natural enemies are preferred for biological control, because they are not
expected to negatively affect non-target organisms. In this publication, a recently compiled
stored-product insect checklist for Germany is discussed in the context of insect ecology and
biological control. The 213 insect species found to be associated with stored products in
Germany were classified according to their feeding habits. About 16% of all species were found to be primary stored product pests. The most species-rich groups are secondary stored product pests and mould feeders with 28% and 29% of all species, respectively. The beneficials (9.1%) comprise 11 species of parasitoids (5.3%) and 8 species of predators (3.8%) which are listed. Changes in species composition and distribution range were discussed for selected species and the impact for stored products protection and biological control were discussed.

**Light filth method on semolina and pasta**

*Locatelli, D. P., Savoldelli, S., Moroni, E., Limonta, L.* ................................................................. 35-40

**Abstract:** Samples of semolina and pasta were collected from one mill and one pasta plant in Italy for six and four years respectively. They were analyzed by AOAC light filth method (225 g). Altogether, 195 semolina were collected from 2007 to 2012. The mean number of insect fragments detected during this period was 4.9, and each year, a mean of one first instar larva of *Stegobium paniceum* (L.) was found. A single mite was detected in only one sample. A total of 156 samples of pasta were analyzed during the period 2009 to 2012 and the mean number of fragments in these samples was 10.1. Mandibles of *Sitophilus oryzae* (L.) and *Tribolium* spp. were the most identified filths. Fragments were mainly derived from infestation prior to milling, both in semolina and pasta samples. In fact, fragment size was lower than the granulometry of semolina. Rodent hair was found in few samples.

**Insecticidal effect of freezing on different life stages of various stored-product insect species**


**Abstract only**

**Ten years of food complaints about cereal products**

*Süss, L., Savoldelli, S., Limonta, L., Locatelli, D. P.* ................................................................. 43-48

**Abstract:** More than two hundred food complaints, coming from food industries, food stores, and customers, were analyzed in our Department of Food, Environmental and Nutritional Sciences (University of Milano, Italy) in ten years. Most of food packages were delivered already open; sometimes the food samples were delivered without packaging. In the case of packaged food, infestation was subsequent to packaging. Cereal products comprised 48% of the samples. Cake and biscuits, pasta, bread and crackers, rice, flour, ravioli, and others (spelt, corn crackers, cereals soup) comprised 32.4%, 31.4%, 11.4%, 8.6%, 7.6%, 3.8%, and 4.8%, respectively, of the cereal products. Lepidoptera were 47% of pests found; *Plodia interpunctella* (Hbn.) was in 88% of samples where Lepidoptera were found. Coleoptera were found in 34% of the samples; *Sitophilus oryzae* (L.) was in 42% of samples that contained Coleoptera. Nine percent of complaints were rodent filth, mainly droppings. The remaining 10% was represented by other pests or filths.

**Sampling adults of stored-product beetles: Detection and mean retention efficiency of cracked corn and food mixture baits**

*Subramanyam, Bh., Hagstrum, D. W., Sehgal, B.* ................................................................. 49

**Abstract only**

**Populations’ growth of cigarette beetle, Lasioderma serricorne, on stored tobacco under temperate and tropical conditions**

*Carvalho, M. O.* ................................................................. 51-64

**Abstract:** The cigarette beetle, *Lasioderma serricorne* (F.) (Coleoptera: Anobiidae), is a well-known insect that infests a wide range of foodstuffs and it is the most serious pest of stored tobacco and cocoa. Cigarette beetle (CB) is a well adapted species in tropical and temperate environmental conditions, although the variability of temperature is a very important ecological factor, which insects can answer in a differently way under the presence/absence of temperature
fluctuation. The rhythms of temperature, together with light, moisture and food, control the seasonal and daily insects’ activity. Experiments were carried out to study the activity of adults under temperate and tropical conditions, in tobacco and cigarette factories and warehouses in Portugal and in a cigarette factory and warehouses in Cape Verde. The records of adults’ activity were obtained monthly using traps with sex pheromone and the environmental conditions of temperature and relative humidity were achieved from thermohygrometers and data loggers. The population growth was calculated based on index of “relative” growth $\frac{\Delta N}{\Delta t}$ (“relative” because was supported on records obtained from trap catches) where $\Delta N$ is the variation of the adults caught in a given period (month) of time and $\Delta t$ is the period of time (month). From the results, larvae hibernation was not observed in Cape Verde and the adults remain active all over the year while in the premises in Portugal there was a period where their activity was lower or absent. The index of relative growth of the CB populations in Portugal was greater when compared with populations in Cape Verde. This different behavior indicated that temperature fluctuations may have a stimulant effect on the population growth.

Population density estimation of stored grain pests based on their acoustic emissions

Eliopoulos, P. A., Givropoulou, E.G., Potamitis, I., Kontodimas, D. Ch. ...................... 65
Abstract only

Detection of insect infestation in stored wheat based on their acoustic emissions

Eliopoulos, P. A., Givropoulou, E. G., Potamitis, I., Kontodimas, D. Ch. ...................... 66
Abstract only

The influence of plant characteristics on the field infestation and resistance status of certain cowpea cultivars to Etiella zinckenella and Callosobruchus maculatus

Amro, A. ..................................................................................................................... 67
Abstract only

Susceptibility of different pulse grains to the infestation of the cowpea seed beetle Callosobruchus maculatus (F.) (Coleoptera : Bruchidae)

Amro, A., Abdel-Galil, F. A. .......................................................................................... 68
Abstract only

Effect of different temperatures, exposure times and host density of Ephesia cautella (Walk.) larvae upon the efficacy of the parasitoid Bracon hebetor Say

Al-Taweel, A. A., Muhsen, A., Hamad, B. Sh., Mahmood, E. A. ................................. 69
Abstract only

Mycotoxicological analysis of stored groundnuts in Southwest of Algeria

Meliani, H., Moussaoui, A. .......................................................................................... 70
Abstract only

Occurrence and identification of insect pests found in stored sunflower- and rape-seeds in France and damage risk assessment

Dauguet, S., Loison, J.-P., Fleurat-Lessard, F. ............................................................. 71-74
Abstract: Sunflower- and rape-seed samples were collected in French grain silos (34 in 2002 and 121 in 2003), at the surface of bulked grain with the method of surface non-random sampling during the spring season. Insects were counted after sample sieving and species identified and sorted in different groups of nuisibility. In rapeseeds, very few pests were found, except mites. On the other hand, sunflower-seed samples were regularly infested, mainly by secondary and mycophageous insects, which do not damage seeds. A parallel survey carried out among 85 grain store managers was processed to set up the relationships between the storage structures
characteristics, the storage management practices and the pest infestation risks. It showed that good storage practices are limiting storage insects’ occurrence.

**Sitophilus zeamais: water balance and behavior**

*Guedes, N. M. P., Braga, L. S., Silva, L. B., Guedes, R. N. C.* ................................. 75

Abstract only

**The use of bio-test in the disinfestation of food industries**

*Süss, L., Cassani, S., Gallizia, F.* ................................................................. 77-79

Abstract: In 2012 were given to several Pest Control Companies 387 bio-tests. The treatments were carried out in mills and food industries with sulphurilfluoride or with hot air (heat treatments). The species employed in the bio-tests were *Tribolium confusum, Ephestia kuehniella, Plodia interpunctella, Sitophilus oryzae* and *Lasioderma serricorne*. In 19 cases survival was recorded. In these few cases localized treatments with pesticides became indispensable.

