

IOBC/wprs Bulletin Vol. 25(3) 2002

Working Group „Integrated Protection in Stored Products“, Proceedings of the meeting in Lisbon (Portugal), 3 – 5 September, 2001. Edited by: C. Adler, S. Navarro, M. Schöller & L. Stengard-Hansen. ISBN 92-9067-140-6 [xii + 267 pp.]

Species richness and pest control complexity: Will multispecies infestations always require a „multi-bioagent“ control?

V. Stejskal, J. Hubert, J. Luká..... 1

Abstract: A huge number of pest species is associated with stored commodities. In a particular store one may expect a permanent occurrence of many pest species. Control of multi-species infestations by multi-bioagent control will increase pest control complexity, and decrease the acceptance of this strategy by farmers. Therefore, the aims of this paper were to (i) analyze factors which may affect the complexity of bio-control, and (ii) to explore the pest-species richness and chance for their bio-control in stores in the Czech republic (CZ).

Fifty-six arthropod species, 31 insect and 25 mites, were found during a recent faunistic research of stored product pest (SPP) in CZ. However, only few pest species were present at particular stores. Samples of commodities taken from stores (1 sample = 1 chamber of silo/flat store) were most frequently infested by 1 followed by 2 and 4 pest species, 23 % took uninfested samples. In stored grain we found prevalent (23%) the “single species” infestation of stored grain and 18 % of samples was infested by 2 species.

The multi-species infestation potentially requires more complex management. Nevertheless, it seems that the control of multi-species infestation by several biological agents is necessary only if the Acari-Insects occur together. The “Acaro-complex” may be managed by a single predator *Cheyletus eruditus*. Among insects only the bio-control of Coleoptera is available and necessary. This can be accomplished by an augmentation of one or two species of polyphagous parasitoids (e.g. *Lariophagus distinguendus*, *Anisopteromalus calandrae* or *Holepyris sylvanidis*). Lepidoptera is now economically unimportant in stored grain of CZ. The bio-control of Psocid-complex is not known.

Introducing biological of control of SPP in CZ is probably less difficult than it may be expected from considering only the species richness of SPP pests.

Key words: biological control, stored pests, beetles, parasitoids, predators.

Pheromones and Integrated Pest Management in stored products

P. Trematerra..... 9

Abstract Crucial factors for Integrated Pest Management (IPM) in stored-products include understanding factors that regulate systems, monitoring insect populations, maintaining good records and using this information to make sound management decisions. The employment of pheromones is one of the most promising techniques aimed at the control of stored-product pests. These substances can lead to a drastic reduction of chemical treatments, thus determining remarkable economic advantages and improvement of product quality, protecting goods from residual insecticides noxious to the consumer. In recent years, considerable progress has been made in the monitoring and control of stored-product insects, Coleoptera and Lepidoptera, by pheromones also used in mass-trapping, attracticide (lure and kill) and mating disruption methods. In stored-product IPM different tolerance thresholds should be established for the various pests depending on their economic impact and on the "filiere place" where they are found. If a limited number of insects can be tolerated at times in a warehouse containing raw materials, in food-processing plants and warehouses containing finished products, the threshold must be necessarily zero. In that context, "insectistasis" can be readily achieved by continual supervision of environments by traps in combination with a limited number of preventive and curative measures appropriately timed.

Key words: Pheromones, insects, stored products, IPM.

The use of entomopathogenic fungi for stored product pest control - The "MYCOPEST" project

K. B. Wildey, P. D. Cox, M. Wakefield, N. R. Price, D. Moore, B. A. Bell..... 15

Abstract The need to find alternatives to conventional pesticides for stored product pest control has been recognised by the UK Government and Industry, in a jointly funded 'LINK' project of four years duration. The project focuses on the use of entomopathogenic fungi to control residual

infestation in storage structures. Samples of UK sourced, insect specific, fungi have been tested against beetles, psocids, moths and mites in the laboratory. Some strains of fungus have achieved 100% kill of test insects and mites 10 days after initial contact. Results to date have indicated levels of activity that could lead to development of a practical mycopesticide against stored product pests.