**Session 3: Utilization of phytochemicals and semio-chemicals in stored product IPM**

**Phytochemicals and semio-chemical use in Integrated Protection of stored products programs**

*Tapondjou, A. L.* ................................................................. 83-97

Abstract: During storage, foods are currently destroyed by insects and other pests. These pests generally carried in their body fungus that can produce mycotoxins which cause risks to humans and animals; thus, the interaction between pest infestation and fungus contamination in stored food has been established. Generally damages caused by pest and fungi are reduced through chemical control, but there is a strong debate about the safety aspects of chemical preservatives since they are considered responsible for many carcinogenic and teratogenic attributes as well as residual toxicity. With the growing interest of the use of either essential oils or plants extracts as alternatives to synthetic chemicals for stored product protection, screening of plant extracts, essential oils and their derived components for insecticidal and anti-fungal properties has become of increasing importance. As the matter of fact, several articles in the literature published plethora of compounds from plant origin exhibiting both insecticidal and fungicidal activities. There is therefore a need of knowledge on phytochemicals and plants that could be used as insecticides and fungicides. Here, we review chemicals of plant origin and species with insecticidal and fungicidal activities. An exhaustive literature search was conducted using scientific databases, chemical databases, botanical databases, and books to identify published papers related to insecticidal and fungicidal chemical compounds stemmed from plant species and it was established that 3 main chemical classes were most cited for these activities: alkaloids, phenolics, and terpenoids. This review presents plant species and some of their chemical constituents of importance exhibiting both insecticidal and fungicidal activities and that could be used as alternative for integrated protection of stored products.

**Suppression of Plodia interpunctella moth populations infesting wheat warehouses in Israel using mating disruption**

*Kostyukovsky, M., Trostanetsky, A., Quinn, E., Bernstein, S., Rafaeli, A.* .......... 99-104

Abstract: Indian meal moth (IMM) *Plodia interpunctella* is a common and harmful insect pest in stored grain and dry food in Israel. Usually, chemical treatment, such as fogging, residual insecticides or fumigation is used for IMM control. Despite the high efficacy of these traditional measures, their disadvantages, particularly their negative impact on the environment and public health have led to intensive research focused on safe and eco-friendly alternatives. In recent years, the use of sex pheromone for mating disruption of IMM was suggested. The purpose of the present investigation was to study the efficacy of mating disruption of *P. interpunctella* using sex
pheromones in suppressing moth populations in wheat warehouses in Israel. The study was conducted in small scale (15 m$^3$ filled with 3 ton of wheat grain) and two commercial scale warehouses (each one of 3000 m$^3$ filled with 2000 ton of wheat grain) in the central part of Israel. The Prescription Treatment$^\text{TM}$ brand ALLURE$^\text{MD}$ (Whitmire Micro-Gen Research Laboratories, Inc., MO, USA) with 93% of active ingredient (Z-9, E-12-Tetradecadien-1-yl acetate) was used for mating disruption. Evaluation of IMM populations was performed using two methods: the first, based on pheromone traps containing pheromone dispensers SP LOCATOR (AgriSense BCS Ltd, UK) and the second, based on food traps containing culture media used for IMM rearing. The small scale warehouse was initially tested as a control (without mating disruption) and then as a treatment (1 dispenser per 15 m$^3$). Two commercial warehouses were used for control and treatment (1 dispenser per 30 m$^2$) in parallel. It was found that both of the tested methods were suitable for evaluating IMM population levels. In the small scale warehouse experiment, an initial population of 40 introduced pupae, control-treatments resulted in 543 F1 males caught in the pheromone traps, (means of 136 males/trap) with a total F1 population of 1086 (males and females). Using food traps for evaluating population levels, the total number of F1 was 716 (both males and females) (means of 144/trap). On the other hand, after mating disruption the 231 total F1 adults were caught (means of 23/trap) resulting in a 70% suppression of IMM in the first generation. However, when higher initial populations were tested (300 introduced pupae), the treatment was ineffective. On testing the efficacy of mating disruption in the commercial scale warehouses, with the initial density of the population of 1 male/pheromone trap, the numbers of trapped males were significantly less compared with the non-treated warehouse after a month of treatment: 1.5 and 7.0 adults per trap, respectively. However, at the end of the second month the numbers of trapped moths in the treated and non-treated warehouses were almost equal: 19.3 and 20.5 adults per trap, respectively. It can thus be concluded that mating disruption can indeed suppress populations of IMM in warehouses, however when populations reach high levels chance encounters prevail and thus mating disruption should be implemented within an integrated pest management program thereby maintaining pest populations at low levels.

Impact of intensive trapping of *Sitophilus oryzae* with probe or PC traps baited by pheromone or food attractant on insect population dynamics

Fleurat-Lessard, F., Fuzeau, B. ................................................................. 105-111

Abstract: In large flat-storage facilities, primary insect pest populations that were quiescent at the end of winter season start again their multiplication when located in zones where temperature exceeds again the lower limit for development. This situation generally takes place close to the surface of the bulk. Early detection of insect presence in this zone is crucial in IPM programs. A pilot scale trial was carried out to evaluate the potential of high density trapping in this upper zone of a grain bulk. This trial had three objectives: i/ to evaluate the percentage of *Sitophilus oryzae* adults that can be caught through high-density network of traps displayed from the surface of the wheat bulk, baited with lure or attractant, vs. non-baited; ii/ to compare the yield of the different traps when baited or not with sitophilure and/or attractive oil; iii/ to evaluate the impact of trap catches on the rice weevil population dynamics. A randomized experimental design was built with 400 kg wheat batches stored in containers. After initial infestation of each wheat batch by a low density of hidden stages of *S. oryzae* and setting traps, the grain condition was continuously monitored and insect catches were checked every 3 weeks during 4 months of storage at 22 to 25 °C. The percentage of weevils trapped by this high-density trapping (10 traps per 400 kg batch) reached more than 30% in the better case with a peak during the second month of storage. At the same period, it was observed a significantly reduction of weevil numbers in traps baited with sitophilure. Conversely, traps with attractive oil catch significantly more weevils. Nevertheless, in spite of the high number of weevils trapped, the population dynamics trends were not significantly affected by continuously trapping a part of the population in the conditions of this pilot trial.
Effect of drying regime on the insecticidal efficacy of Cameroonian neem seed oil against *Sitophilus zeamais* Motsch. and *Callosobruchus maculatus* Fab.

Tofel, H. K., Nukenine, E. N., Adler, C. ................................................. 112

Abstract only

Insecticidal formulation based on *Ocimum gratissimum* essential oil and montmorillonite clays for maize protection

Nguemtchouin Mbouga, M. G., Ngassoum, M. B., Kamga, R., Cretin, M., Chalier, P. .................................................. 113-121

Abstract: An insecticidal formulation based on *Ocimum gratissimum* essential oil and montmorillonite clays was develop for maize protection. The insecticidal effects of formulations based on *Ocimum gratissimum* essential oil and montmorillonite have been improved after modifications of the clay by CTMA in relation to their higher sorption capacity. Insecticidal tests have been conducted against the maize weevil *Sitophilus zeamais*. The insecticidal effects of the essential oil persisted for about 7, 45 and 110 d, respectively for crude essential oil after adsorption on unmodified and modified clay. The findings suggest that formulations based on essential oils and modified clays should be considered as alternatives to synthetic insecticides for use in pest control of stored products.

(Re-)discovering cucujolides – Infochemicals for *Oryzaephilus surinamensis* and *Cephalonomia tarsalis* with potential for biological control

Collatz, J., Mack, P., Hötling, S., Schulz, S., Steidle, J. L. M. ................................................. 122

Abstract only

Screening of plant extracts as repellent against stored-product insects

Guruprasad, B. R., Pasha, A. ................................................................. 123-128

Abstract: Use of phytochemicals as natural insecticides to control stored product insects is an important area of work. Studies were conducted to test the repellency of *Trichilia connaroides* and *Clerodendron inerme* methanol extract of leaf against three stored-product insects, the lesser grain borer *Rhyzopertha dominica*, the red flour beetle *Tribolium castaneum* and the cowpea weevil *Callosobruchus chinensis*. The area preference method was used to determine the response of insects to the repellents by measuring their movement from the treated region on filter paper strip. The average repellency of 100, 250, 500, 750 and 1000 ppm concentrates from *T. connaroides* and *C. inerme* leaves totally achieved class III (60.1–80% repellency) and class V (80.1–100% repellency) respectively after 24 h observation. The order of repellent activity was *C. chinensis* < *T. castaneum* < *R. dominica*. The concentrate of methanol-extract of *C. inerme* leaves was found to be more effective than *T. connaroides*. These plant extracts can be exploited as promising stored product insect control agents.

The utilization of saturated atmospheres from *Syzygium aromaticum* and *Mentha pulegium* essential oils against rice fungi

Magro, A., Barros, G., Matos, O., Carolina, M., Bastos, M., Mexia, A. .................. 129-134

Abstract: Storage of rice is a specific ecosystem, conditioned by several factors that are difficult to control, like temperature, relative humidity, water content, oxygen availability. This is especially true in underdeveloped countries where technological innovations such as refrigeration and controlled atmospheres represent huge investments.

Storage under deficient conditions can originate insect or fungi attack, inducing organoleptic changes (taste, flavour and appearance), nutritional losses or even mycotoxin contamination. This causes significant economic losses and serious health problems. Currently the use of synthetic pesticides is restrained by regulation and political pressure due to carcinogenic and teratogenic effects, and to high residual acute toxicity. It is also important to consider their long degradation times, environmental pollution issues and collateral effects on consumers. Due to such reasons, populations have become more interested on natural food conservatives.
The use of essential oils from aromatic plants may be a practical alternative to the use of synthetic pesticides in preventing deterioration caused by fungi on stored rice. So in this study it was evaluated the potentiality of Syzygium aromaticum and Mentha pulegium essential oils to promote saturated atmospheres capable of protect the rice against Aspergillus candidus, A. niger, Fusarium culmorum and Penicillium islandicum.

Comparative insecticidal efficacy in the Sudano-Guinean versus Sudano-Sahelian agro-ecological zones of Cameroon of FossilShield and NeemPro against Sitophilus zeamais on maize in storage
Nukenine, E. N., Kouninki, H., Mblama, R., Adler, C. .................................................. 135
Abstract only

Mating disruption of stored product Pyralidae: results from large-scale trials in Europe
Abstract only

Small bin trial of pea extract mixed with pyrethrins to control stored-product insects
Abstract only

Study of analysis, insecticidal and antimicrobial activity of the essential oils of Ferula vesicerritensis and Thymus munbyanus
Benchabane, O., Hazzit, M., Mouhouche, F., Rostum, H. A. ................................. 139
Abstract only

Effectiveness of Laurus nobilis and Mentha pulegium essential oils against Sitophilus zeamais Motschulsky (Coleoptera: Curculionidae) on stored maize
Conceição, C., Barros, G., Magro, A., Matos, O., Barbosa, A., Mexia, A. ........... 141-146
Abstract: Laboratory studies were carried out to evaluate the effects of some essential oils from Laurus nobilis and Mentha pulegium against unsexed adult insects aged from 1 to 7 d of Sitophilus zeamais on stored maize. The concentrated essential oils at different volumes of 0.5 µl, 1.5 µl, 2.5 µl, 5.0 µl and 10 µl, were poured on filter papers with 2 cm Ø each. For diluted oils, the fixed volume of 15 µl of different concentrations of 1:150 v/v, 1:100 v/v, 1:75 v/v, 1:50 v/v and 1:10 v/v either in methanol or n-hexane were used to impregnate the filter papers. Treatments with the concentrated oils were more effective particularly those from Mentha pulegium. All the concentrations used from L. nobilis provided 100% adult mortality and no progeny production was achieved. L. nobilis has revealed 100% adult mortality at 0.796 µl/cm². Regarding the treatments with diluted oils once again the oil from M. pulegium provided 100% adult mortality at concentrations of 1:50 v/v and 1:10 v/v. L. nobilis was not effective at any of the concentrations used. There were no significant differences between the solvents used.

Identification of pure compounds in dried apricot and apple electrophysiologically active in Plodia interpunctella (Huebner)
Ndomo, A. F., Weissbecker, B., Schütz, S., Fragstein und Niemsdorff, M. von, Reichmuth, Ch., Ulrichs, C., Adler, C. ................................................................. 147
Abstract only

Efficacy of Lippia adoensis essential oil against Sitophilus zeamais (Coleoptera: Curculionidae) as influenced by leaf age
Gangué, T., Nukenine, E., Adler, C., Ulrich, D. ............................................................. 148
Abstract only
Refrigerating conservation of apples and in vitro testing different essential oils to control storage rots pathogens
Belguendouz, R., Dit Allah, M., Amraoui, F. ............................................................... 149
Abstract only

Chemical composition, antioxidant and insecticidal activities of essential oils and ethanolic extracts from Algerian Rosmarinus eriocalyx and Lavandula stoechas
Menaceur, F., Hazzit, M., Ferhat, Z., Baaliouamer, A., Mouhouche, F. ..................... 150
Abstract only

Toxicity of Newbouldia laevis (Seem) against the Angoumois grain moth, Sitotroga cerealella (Olivier) in paddy rice
Ashamo, M. O., Adetogo, T. A. .............................................................................. 151
Abstract only

Session 4: Non-chemical control of pests and pathogens at the post-harvest stages

Non-chemical control in stored grain and other durables
Adler, C. ........................................................................................................... 155-158
No Abstract

Mortality of Carpophilus hemipterus eggs and larvae under the influence of thermal disinfestations
Navarro, S., Navarro, H., Finkelman, S. ............................................................... 159-165
Abstract: The dry date cultivars grown in Israel pests may become infested in the orchard. Where pest management is insufficient, dates are brought to the warehouses with some Nitidulidae beetles and Phycitidae moths infestation. Therefore, to prevent further damage during storage within the warehouses and to remove the insects from the dates, insect control should be carried out by disinfesting the dates as they reach the packing stations. Thermal disinfestation technology has been successfully implemented by the transfer of hot air through a channel where dates are placed on trays. In earlier laboratory and commercial thermal disinfestation trials the effectiveness in disinfesting dates from larvae and adults was demonstrated. Exposure of dates to 50 °C for 3 h exposure was shown to be the most effective treatment for removing the insects from the dates and to control them. The present investigation was carried out during the development of the thermal disinfestation technology and addressed to examine the effectiveness of heat on eggs and larvae stage of Carpophilus hemipterus. In laboratory studies, the influence of 50 °C on the levels of mortality of C. hemipterus eggs was examined over a 3 h exposure period at r.h. of 20% to simulate commercial disinfestation treatments. Complete egg mortality was achieved after 3 h exposure. Since dates are disinfested at various moisture contents, the effect of r.h. on the effectiveness of the treatment was questioned. Therefore, on a separate laboratory experiment, survival of the larva stage of same species exposed to 50 °C at 15, 65 and 95% r.h. for 5, 30, 60, 90 and 120 min was examined. Complete mortality was achieved in all r.h. at a period above 60 minutes. There was no dependence of mortality on the r.h. level within the larva's micro-environment.

Supercooling capacity of the endoparasitoid Venturia canescens (Hymenoptera: Ichneumonidae)
Andreadis, S. S., Spanoudis, C. G., Kamperidou, S. G., Athanassiou, C. G., Savopoulou-Soulmani, M. ........................................................................................................ 166
Abstract only
The use of the parasitoid Anisopteromalus calandrae for the control of the weevils Sitophilus zeamais and Rhyzopertha dominica in rice
Solà Cassi, M., Riudavets, J. .......................................................... 167
Abstract only

Legume entomotoxic type 1 albumins: Promising candidates for the protection of stored cereals
Lamis, K., Eyraud, V., Sivignon, C., Rahioui, I., Da Silva, P., Gressent, F., Rahbe, Y., Royer, C. ................................................................. 168
Abstract only

Efficacy of biofumigation in stored product pest management: a case study with Callosobruchus maculatus F. (Coleoptera: Bruchidae)
Kiruba, S., Israel Stalin, S., Manohar Das, S. S., Papadopoulou, S. ................................. 169
Abstract only

Development of a self-diagnosis software to enhance stored-grain cooling aeration system performance
Losser, E. ...................................................................................... 171-182
Abstract: Investigations about the ways to optimize cooling aeration operations were carried out at the experimental and training station of the French Institute for cereal grain quality, ARVALIS – Institut du végétal, in taking into account meteorological data at a given storage site. An aeration self-diagnostic software was designed in order to enable the grain store managers to check the performances and efficiency of their grain aeration equipment. Based on fundamentals of thermodynamic, this software can determine airflow rate, total pressure and static pressure of the air in an aeration system (canalor duct). The software calculates the number of required hours to achieve each cooling step. This duration is then compared to the number of available time periods to achieve efficient aeration by exploiting specific meteorological data at the storage site or in the vicinity. The software allows to validate the appropriate design of any aeration system.