Key words: Entomopathogenic fungi, stored product pests, *Beauveria bassiana*, *Oryzaephilus surinamensis*, *Lepinotus patruelis*, *Ephestia kuehniella*, *Acarus siro*

Integration of chemical control of cockroaches and biological control of stored-product moths

M. Schöller, A. Reppchen, S. Prozell, A. Beckmann21

Abstract In many situations, stored-product and urban pests occur simultaneously. Cockroaches like the German cockroach *Blattella germanica* or the Oriental cockroach *Blatta orientalis* are common pests in bakeries, food processing facilities and kitchens. As these cockroaches are potential vectors of diseases, they have to be controlled completely. Traditionally, cockroaches are controlled by spraying contact insecticides. Modern approaches include microencapsulated insecticides formulated within a food-bait. For the biological control of stored-product moths the egg-parasitoid *Trichogramma evanescens* is applied commercially in several countries in Europe. *T. evanescens* is known to be very susceptible to contact insecticides, and no strategies of integration of chemical and biological have been described so far for stored-product protection. Therefore, possible side effects of microencapsulated insecticides on *T. evanescens* have been tested. In Germany, three compounds have been shown to be effective against the German cockroach, Fenitrothione, Hydramethylnone and Fipronil. For testing side effects of these insecticides in the laboratory, the guidelines of the IOBC were applied. However, as these guidelines are designed for sprayed insecticides, a suitable modification for the microencapsulated insecticides had to be found. All three insecticides were found to have no side effects on *T. evanescens*, i.e. parasitism and emergence of progeny was not affected. Therefore, the release of *T. evanescens* and the application of the three mentioned microencapsulated insecticides is a promising strategy to integrate chemical control of cockroaches and biological control of stored-product moths.

Key words: stored product protection, urban pests, *Blattella germanica*, *Trichogramma evanescens*, Integrated Pest Management

Stored insect pests in traditional cultivated hulled wheat crop areas of Central-Southern Italy with emphasis on *Sitotroga cerealella* (Olivier)

P. Trematerra, P. Gentile.....27

Abstract: Results of studies carried out on stored insect pests of hulled wheat (*Triticum dicoccum* Schübl., *T. monococcum* L. and *T. spelta* L.) in traditional crop areas of Molise and Basilicata regions (Central-Southern Italy) were reported. Surveys were carried out from 1993 to 2001 in about 50 warehouses of small farms and food factories. Stored hulled wheat revealed infestations of about 20 insect pests. *Trogium pulsatorium* L. (Psocoptera); *Ephestia elutella* (Hb.), *Plodia interpunctella* (Hb.), *Sitotroga cerealella* (Olivier) (Lepidoptera); *Cryptolestes ferrugineus* (Sph.), *Oryzaephilus surinamensis* (L.), *Rhyzopertha dominica* (F.), *Sitophilus granarius* (L.), *S. oryzae* (L.) and *Tribolium castaneum* (Herbst) (Coleoptera) were more frequently found. Among these species the ecology of *S. cerealella* has been studied. The angoumois grain moth infestations can occur during both preharvest and postharvest storage. Using pheromone traps (delta types) baited with 1 mg of Z7E11-16Ac, observations on adult flights in fields of hulled wheat were carried out. The results obtained showed various levels of infestation, with different population abundance, according to the considered areas. In two fields located in Molise region, *S. cerealella* developed two generations before harvesting; the presence of adult males was recorded also after harvesting, until the beginning of September. Moths' activity suggests adult dispersal from the warehouses to hulled wheat fields.

Key words: Stored insects, *Sitotroga cerealella*, traditional warehouses, Central-Southern Italy.

Corcyra cephalonica (Stainton) - an overlooked pest?