This study aimed to determine the reliability of values calculated by the software through a comparison with values measured through more specific assessment tools. The observations made on a fan test bench helped to validate the calculation method. Under real storage site conditions, the correlation between measured and calculated values is variable according to studied criteria (air flow rate, total pressure, static pressure). Overall, software performance, although imperfect, can be considered as acceptable for such a tool that cannot take into account all the specificities of each storage site. In the most critical aeration situations (less than 20 km/h of flow rate, total and static pressures above 200 mm H₂O (2 kPa) and more than 2 °C of air warming), the software gave complete satisfaction. Despite some identified weaknesses, the software can detect sub-optimal situations (e.g. undersized aeration power) in accordance with its original purpose.

Efficacy of diatomaceous earth against the rice weevil Sitophilus oryzae (L.)
after a preventive treatment of wheat
Ciesla, Y., Guéry, B. ........................................................................ 183-191
Abstract: Since 2009, diatomaceous earth (DE) is authorized at the EU level as natural insecticide to control insects and mites in grain stores and also for the treatment of empty stores. It is also registered in different EU countries. Treatments with DE SilicoSec® were carried out in order to prevent wheat infestation by the rice weevil Sitophilus oryzae. Two doses were tested with an application rate of 1 and 2 grams of DE/kilogram of grains and the efficacy was compared to a contact insecticide treatment with pirimiphos-methyl, used in France at 4 mg/kg. For each test series, 50 kg of non-infested wheat were treated in a concrete mixer with diatomaceous earth (2 doses) and pirimiphos-methyl by spraying. Treated wheat was divided in two parts, 25 kg were stored at 15 °C and 25 kg were stored at 25 °C. For each test series, three samples of 1 kilogram of wheat where sampled 24 hours, two weeks, 1, 2 and 3 months after
Efficacy of some microbial control agents and inorganic insecticides against red flour beetle Tribolium confusum (Coleoptera: Tenebrionidae) and Tribolium castaneum and confused flour beetle Tribolium confusum (Coleoptera: Tenebrionidae)

Sabbour, M. ........................................................................................................... 193-201

Abstract: The efficacy of three fungal pathogens, Isaria fumosorosea, Nomuraea rileyi and Verticillium lecanii alone and their combination with natural diatomaceous earth (DE) and silicagel-O-500 and silica-O-750 evaluated against Tribolium castaneum and Tribolium confusum. Results showed that modified diatoms with Calcium hydroxide (Ca-DE) and modified diatoms with Sodium hydroxide (Na-DE) were the most effective treatments against the two tested insects and achieved the highest mortality percentages. T. castaneum achieved the highest tolerant to tested DEs. Cab-O-Sil-750 gave highest mortality against T. castaneum reached to 89, 50 and 12% at concentrations 1, 0.5 and 0.25 g/kg wheat, respectively. The fungus I. fumosorosea was the most effective alone against T. castaneum. Ca-DE and Na-DE treatments strongly enhanced the potency of the tested fungi I. fumosorosea and N. rileyi. Results showed that T. castaneum was susceptible to N. rileyi. Larvae of T. castaneum were more tolerant to V. lecanii alone. In most cases, DE combinations with tested fungi had synergistic effects, while in T. castaneum modified diatoms with aluminium hydroxide (Al-DE) decreased the efficacy of V. lecanii. Both silica gel and diatoms protected wheat better. The egg production was highly suppressed by combination of Ca-DE followed by Na-DE with tested fungi in comparison to untreated control. The combination of Ca-DE/I. fumosorosea strongly suppressed the number of deposited eggs of T. castaneum (87.5 ± 9.6 eggs/female) in comparison to untreated control (277.0 ± 5.9 eggs/female). The most effective DEs modifications were Ca-DE and Na-DE with insecticidal, repellency or ovicidal effects against T. castaneum and had synergistic effects on the potency of tested fungi.

Effectiveness of essential oils of Eucalyptus camaldulensis and Cymbopogon citratus in protecting stored rice against Sitophilus oryzae (Coleoptera: Curculionidae) and Sitotroga cerealella (Lepidoptera: Gelechiidae)


Abstract: The increase in sub-Saharan African rice production and the consequent resurgence of storage pests such as Sitophilus oryzae and Sitotroga cerealella require research measures to preserve the quality and quantity of stored crops. Chemical control methods are widely used on-farm for storage issue, but it is necessary to explore new measures to limit the risks of pesticides to producers and consumers’ health. The objective of this study was to develop alternative technologies based on the treatment of storage bags with the essential oils of Eucalyptus camaldulensis and Cymbopogon citratus to protect stored rice against these key pests. Two methods were used: impregnation of gunny bags and treatment of cotton bags. Gunny bags were
soaked in oils diluted in alcohol at various concentrations (3%, 4% and 5%) corresponding to 2.34 ml, 3.12 ml and 3.9 ml/bag, respectively. Concerning cotton bags, they were treated either with a single oil (dose: 0.25 ml/bag) or with the two oils (half dose: 0.125 ml/bag). Twenty-four hours after application of the oils, 100 g of rice paddy were placed in each bag, and then each was artificially infested with 10 pairs of adults of *S. oryzae* and *S. cerealella*. After 90 days of storage, we assessed the populations of the two pest species and the damage inflicted on the stored rice. Impregnation of gunny bags and treatment of cotton bags with essential oils of *C. citratus* and *E. camaldulensis* effectively protected the stored rice against *S. oryzae* and *S. cerealella*. Moreover, the mixture of the two oils applied on cotton bags covered with plastic film, was the most effective treatment against these pests. Results obtained with these natural products are promising but before extending these technologies, it is necessary to investigate their effect on the quality of treated food and to ensure for consumer safety.

Reproductive strategy and biocontrol potential of *Dinarmus basalis* (Rondani), a koinobiont parasitoid of stored grain pests

*Thakur, D. R.* .......................................................................................................................... 212

Abstract only

High-Temperature-Short-Time (HTST) disinfestation of wheat grain infested by *Sitophilus* spp. pre-emergent stages with a laboratory scale fluidized-bed

*Fleurat-Lessard, F., Fuzeau, B.* .............................................................................................. 213-222

Abstract: A laboratory test-bench was built up to simulate high-temperature-short-time (HTST) exposure of infested grain samples by hidden stages of *Sitophilus granarius* or *Sitophilus oryzae* in a fluidized bed in order to model temperature exposure time relationship. The reduction of emergence of the two weevil species (*S. granarius* in bread making wheat and *S. oryzae* in durum wheat) was determined after different exposure times in the fluidized bed exposure chamber crossed by 2 m/s airflow at inlet air temperatures of 60, 90, 120 and 150 °C. The influence of a grain moisture content from 14 to 19% w.b. on lethal time 50% (LT50) and lethal time 99% (probit 8 or LT100) was also observed. The main microbiological and technological characteristics checked on grain samples after heat treatment were measured. Higher the moisture content longer the exposure time required for the same mortality rate to be achieved. The “temperature-exposure time products” assessed at LT50 and LT100 were modeled as asymptotic negative regression curves. LT100 was observed in less than 10 s exposure time for temperature at air inlet of 120 and 150 °C, whatever the moisture content level. The reduction of fungal colonies was more important with long exposure time at moderately high temperature (90 °C) than with short exposure time at very high temperature (150 °C) (giving similar levels of insect mortality rate). For bread-making wheat, it was not observed significant changes in alveogramme rheological test parameters processed with white flour extracted from heat-treated wheat samples, provided that air temperature and initial grain moisture content are at moderately high level (less than 150 °C and 15% m.c.). The HTST treatment of cereal grain is an efficient and rapid method of control of weevil internal feeder stages and may be developed at practical scale for organic cereals or high-added-value use for special healthy cereal food disinfections.