D. Bartels.....33

Abstract One part of the investigation focussed on the development of *Corcyra cephalonica* on cocoa beans and its limiting factors. Four different factors were studied: 2 and 10 first instar larvae

were placed on cocoa beans taken from two different lots (from Ivory Coast and from Papua New Guinea), with damaged and with intact testae, conditioned and held at 50 ± 5 % and 87 ± 5 % r.h., at $30 \pm 1^\circ\text{C}$. Infestation rate and number of imagoes hatched per bean were influenced mainly by the condition of the testae and the moisture content. The first instar larvae were hardly capable of infesting infest raw cocoa with intact testae. Testae the damp beans could be attacked more easily. The developmental time depended mainly on the cocoa qualities, ranging from 31 d on damp cocoa beans from Ivory Coast to 144 d on dry beans from Papua New Guinea. Best results of - larval development were reached on cocoa beans from Ivory Coast with damaged testae and by two inserted first instar larvae: 50 % completed development at 87 ± 5 % r.h. with a mean of 35.5 d, 80 % at 50 ± 5 % r.h. with a mean of 48.2 d. The cocoa quality did not seem to n the oviposition rate. The mated females laid an average of 231.3 (± 81) eggs, with a maximum of 431. In further experiments it was observed that later instar larvae could easily spread even on dry cocoa beans with intact testae. In a two-choice arena, the females did not prefer damp to dry cocoa beans for oviposition. They strongly preferred crevices for oviposition and avoided laying eggs on smooth surfaces. The chemical stimuli of the cocoa beans seemed to be less important, as a similar oviposition response could be elicited by gauze. There are two aspects of the exhibited behaviour contributing to inconspicuous development of infestations: solitary larvae did not migrate before pupation and females ceased flight activity soon after mating.

Key words: cocoa beans, *Corcyra cephalonica*, oviposition, pest status, rice moth

Insects and mites of stored products in the northeast of Spain

J. Riudavets, É. Lucas, M. José Pons.....43

Abstract: Insects and mites associated with stored products were surveyed from 1999 to 2001 in the northeast of Spain. Sixty-two samples from several cereals, dried fruits, legumes, herbs, spices and processed food products were collected in 11 localities. A total of 29 species of arthropods representing six orders and 15 families were found, predominantly Coleoptera and Lepidoptera. Among pests, the rice weevil, *Sitophilus oryzae* (L.) and the lesser grain borer, *Rhyzopertha dominica* (F.) were the most abundant species in stored cereals. The cigarette beetle, *Lasioderma serricorne* (F.), the rust-red flour beetle, *Tribolium castaneum* (Herbst), the sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.) and the Indian meal moth, *Plodia interpunctella* (Hübner) were the most numerous and widely distributed species sampled in residues of food products. One predatory mite and five Hymenoptera species were considered to have potential for biological pest control.

Key words: survey, stored product pests, natural enemies, northeast of Spain

The feeding interactions of astigmatid mites (Acari: Astigmata) and microfungi in stored grain habitats (Mini-Review)

J. Hubert, J. Mourek.....47

Abstract: Stored grain represents anthropogenic habitats; consisting of (i) grain, (ii) plant debris, (iii) microfungi and (iv) arthropods. The microfungi growing on the grain may serve as a possible food source for the astigmatid mites. **The interaction between the mites and fungi includes 3 main topics. (1) The fungi could serve as possible food sources for astigmatid mites. The mites need specific digestive enzymes to utilize fungal food sources. (2) The fungi differ in their attractiveness and palatability due to the content of mycotoxins and secondary metabolites in fungal cells. There are differences between spores and mycelium in microfungal species. Some microfungal spores are passed through the mites gut without digestion. (3) The mites strongly influence fungal mycelium by grazing.** The numbers of microfungal colonies might change after the infestation of the stored grain by mites. The mites also disperse fungal spores on their bodies and in their faeces, however due to their small moving distance the dispersion can not be so important in stored grain habitats. The positive effect of mites feeding on mycelium respiration was reported in the conditions of nutrient rich substrates and patches distribution of microfungi. **The knowledge of the interactions of mites and fungi from the field and laboratory observations is reviewed and applied into the stored grain habitats.**

Key words: mites, grain, fungi, feeding, digestive enzymes

Survey and estimate of moth population density in a flour mill in Cape Verde Islands

A. Paula Pereira, M. Otilia Carvalho, J. Rodrigues, A. Mexia53

Abstract: A survey was conducted in a flour mill in Cape Verde Islands and a total of 11 species of insects and mites were found. The most common species were *Tribolium confusum* and *Corcyra cephalonica*. Pheromone traps were used to estimate moth population density at different points within the flour mill in Cape Verde. *Ephestia cautella* was the dominant species on wheat silos while *E. kuehniella* was a significant pest throughout the milling process. Adults of *E. kuehniella* occurred within the flour mill during the entire year. The index of dispersion indicated that the adults might follow the aggregate pattern, at high relative densities. With the decrease of mean trap catches the adult males' populations seemed to be randomly or uniformly dispersed.

Key words: pheromone trap, *Ephestia cautella*, *Ephestia kuehniella*, flour mill, spatial pattern

Density and spatial pattern of cigarette beetles and tobacco moths in Cape Verde Islands

M. Otilia Carvalho, A. Paula Pereira, F. Santos, A. Mexia65

Abstract: Pheromone traps were used over a 2-year period to study the density and spatial pattern of *Lasioderma serricorne* and *Ephestia elutella* in a cigarette factory located in Mindelo, Cape Verde Islands. Under such subtropical conditions, *L. serricorne* was considered to be a major pest of tobacco while *E. elutella* was a minor pest. *E. elutella* was recorded occasionally in the regular monitoring and trap catches were very low. The relative population density of *L. serricorne* was high during these trials and the spatial pattern tends to be aggregated.

Key words: pheromone traps, *Lasioderma serricorne*, *Ephestia elutella*, stored tobacco, population density, spatial pattern

Population fluctuations of *Lasioderma serricorne* and *Ephestia elutella* in stored tobacco

M. Otilia Carvalho, A. Paula Pereira, A. David, A. Mexia73

Abstract: Fluctuations in the population densities of *Lasioderma serricorne* and *Ephestia elutella* in stored tobacco were recorded from pheromone trap catches. Both species occurred together and feed on stored tobacco. Seasonal changes in population size are discussed and may result from variations in the external physical environmental factors.

Key words: pheromone trap, *Lasioderma serricorne*, *Ephestia elutella*

A survey of mycological, entomological and storage conditions in agricultural stored products in São Tomé e Príncipe

A. Magro, C. Mateus, A. Maia, E. Luna de Carvalho, A. Lima, I. Paquete, R. Oliveira, C. Rodrigues Júnior, A. Mexia81

Abstract: Fluctuations in the population densities of *Lasioderma serricorne* and *Ephestia elutella* in stored tobacco were recorded from pheromone trap catches. Both species occurred together and feed on stored tobacco. Seasonal changes in population size are discussed and may result from variations in the external physical environmental factors.

Key words: pheromone trap, *Lasioderma serricorne*, *Ephestia elutella*

Current status of temperature control in port terminal silos in the Cape Verde Islands

A. Maia, A. Barbosa, A. Paula Pereira, P. Cardoso, A. Mexia87

Abstract: Cape Verde is an archipelago of ten islands located in the Atlantic Ocean, 750 km west of the Senegal coast. The country is largely dependent on cereals, importing around 70-90% of its needs, with maize being the most important with 60-70% of all cereals imported.

The storage system comprises both bulk and bag storage. Two port terminal elevators in two distinct islands guarantee the receiving in bulk from ships and grain storage in bulk for variable periods. Stores along all islands guarantee an additional storage capacity as well as grain handling in bags. One of the port terminal elevators is located in Praia – the capital of Cape Verde – in the Santiago Island, and the other in Mindelo in the S. Vicente Island.