Application of biological control agents and pheromone traps for controlling *Ephestia* spp. in date warehouses of two provinces in Iraq


Abstract only
Insecticidal effect of ozone against different life stages of *Plodia interpunctella*, *Tribolium confusum*, *Cryptolestes ferrugineus* and *Oryzaephilus surinamensis*  
Athanassiou, C. G., Kavallieratos, N. G., Isikber, A. A., Öztekin, M. S.  224

Abstract only

Investigations on the microsporidian pathogen of *Plodia interpunctella*  
(Lepidoptera: Pyralidae) in Turkey  
Acar, K. F., Yaman, M., Güngör, P.  225

Abstract only

Insecticidal activity of homologous protein peas (*Pisum sativum* L.)  
Mebarkia, A., Rahbé, Y., Makhlouf, M.  226

Abstract only

Stored-product insect natural enemies in wheat industry in Sicily  
Suma, P., Amante, M., Bella, S., La Pergola, A., Russo, A.  227-233

Abstract: The cultivation of wheat in Sicily (Italy) has its origins in ancient times and today it turns out to be the one that invests the largest areas in the island. Connected to this cultivation, a flourishing industry of primary and secondary processing has been developed and is particularly competitive in the global market thanks to the qualitative features of Sicilian durum wheat. In the last decade research activities were undertaken in order to implement hygienic quality by studying infesting arthropods and by developing integrated control methods. In this context, during the monitoring activities of the stored grain pests carried out over the past decade in several grain industries and warehouses in Sicily, the following natural enemies were collected: *Withius piger*, *Xylocoris flavipes*, *Anisopteromalus calandrae*, *Theocolax elegans*, *Habrobracon hebetor*, *Venturia canescens*, *Cephalonomia* spp. More extensive researches are currently in progress for some of these species. Here we discuss their potential use in the framework of the IPM programs.

Testing the insecticidal efficacy of individual and combined use of four different natural substances against granary weevil (*Sitophilus granarius* L.) adults under laboratory conditions  
Trdan, S., Bohinc, T.  235-241

Abstract: Laboratory experiment was carried out to evaluate the impact of different environmentally acceptable substances on the mortality of the granary weevil (*Sitophilus granarius* L.). We treated wheat grains with diatomaceous earth, quartz sand, leaf powder of neem tree, and wood ash. Wheat grains were also treated with combinations of diatomaceous earth and wood ash, leaf powder of neem tree and wood ash, quartz sand and wood ash, and with a combination of all four different. Substances were applied at different concentrations. Mortality of granary weevil adults was tested at 3 different temperatures (20, 25, and 30 °C) and 2 different relative humidity levels (55 and 75%). Mortality was evaluated 7th, 14th and 21st day after exposure. We have detected significant impact of different substances on the mortality of granary weevil adults. Significantly the highest mortality of the beetles was established in treatments with individual use of 2.5 w% wood ash (69.73 ± 2.52%), with combined use of diatomaceous earth (450 ppm) and 2.5 w% wood ash (71.94 ± 2.40%), and with combined use of quartz sand (450 ppm) and 2.5 w% wood ash (68.72 ± 2.80%). Combination of 4 different substances (diatomaceous earth [225 ppm], wood ash [1.25 w%], leaf powder of neem tree [0.625 w%], quartz sand [225 ppm] provoked 68.76 ± 2.75% mortality. We established that wood ash in single or combined use can perform environmentally acceptable alternative to synthetic insecticides in controlling granary weevil adults, however for final confirmation of this thesis we have to study the activity of the substances against the eggs and the larvae of the pest.
Effect of fluctuating temperatures on development of the koinobiont endoparasitoid *Venturia canescens* (Hymenoptera: Ichneumonidae)


Abstract only

First application in France of heat disinfestation of a large wheat mill


Abstract: Thermal disinfestations of flour mill structures and equipment were traditionally used before the 1960’s, but they have been replaced by methyl bromide fumigation until the international ban of methyl bromide in 2005. During the last decade, heat disinfestation of flour mills was developed in Northern America and in some European countries from the 2000’s workshops of heat disinfestation of wheat mills were carried out. In France, the first industrial application of this technology was attempted in 2010 for the disinfestation of a large wheat mill and was carried out by Agronet Company in collaboration with INRA Research Laboratory in Bordeaux. The heating of the flour mill was performed from electric heat generators of Thermonox® technology (Germany). The electric heaters are forced heat air ventilators enabling to reach the target temperature of 50 to 55 °C in about 10-12 h in all parts of the mill. Then, temperature is maintained at this level during 24 to 36 h and optimized from the indications of temperature sensors in order to obtain complete mortality of insects, whatever their development stage. Encaged insects (*Tribolium castaneum* and *Rhyzopertha dominica*) placed in the mill during mill heating were killed at more than 97%. Very few survivals were only observed on the floor at the ground level of the mill. The reproductive capacity of individuals surviving thermal exposure was severely reduced. This first industrial application of heat disinfestation process to a large wheat mill confirmed the results of laboratory studies performed earlier at INRA Laboratory. The economic evaluation of the heat treatment in the conditions described above revealed that it is competitive compared to fumigation with similar requirements in the preparation of the building before treatment. This technology seems very promising for periodic eradication of insect colonies in cereal processing industries without use of pesticide.

Potential of *Anisopteromalus calandrae* and *Lariophagus distinguendus* (Hymenoptera: Pteromalidae) as biocontrol agents of *Callosobruchus maculatus* (Coleoptera: Bruchidae)

Benkhellat, O., Moali, A., Monge, J. P. ................................................................. 253

Abstract only

Biological and molecular analysis of an isolated granulovirus *Tecia solanivora* collected in Páramo Mucuchíes of Merida, Venezuela


Abstract only

Diversity of insect pathogenic fungi infecting stored grain insects in Punjab, Pakistan

Wakil, W. .................................................................................................................... 255-261

Abstract: The occurrence of insect pathogenic fungi isolated from stored grain insect pests collected from various locations of Punjab, Pakistan was investigated. In these surveys, a total of 25,720 insects from six different species were evaluated and 195 isolates from 24 different fungal species were identified. The recovered fungal species included: Ascomycetes *Beauveria bassiana* sensu lato (Balsamo) Vuillemin (Hypocreales: Clavicipitaceae), *Metarhizium anisopliae* sensu lato (Metschnikoff) Sorokin (Hypocreales: Clavicipitaceae), *Purpureocillium lilacinum* (Thorn) Samson (Hypocreales: Ophiocordycipitaceae) and *Lecanicillium attenuatum* (Zare and W. Gams) (Hypocreales: Clavicipitaceae). The cadavers of *Tribolium castaneum* Herbst were significantly infected with the fungi followed by *Sitophilus oryzae* L., *Rhyzopertha dominica* F., *Cryptolestes ferrugineus* Stephens and *Callosobruchus maculatus* F., while, the least were recovered from *Trogoderma granarium* Everts.
Session 5: Chemical control in stored product IPM programs

Chemical control in stored products

Arthur, F. H. .......................................................... 265-273

Abstract: Insect pest management in raw stored grain and in grain-based finished products presents many challenges for the 21st century, especially when viewed on an international scale. The complexity of storage structures, economic aspects of utilizing chemical controls in different sectors encompassing stored products, regulatory and environmental considerations, a low tolerance for insect damage in finished products, and expectations of consumers are just a few examples that pose challenges for research. Selected key issues will be presented and discussed in relation to research needs for the future and how scientists involved in stored product research can address those needs.

Relative importance of fumigation in integrated management of stored-grain insect pests in some EU countries (France and Germany)

Ducom, P., Frérot, E., Reichmuth, C. .......................................................... 275-294

Abstract: Fumigation with phosphine remains one of the key methods in controlling pests in stored grain. Additionally carbon dioxide and nitrogen with some residual oxygen serve this purpose to a lesser extent. Various other chemicals and methods complete the whole spectrum of integrated pest management where fumigation often presents the last option after other alternatives have failed or do not present feasible options. Grain especially in bulk as stored in silo bins or granaries over several months or even some years is target for some specialised species of insect and mite pests. Prevention, detection and control of these synanthropic pests are difficult and hardly complete. Fumigation offers an economic possibility of thorough disinfestation without moving the grain. Phosphine as a grain fumigant is threatened by resistance of progeny of sublethally treated insects. A quick test for resistance has been developed by Reichmuth to offer practitioners the opportunity to determine the degree of tolerance towards phosphine of occurring insects prior to fumigation. Proper adaptation of the dosage according to this degree of tolerance or resistance still allows complete control the pests.