Analysis of data from 1998 to 2000 of the Praia port terminal elevator showed that maize for human consumption, mostly white dent, was stored for longer periods than maize for animal feed, mostly yellow. The respective upper limits of allowed initial moisture content, for storage, of 12.5 %, w/w and 14 %, w/w were largely determinant on the storage length. Although the temperatures were recorded only daily, in some aerations it was possible to follow the cooling/heating front. In some situations, fumigation, bin transfer and aeration made it possible to extend the periods of storage in safe conditions.

Insects and mites associated with stored products and their arthropod parasites and predators in Khuzestan province (Iran)

B. Habibpour, K. Kamali, J. Meidani89

Abstract During 1999–2000, a faunistic survey was conducted in Khuzestan province, Iran to collect and identify insects and mites, including pests and their natural enemies associated with stored products. The faunal studies provided a fundamental knowledge for a better understanding of ecological aspects. The identified species are listed in 3 categories: I) Destructive insects and mites, a total of 29 species from 20 families belonging to 8 orders were collected and identified; II) Insect predators and parasitoids, *Xylocoris* sp., *Habrobracon hebetor*, *Habrobracon brevicornis*, *Choetospila elegans*, *Pteromalus* spp., *Anisopteromalus* spp., *Cephalonomia tarsalis*, *Laelius anthrenivorus*; III) Predatory mites: *Hypoaspis (Geolaelaps) aculeifer*, *H. (Pneumolaelaps) sclerotarsa*, *Proctolaelaps pygmaeus*, *Macrocheles* sp., *Acaropsis docta*, *Cheyletus malaccensis*.

Key words: stored products pests, parasitoids, predatory mites, Iran

Modular design of “Standard Pest-Monitoring Procedure”

V. Stejskal93

Abstract: IPM is based on cost benefit analyse. Full costs of monitoring therefore should be included into decision-making process. In this paper is proposed a modular design of “standard pest-monitoring procedure (SPMP)” which enables the flexible economic evaluation of pest monitoring. Economical optimisation of pest monitoring and sampling in stored product environment is discussed.

The use of light traps for monitoring flies in a cheese industry in Sicily

A. Russo, M. Candida Vasta, A. Verdone, G. Eros Cocuzza99

Abstract Species composition and population dynamics of Diptera infesting a dairy in Sicily were monitored weekly using light traps from November 1998 to October 1999. During the year, mean captures of Diptera were highest in November (2185.5) at the beginning of the study. From December to March, population of flies were strongly depressed. In April and May the mean captures increased rapidly (from 321 in March to 876 in May), maintaining these values until October (1538). The highest number of pests were recorded in the production area of cheese. A brief comment is given for each species recovered more frequently.

Key words: Diptera, Muscidae, Phoridae, Sphaeroceridae, Psychodidae, Fannidae, Milichidae, IPM.

Trichogramma turkestanica against *Ephestia kuehniella* in flour mills: extent of host-feeding and initial results of a field trial

L. Stengaard Hansen, K.-M. Vagn Jensen105

Abstract The Mediterranean flour moth *Ephestia kuehniella* is a major pest in European flour mills. The possibilities for biological control of *E. kuehniella* have been investigated. The egg parasitoid *Trichogramma turkestanica* has been subjected to studies concerning the relationship between temperature and parasitism and host-feeding. *T. turkestanica* females killed between 1.7 and 9 host eggs by host-feeding per day, the number increasing with temperature in the range 15°C and 30°C. A field trail was conducted with this natural enemy in an industrial flour; parasitoids were released in flour rooms in two silo buildings. The results varied in the four rooms. Data are being analysed to find an explanation to the different results.

Key words: flour mills, biological control, *Ephestia kuehniella*, *Trichogramma turkestanica*, egg parasitoid

Oviposition of *Venturia canescens* (Gravenhorst) (Hymenoptera:

Ichneumonidae) parasitizing the Indian meal moth *Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae)

G. Heinlein, M. Schöller, S. Prozell, Ch. Reichmuth109

Abstract: The Indian meal moth *Plodia interpunctella* causes severe damage to stored agricultural products and raw materials for food production like nuts, dried fruits, cocoa beans and even cereal grain. Residue-building contact insecticides or fumigants like phosphine serve as chemicals of choice for the control of this pest. The parasitic wasp *Venturia canescens* has been identified as a natural enemy of larvae of the Indian meal moth and other pyralid moths. Parasitism is a key factor for the evaluation of the suitability of this wasp for biological control. This aspect was investigated at different temperatures and feeding conditions. Ten last-instar larvae of *P. interpunctella* were exposed to one wasp for 4 h. This was repeated at 24 h-intervals until the wasps died. Of the larvae exposed, 76, 56 and 76% were parasitised at 20°C without honey, 20°C with honey and 25°C with honey, respectively. The wasps deposited a maximum of six and eight eggs per host at 20°C and 25°C, respectively. The maximum number of eggs laid per day was 23, 30 and 31 at 20°C without honey, 20°C with honey and 25°C with honey, respectively. The maximum number of progeny per female, 159, was recorded at 20°C with a honey-fed parasitoid. Increasing the temperature from 20°C to 25°C led to deposition of twice as many eggs. Honey as additional diet increased parasitism. Interestingly, the development of the larvae was adjusted to the speed of development, which led to survival of the wasp during winter in diapausing host larvae.

Key words: stored product protection, biological control, endoparasitoid, diapause, oviposition.

Effectiveness of the wasp *Lariophagus distinguendus* Förster (Hymenoptera: Pteromalidae) in biological control of the weevil *Sitophilus granarius* L. (Coleoptera: Curculionidae) in stored grain

A. Reppchen, Ch. Reichmuth, M. Schöller, S. Prozell, J.L.M. Steidle115

Abstract: Reproductive capacity and longevity of *Lariophagus distinguendus* Förster (Pteromalidae) was examined under different conditions in the laboratory with larvae of the granary weevil *Sitophilus granarius* L. (Curculionidae) as hosts. Reproductive capacity varied largely between *L. distinguendus* strains of different origin. Longevity was increased in the presence of hosts, probably due to host feeding by the parasitoids. Different host-parasitoid-ratios were investigated in order to promote the determination of the number of parasitoids necessary to be released for a successful use in practice. The results were discussed with respect to the potential use of *L. distinguendus* for the biological control of the granary weevil.

Key words: *Lariophagus distinguendus*, *Sitophilus granarius*, Biological control, Stored grain, Fecundity, Longevity

Biological control potential with native *Dinarmus* wasp species in grain legumes stored on farm

S. Dorn, D. Schärer, I. Schmale, F. Wäckers, C. Cardona, S. Ignacimuthu119

Abstract: Grain legumes stored on-farm in the tropical belt are prone to infestation by bruchid weevils, often even before harvest. When left untreated, weevil populations can grow exponentially and can completely destroy crops within a few months. Non-toxic means of control offer particular promise as they are safe for handling and for the consumer (Dorn, 1998). Efficacy, reliability and environmental safety may, however, be critical issues.

We identified native *Dinarmus* wasp species (Hymenoptera: Pteromalidae) as effective natural antagonists of bruchid weevils both in Columbia and India, thus did not have to introduce exotic species with their inherent risk for non-target insects. *Dinarmus* spp. destroy their host by both oviposition and host feeding (Schmale *et al.*, 2001). Host feeding adds an interesting aspect to biological control as it can lead to a rapid elimination of the pest population, and to an eradication of any insect in the stored good within one generation. To increase reliability of the control under variable conditions, the combination of biological control with host plant resistance has been examined. The promise of such integrated control programs is discussed.