The situation with phosphine in France and Germany is presented. In France, despite registration of the fumigant phosphine, contact insecticides like deltamethrin are regularly preferred as protectants to avoid later infestation of prophylactically treated grain. This prophylactic approach is not in accordance with the German food law. Therefore in Germany, contact insecticides must only be applied after infestation. Since the movement of the grain after detection of insect infestation is costly, fumigation of the stored grain, preferably with phosphine, is the method of choice. Tablets, pellets, bags, blankets, strips and plates, as well as of pure magnesium phosphide and cylinder gas (phosphine in nitrogen), are registered.

Phosphine fumigation of sunflower seeds: efficacy on insect pests and phosphine residues in seeds

Dauguet, S. ........................................................................................................... 295-298

Abstract: A study was conducted on the phosphine fumigation on sunflower seeds, in order to control insect infestation, in collaboration with the National Laboratory of Stored Foodstuffs (French Ministry of Agriculture). It was performed on two kinds of fumigations: Fumigation during storage that eliminates all stages of insects with a PH3 standard dose 1.5 g/m3, and fumigation just before bin downloading, including low-dose shock action removes only adults (PH3 dose between 0.045 and 0.09 g/m3) for foodstuffs for sale to be processed (effective control persisting during two weeks).

In order that the residual concentration of phosphine fell below the maximum residue limit in seeds (10 µg/kg), the waiting time required was variable according to the conditions of temperature and duration of the fumigation. Thus, in the case of fumigation during storage at 1.5 ppm g/m3, it takes between 3 and 30 days for complete phosphine desorption. For the fumigation just before unloading at 0.045 to 0.09 g/m3, no phosphine residues can be detected after 24 hours, whatever the temperature. For a good efficiency of phosphine gas, the temperature
of the seeds should be at least 10 °C. These two types of fumigation showed very good control of insects found in sunflower seeds. They may be integrated in IPM (Integrated Pest Management) programs for oilseed protection against possible infestation by some insect pest species.

**Physical and chemical control agent thresholds for action on storage insects**

*Bell, C. H.* ................................................................. 299-308

**Abstract:** Many factors are involved in the successful application of a control measure, whether using a chemical pesticide or whether altering the physical environment by manipulation of temperature humidity or oxygen level. Setting the dosage for a contact insecticide, fumigant or low oxygen level needs to take into account firstly the period of time insects will be exposed while factors such as temperature and humidity are also of critical importance. For any treatment to work at a particular temperature, an adequate presence of the control agent needs to be achieved and maintained where the target pest species are actually living. A spectrum of concentration threshold levels for full efficacy exists among individuals of each species and stage, some responding much earlier than others as concentrations are lowered. Threshold temperature spectra for the upper and lower limits of survival also exist, in close relationship with humidity, again individuals differing in their response.

Besides having some knowledge of the thresholds for survival, pest control operators also need to consider temperature thresholds for mobility and flight. Even light levels can have high importance. These aspects and their interrelations are discussed.

**Active cell phosphine generator SGF-M2 and fumigation technologies with its use**

*Malushkov, G., Tikhonova, L.* ................................................................. 309-314

**Abstract:** Phosphine Generator SGF-M2 is an independent physico-chemical system. The fumigant gas, phosphine, produced by the generator, is injected into the object of fumigation through tubing as a result of the chemical reaction energy and generated pressure. The total time of phosphine gas (80 g) development is 2 hours for each generator. Fumigation of grain in a silo with SGF-M2 was carried out without grain transfer using the natural convectional airstreams, driving the so-called "fumigation wave" – a high phosphine concentration region produced by the generator. The "fumigation wave" method allows reduction of the fumigant gas use and shortening the exposure time. Fumigation of grain in hopper cars with SGF-M2 takes 15 hours only.

**Improved speedbox as an effective instrument for phosphine fumigation**

*Kostyukovsky, M., Trostanetsky, A., Quinn, E., Bernstein, S., Hazan, T.*.......... 315-320

**Abstract:** Phosphine is mainly in use today for stored product insect pest control, after the phase out of methyl bromide in developed countries due to its ozone depletion effects. However, some limitations, such as low temperatures and relatively long exposure time, limit the use of phosphine. In order to overcome these difficulties, a special devise, called “speedbox” has been developed by Detia Degesch GmbH, Germany. Currently, the improved model of speedbox was evaluated for phosphine fumigation against stored product insects. The experiments were conducted in a fumigation room (15 m³) and in commercial container. Internal coleopterans *Sitophilus oryzae*, *Rhyzopertha dominica* and *Callosobruchus maculatus* and external coleopterans *Oryzaephilus surinamensis*, *Trogoderma granarium*, *Tribolium castaneum* and lepidopterans *Plodia interpunctella* and *Ephestia cautella* were used as test insects. All developmental stages of these species were tested. The used phosphine concentrations were 2-8 g of gas/m³. Exposure time was 2 to 4 d. The phosphine concentration was monitored by Bedfont device model 415 and Draeger tubes. Three phosphine gas sampling points were located at the top, middle and bottom of the fumigation room while one point was placed among the bags containing wheat or chickpeas. The temperatures of intergranular air and of the room space, as well as outdoor air relatively humidity were also recorded. At 4 g/m³, the phosphine concentrations of 370 ppm, 1100 ppm and 2000 ppm (a maximum of the monitor range) were reached just after one, 3 and 9 h from the beginning of the fumigation, respectively. At 6 g/m³, the concentrations of 1000 ppm and 2000 ppm were reached just after 3 and 6 h, respectively.
The total mortality of all tested insects and stages was recorded. In the commercial container fumigations similar results were obtained. The use of improved model of speedbox allows reaching higher by 20-30% phosphine concentrations, getting effective concentrations in a shorter time compared with the basic model and especially with the application of tablets and thus decrease the exposure time of the fumigation. The speedbox also allows to achieve an even distribution of the gas in the treated space and to enable effective fumigation at low temperatures. The use of the speedbox opens novel possibilities for phosphine fumigation also as a quarantine treatment.

Influence of egg morphology on ovicidal efficacy of fumigants

**Abstract:** There is great variability in the way eggs of different stored-product insect pests respond to fumigation treatments. Doses of sulfuryl fluoride required to kill *Carphophilus hemipterus* (L.) (Coleoptera: Nitidulidae) eggs are higher than those required to kill *Lasioderma serricorne* (Fabricius) (Coleoptera: Anobiidae), *Ephestia elutella* (Hübner) (Lepidoptera: Pyralidae), and *Amyelois transitella* (Walker) (Lepidoptera: Pyralidae) eggs. No published explanation for this variability exists. The external morphology of insect eggs has been extensively studied using the scanning electron microscope (SEM). However, these studies have focused on elucidating external morphology of insect eggs in order to develop phylogenetic relationships and to facilitate tracing origin of infestations in domestic and international trade. No studies have addressed the relationship between respiratory structures on the chorion surface that facilitate gaseous exchange and relative tolerance of insect eggs to fumigants. Therefore, the objective of our study was to use a SEM to compare the abundance, distribution, and location of egg respiratory structures of *C. hemipterus* with those of *L. serricorne*, *E. elutella*, and *A. transitella* in order to determine how respiratory structures of stored-product insect eggs may be related to their tolerance to fumigants. We found that *C. hemipterus* eggs have only two aeropyle(s) at the anterior pole, and no micropyle(s). *E. elutella* had many aeropyle(s) and a single micropyle per egg whereas each *A. transitella* and *L. serricorne* egg had many aeropyle(s) and several micropyle(s). In *C. hemipterus* eggs with only 2 aeropyle(s), the route for fumigant entry may predominantly be diffusion through the chorion whereas in *L. serricorne*, *E. elutella*, and *A. transitella* entry is mostly through aeropyle(s) and micropyle(s). Fumigant entry into eggs by diffusion through the chorion may be comparatively slower compared to entry through aeropyle(s) and micropyle(s). Although confirmatory measurements of fumigant diffusion into eggs are needed, our findings provide a possible explanation for why *C. hemipterus* eggs are more tolerant to fumigants than *L. serricorne*, *E. elutella*, and *A. transitella* eggs.