Predation by *Blattisocius tarsalis* (Acari: Ascidae) on stored product pests

J. Riudavets, M. Maya, M. Monserrat121

Abstract: Studies were conducted on the predation of *Blattisocius tarsalis* (Berlese) on several stored product pests under controlled laboratory conditions. Adults of *B. tarsalis* were able to prey on eggs of the mould mite (*Tyrophagus putrescentiae* (Schrank)), the Indian meal moth (*Plodia interpunctella* (Hübner)), the Mediterranean flour moth (*Ephesia kuehniella* Zeller), the cigarette beetle (*Lasioderma serricorne* (Fabricius)), the rusty grain beetle (*Cryptolestes ferrugineus* (Stephens)), the rust-red flour beetle (*Tribolium castaneum* (Herbst)), the bean weevil (*Acanthoscelides obtectus* (Say)), and first instar nymphs of the booklouse (*Liposcelis bostrychophila* (Badonnel)). Functional responses of *B. tarsalis* females to eggs of *P. interpunctella* and *L. serricorne* were compared. Results suggested a type II functional response. Attack coefficients of *B. tarsalis* on the two prey species were not significantly different. As opposed to this, *B. tarsalis* spent less time handling eggs of *L. serricorne* than eggs of *P. interpunctella*.

Key words: Predation, functional response, biological control.

Occurrence of Hymenopterous parasitoids of stored product pests in Greece

P. A. Eliopoulos, C.G. Athanaïou, C.H. Buchelos127

Abstract: During a two-year survey on the insect fauna of stored products in Greece, sixteen species of hymenopterous parasitoids were collected on various stored products from different localities. The survey was conducted on grain, flour, legumes, tobacco and dried fruits stored in varying quantities and different types of storage facilities, flourmills and household stores. All parasitoid species collected, are recorded for the first time in Greece. The highest percentage of parasitoid presence was recorded in dried fruits, tobacco and flour. Eight parasitoids attacked coleopterous hosts, six attacked lepidopterous ones and two species attacked both. The most dominant wasps were, in decreasing order, *Holepyris sylvanidis* (Bréthes) (Bethyridae), *Anisopteromalus calandrae* (Howard) (Pteromalidae), *Venturia canescens* (Gravenhorst) (Ichneumonidae), *Cephalonomia tarsalis* (Ashmead) (Bethyridae) and *Theocolax (Choetospila) elegans* (Westwood) (Pteromalidae). The most frequent parasitoid was *A. calandrae* followed by *H. sylvanidis*, *Th. elegans*, *V. canescens*, *Habrobracon (Bracon) hebetor* Say (Braconidae) and *C. tarsalis*. The phenomenon of co-occurrence of two or more parasitoids was observed in many cases. The most common pairs of coexisting wasps competing for the same host were: *A. calandrae* - *Th. elegans*, parasitizing *S. oryzae* and *R. dominica*, *H. sylvanidis* - *C. tarsalis*, parasitizing *Tribolium* sp., *Oryzaephilus* sp. and *Cryptolestes* sp. and *V. canescens* - *H. hebetor*, parasitizing moth larvae.

Key words: stored products, parasitoids, biological control, dominance, frequency, co-occurrence, Greece

Bugs in space: aspects of the system *Callosobruchus maculatus* (Col.:

Bruchidae) and *Uscana lariophaga* (Hym.: Trichogrammatidae) in stored cowpea

C. Stolk, W. van der Werf., A. van Huis141

Abstract: We have studied and described the following spatial aspects of the interaction between the bruchid *Callosobruchus maculatus* and its natural enemy *Uscana lariophaga* in stored cowpea: the three-dimensional spatial oviposition pattern of individual *C. maculatus* females; foraging behaviour of *U. lariophaga*; and host finding behaviour of *U. lariophaga*. The results are discussed from the perspective of the foraging behaviour of *U. lariophaga* in stored cowpea.