Effect of deltamethrin and spinosad on phosphine resistant strains in comparison with laboratory strains of four stored product pest species

**Abstract:** Scope of the study was information on alternative treatment against the most reported phosphine resistant species, *C. ferrugineus*, *R. dominica*, *S. oryzae* and *L. serricorne*. In Germany deltamethrin (DM) containing pesticides are registered for commodity and empty room treatment since 2011. Spinosad (SP) has been reported as promising active substance for grain protection. Tests were performed with commercially available products K-Obiol® EC 25 and Spintor®. Wheat was impregnated with solutions containing insecticide at a dose of 0.25 mg/kg DM and 1 mg/kg SP, respectively. Adults of laboratory and phosphine resistant strains from the insect stock of Julius Kühn-Institut were used for bioassays. Adults were placed on insecticide treated wheat at 25 °C and 62-65% r.h. Mortality was checked after 24 h, 48 h, and 2 weeks. Results after short exposure (24 h and 48 h, respectively) indicate mortalities below 35% in all cases. *R. dominica* generally showed highest susceptibility to the insecticides: After 2 weeks 100% mortality was achieved on DM treated substrate and about 95-98% mortality on SP treated substrate for both strains. *L. serricorne* was not notably affected by exposure to SP within its comparatively short lifetime. Differences between laboratory and resistant strains were a slightly higher mortality for resistant strains of *C. ferrugineus*, *S. oryzae* and *R. dominica* due to
SP exposure and after 2 weeks *C. ferrugineus* phosphine resistant strain showed a higher mortality (36%) compared to the laboratory strain (8%). Exposure to DM had nearly no effect to *L. serricorne* phosphine resistant strain. Results indicate that deltamethrin and spinosad principally have potential in control of phosphine resistant strains. However, a successful treatment depends on the individual species. As found by chance the coexistent resistance to phosphine and high tolerance to deltamethrin in a strain of *L. serricorne* needs further consideration.

**Improving phosphine fumigation by sealing and using a closed-loop system**

*Bonjour, E. L., Jones, C. L., Beeby, R. L.* .................................................. 337-341

**Abstract:** Failure to kill all grain-inesting insects when fumigating a storage structure occurs for several reasons: leaks in the facility, poor gas distribution, emergence of surviving insects following a poor treatment, and insect resistance. Fumigation can be improved by using a closed-loop fumigation (CLF) system where the base ducts are pressurized to force the gas mixture upward through the grain mass which provides better gas distribution through the grain. Before using CLF, the structure must be well sealed. Materials used for sealing include closed-cell foam, silicone, gray tape, 6 mil plastic attached with adhesive spray and elastomeric roof coating. Areas to seal on metal bins include aeration fan motor connections, fan inlets, fan transitions, roof eaves, sidewall seams, bin base joints, side and roof entry doors, roof vents, and CLF piping. On concrete silos, also seal downspouts, inner and outer connecting vents and manhole covers. A correctly installed CLF system will use less fumigant, save on labor costs after initial installation, and cause less worker exposure which will lead to less health costs. In a test at a concrete facility that was divided into two sections where one half received conventional treatment and the other half had a CLF system, phosphine levels reached over 2,000 ppm on the CLF side and only a maximum of 100 ppm on the conventionally treated side. Sealing and using a CLF system will save money and result in better control of insect pests.

**Residual toxicity of spinetoram on various surfaces to adult**

*Acanthoscelides obtectus* Say (Coleoptera: Bruchidae)

*Işikber, A. A., Sağlam, Ö., Çelik, A.* ................................................................................. 343

**Abstract only**

**Phosphine resistance in the Indian meal moth infesting stored dates in Tunisia**

*Mediouni Ben Jemâa, J., Eyet Limam, E.* ................................................................. 344

**Abstract only**

**Efficacy of β-cyfluthrin and chlorpyrifos-methyl plus deltamethrin applied to concrete surfaces against field strains of three stored-grain insect species**

*Sehgal, B., Subramanyam, Bh.* ................................................................................. 345-354

**Abstract:** The insecticides β-cyfluthrin and chlorpyrifos-methyl plus deltamethrin are approved in the United States for empty bin treatments prior to storing newly-harvested wheat. The susceptibility of adults of 16 field strains of the red flour beetle, *Tribolium castaneum* (Herbst); seven strains of sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.); and two strains of the lesser grain borer, *Rhizopertha dominica* (F.), collected mainly from farm-stored grain in Kansas, USA, to commercial formulations of the two insecticides at labeled rates was evaluated on concrete surfaces. Concrete-poured 9-cm diameter plastic Petri dishes were used to simulate the concrete floor of empty bins. Adults of laboratory strains of the three species were first exposed to insecticide-treated concrete surfaces for 1 to 24 h to standardize the exposure times for field strains. Based on the time required for ~ 100% mortality of laboratory strains, the adults of *T. castaneum* and *O. surinamensis* field strains were exposed to β-cyfluthrin for 24 h while *R. dominica* were exposed for 2 h. Adults of all species were exposed for 8 h to chlorpyrifos-methyl plus deltamethrin-treated concrete. Chlorpyrifos-methyl plus deltamethrin did not control all *R. dominica* and most *T. castaneum* and *O. surinamensis* field strains. β-cyfluthrin was...
extremely effective against R. dominica but ineffective against T. castaneum and O. surinamensis field strains as evidenced by low mortality and high progeny production. Exposing the two least susceptible field strains of O. surinamensis and three of T. castaneum to one to four times the high labeled rate of β-cyfluthrin resulted in only 36 to 90% mortality. Reduced susceptibility in field strains to β-cyfluthrin may be due to inherent formulation deficiency or low levels of tolerance or resistance.

A comparison of immediate and delayed efficacy of currently used chemical insecticides with bio-based or mineral alternative active substances for stored-grain insect control
Fleurat-Lessard, F., Fuzeau, B., Serrano, B. ............................................................. 355-360

Abstract: A comparative study was performed in treating 50-kg wheat batches either by currently used contact insecticides or by non-synthetic alternative active substances (a.s.) for control of stored-grain pests (Sitophilusoryzae and Rhyzoperthadominica). The first group of a.s. was: cypermethrin (CYP), chloropyriphos-methyl (CM), deltamethrin (DM), natural pyrethrins (synergized or not), and pyrimiphos-methyl (PM); the second group of a.s. was: methoprene (with CM), diluted neem oil, spinosad (with or without CM), DE, and silicagel + Sodium bicarbonate. Two series of assays were performed: the first series was destined to the evaluation of immediate efficacy of a.s. on the target insects (curative treatment), and the 2nd series was destined to evaluate the duration of complete protection of treated grain against an external infestation (preventive treatment). The trials were performed in accordance to official method of testing grain insecticides (French AFPP-CEB Method N° 106).

With the two organo-phosphates (CM and PM), the efficacy of curative treatments was near 100% on S. oryzae, but less than 65% for R. dominica, 7 d after treatment. For the pyrethroids (CYP and DM), complete mortality of the two insects was obtained up to 8 weeks after treatment. Natural pyrethrins and spinosad (alone) effectively controlled R. dominica. In the case of preventive control assay, either organo-phosphates or pyrethroids appropriately controlled S. oryzae for 6 months. R. dominica adult mortality with organophosphates was ≤ 58% immediately after treatment. However, the survivals were not able to reproduce (observed on the two species). Among alternative non-synthetic a.s., only spinosad (dose 1.0 mg/kg) and synergized pyrethrins exhibited a significant efficacy, the former when associated with CM at half registered maximum dose (1.625 mg/kg), spinosad alone at 1.5 mg/kg being active on R. dominica, only. These results should facilitate the selection of appropriate a.s. for the control of identified grain-insect-pest species.

Feeding deterrent activity of new alpha-asarone congeners designed using a molecular modeling towards insect storage pests
Łozowicka, B., Kaczyński, P. ........................................................................... 361

Abstract only

Weevil x insecticide: Does 'Personality' matter?
Morales, J. A., Guedes, N. M. P., Della Lucia, T. M. C., Guedes, R. N. C. .............. 362

Abstract only

Phosphine resistance in rusty grain beetles, Crytopolestes ferrugineus (Stephens), (Coleoptera: Laemophloeidae) from stored wheat in Oklahoma
Konemann, C. E., Opit, G. P., Shakya, K., Bajracharya, N. S. .................................. 363-366

Abstract: Phosphine gas, or hydrogen phosphide (PH₃), is the most common insecticide applied to durable stored products worldwide and is routinely used in the U.S. for treatment of bulk-stored cereal grains and other durable stored products. Research from the late 1980s revealed low frequencies of resistance to various residual grain protectant insecticides and to phosphine in grain insect species collected in Oklahoma. Recent research conducted using populations of stored-product insects collected from Oklahoma commercial grain storage facilities showed that one Tribolium castaneum (Herbst) (Coleoptera: Tenebrionidae) population was 119-fold more
resistant than the susceptible strain and a population of *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae) that was over 1,500-fold more resistant. The present work, which employed the same previously established protocols for phosphine toxicity as in earlier studies, evaluated adults of 13 populations of *Cryptolestes ferrugineus* (Stephens) (Coleoptera: Laemophloeidae), collected from four counties in the state of Oklahoma. All the 13 populations were resistant to phosphine. Two of the populations showed extremely high resistance frequencies of up to 100%. Future research will focus on conducting a wider survey of phosphine resistance in *C. ferrugineus* from Oklahoma and to perform dose-response tests to determine levels of resistance in field-collected populations with high resistance frequencies.

**Insecticidal effect of chlorantraniliprole against major stored product insect pests in different grain commodities**  
*Kavallieratos, N. G., Athanassiou, C. G., Boukouvala, M. C.*  
367  
Abstract only

**Insecticidal efficacy of thiamethoxam against *Tribolium confusum* Jacquelin du Val**  
(Coleoptera: Tenebrionidae) adults on concrete  
*Kavallieratos, N. G., Athanassiou, C. G., Markoyiannaki-Printziou, D., Goundy, V.*  
368  
Abstract only

**Determination of hexamethylenetetramine in foods by gas chromatography-mass spectrometry**  
*Lim, H.-S., Choi, J.-C., Shin, D.-W., Oh, J.-M., Song, S.-B., Kim, M.*  
369  
Abstract only

**Session 6: Integrated protection of stored products, decision support tools and integrated approach**

**Does hermetic grain storage make sense in Central Europe?**  
*Adler, C., Ndome-Moualeu, A. F.*  
373-377  
Abstract: In a national research project we intend to determine the efforts needed to render horizontal grain storages hermetic following the Australian example. The effects that this may have on the quality of grain stored for several years will be monitored. Another aspect of the project is a laboratory study on vacuum packaging and the effects of various residual oxygen contents and different grain moisture contents on wheat quality. This is done in order to identify suitable methods for long-term grain storage with a mechanical barrier avoiding pest attack. The long-distance orientation of stored product insects is usually influenced by volatile cues. During the project grain volatiles are determined in and around grain storages to prove the correlation between a gradient of attractive volatiles and attack by flying insects. The long-term grain storages tested may be a model for storages of organic grain that can achieve a higher market price per ton but also for grain storage in general. Since in 2007/2008 the world-market value of grain doubled, an improved grain storage technology may be economically even more advisable than before.

**Decision support tools and IPM in food chain**  
*Trematerra, P.*  
379-393  
Abstract: There are a number of tools available for pest management in stored product protection and in the food industry, but often the effectiveness of these approaches and how best to integrate them into a coherent and effective Integrated Pest Management (IPM) programme are not well understood. Limited acceptance of IPM in food facilities is partially explained by a combination of: costs of responsive pest control interventions; difficulty in sampling properly combined with unreliable sampling data; calculations of action thresholds being too simplistic. In
operational practice precise treatment thresholds and economic injury levels have not been developed, and standards and rejection criteria are inconsistent and difficult to apply. As a result, treatments based on an economic threshold are not typically performed and control strategies are often applied preventively, even when using tactics that do not have any residual effect. In current practice, many locations still rely on calendar-based pesticide applications and have little understanding of the basis of pest management. The main objectives of the paper are to analyse aspects related to decision support tools in stored-product protection and their integrated application in practice.

Technical and economic analysis of pest management practices for stored wheat in 14 grain elevators in France

Vancrayenest, L., Frérot, E., Crépon, K. .................................................. 395-402

Abstract: Technical audits were achieved in 14 grain elevators in order to record pest management practices and to evaluate the cost of insect control management practices. Stored grain elevators that were selected for this study were representative of the different ways of insect pest prevention and control system in France. The selection of storage sites was based on the results of a previous study led on 95 elevators that identified 6 key-factors correlated with pest infestation: type of storage bin (vertical silo or ‘flat’ store), preventive sanitation of empty storage structures, grain cleaning, grain aeration, insecticide treatment on grain, grain temperature monitoring equipment. By combining these 6 factors, 7 modalities of pest management have been described. For each modality, two grain elevators that theoretically apply each modality have been sampled among the 95 elevators surveyed in Leblanc et al. surveys in 2010 and 2011. The evaluation carried out after the visit of the selected storage facilities revealed that pest management was mainly based on chemical treatment whatever the kind of insect management system was applied. Although all the visited elevators were equipped with ambient-air aeration systems, the airflow rate and the cooling time were often found inadequate to efficiently cool all stored grain bins. Grain cleaning cannot be made systematically at reception because harvested grain lots needing cleaning are delivered at a much higher rate than the grain cleaner can receive. Pest management costs were assessed in the range 0.17 €/t to 1.19 €/t, according to the 7 modalities. The major variation factor was the type of pesticide used. The economic loss related to price penalties in the case of quality defect at the supply of domestic or export grain markets for cereals are not considered as a driving factor for insect pest management policy adaptation by grain-elevator managers.

Influence of grain storage practices or kind of structure and pesticide use on insect presence in wheat bulks after a long-term storage: a multi-dimensional analysis

Leblanc, M.-P., Fuzeau, B., Fleurat-Lessard, F. ................................................. 403-420

Abstract: A survey of stored-wheat bulks in France was carried out during two years in the spring seasons of 2010 and 2011 to improve the knowledge about the relationships between grain storage practices, preventive sanitation, grain insecticidal treatment, stored-grain temperature management, and presence of insect species in grain samples. Ninety-four wheat storage sites were surveyed each year (after 8-9 month storage). Besides the quantitative analysis of grain samples for insect presence and residue content, a questionnaire was submitted to grain-store managers to record their storage practices, the characteristics of their equipment for grain quality preservation, and the preventive and corrective means they use for insect control. The data from these two groups of variables were processed in a multidimensional statistical analysis to reveal significant correlations between grain management practices for sanitary quality maintenance and the level of presence of insects in wheat samples.

A strong relation was observed between the kind of storage structure and the frequency of insect presence in wheat samples. Flat storage of large grain bulks was the most risky storage structure vs. vertical storage in metal or concrete bins. A relationship was observed between the frequency of insect presence in samples and stored grain temperature levels and also with the lack of temperature measurement equipment installed inside grain bins linked to cooling aeration.
systems. Preventive sanitation before the grain harvest period, i.e. systematic cleaning and insecticide spraying of unfilled bins, was related to 50% reduction of insect presence in corresponding grain samples. The preventive chemical treatment of harvested grain before long-term storage was not related to a limitation of insect presence in samples taken after 8-9-month storage period. The results of this representative survey give objective arguments for the implementation of good IPM practices and risk prevention for grain sanitary quality preservation during long-term storage periods.