Key words: cowpea, *Callosobruchus maculatus*, *Uscana lariophaga*, spatial oviposition pattern, foraging behaviour, host finding

Determination of stability of essential oil constituents as repellents

I. Tunç, F. Erler145

Abstract: Chemicals that exert repellent activity offer two advantages in stored product environments: Contamination of stored food by material applied is minimized as it may take place only by repellent particles suspended in air, and food, presumably, is protected without contamination by pests. Repellents are, however, desired to show a long lasting activity for long term protection of food in closed spaces of storages. A system that allows to test activity of known concentrations of repellents in air at given intervals of time with minimum loss of material during run of tests was designed in order to determine stability of repellent activity. The device consists of a glass Y-tube with arms, one connected to a repellent containing jar and the other one to a control jar. A low rate air movement was created by sucking the air in jars through arms of the Y-tube with a peristaltic pump connected to the stem (main arm). The lowest air flow rate that gave the highest difference between numbers of test insects preferring one of the arms was 0.33 ml/s in main arm of the olfactometer and the shortest period needed for the highest number of insects to make a preference between the arms of olfactometer was 90 seconds in tests conducted on *Tribolium confusum* du Val adults using essential oil constituents. Repellency of 8 essential oil constituents anethole, carvacrol, 1,8 cineole, *p*-cymene, menthol, α -terpinene, terpinen-4-ol and thymol was tested 5 times within a period of 8 weeks, at the beginning, at the end of 1th, 2th, 4th and 8th weeks. Approximate total loss of material during run of tests was estimated 10% after 8 weeks. Loss of material can be reduced further by using jars of larger capacity. All compounds showed repellency in varying degrees against *T. confusum*. Repellency of all compounds gradually decreased as the time passed.

Potentials of cinnamaldehyde and methylchavicol as grain protectants against four insect pests of stored products

P.C. Ojimekwe, C. Adler147

Abstract The efficacy of cinnamaldehyde (zimtaldehyde) and methylchavicol (4-allyl-anisol) as repellents, toxicants and grain protectants against infestation by *Callosobruchus chinensis*, *Oryzaephilus surinamensis*, *Sitophilus granaries* and *Sitophilus oryzae* was investigated under laboratory conditions (25±1°C and 60±5 % r.h.). The experiments carried out include contact and fumigant toxicity assays, treatment of grains with test compounds as admixtures and repellency assays. Both cinnamaldehyde and methylchavicol showed a high efficacy as contact insecticides on the experimental insects. They were more potent against *C. chinensis* and *O. surinamensis* (≥ 15 µl/ml of the test compounds induced 100 % insect mortality) than against *S. granaries* and fumigant toxicity assays, treatment of grains with test compounds ad admixtures and repellency assays. Both cinnamaldehyde and methylchavicol showed strong efficacy as contact insecticides towards the experimental insects. They were more potent against *C. chinensis* and *O. surinamensis* (> 15 µl/ml of the test compounds induce 100 % insect mortality) than against *S. granaries* and *S. oryzae*. Increasing the exposure time to 48 hours effectively increased the mortality rate of *S. granarius*. Cinnamaldehyde was more effective as a fumigant than methylchavicol. It also showed stronger repellency than methylchavicol. Both compounds showed strong contact toxicity against the stored product insect pests used for experiments.

Key words : phytochemical, *Callosobruchus*, *Oryzaephilus*, *Sitophilus*, repellent, toxic

Ability of products derived from the leaves of *Clausena anisata* to protect stored legumes from attack by *Callosobruchus maculatus* and *C. chinensis* (Coleoptera, Bruchidae)

A.L. Tapondjou, C. Adler, H. Bouda, Ch. Reichmuth.....153

Abstract Dried ground leaves of *Clausena anisata*, essential oil extracted from leaves and anethole, identified as the principal constituent of this oil, were tested under laboratory conditions for their ability to protect stored legumes from attack by *Callosobruchus maculatus* L. and *C. chinensis* on mung bean (*Vigna mungo*) and green peas, respectively. Contact toxicity and repellency was tested on filter paper, contact toxicity also by a treatment of beans. Beans treated with dried ground leaves or essential oil extract, respectively, caused significant reductions in the survival rate and number of progeny production. There was more than 90% adult mortality and reduction in adult emergence in grain treated either with one of the two materials at a dose of 5g / 50g grain for dried ground leaves or with 8µl / 40g grain for the essential oil.

Essential oil and anethole impregnated on filter paper discs or coated on beans were found to be highly toxic to both insect species with anethole evoking the highest toxicity especially when coated on grains. The LD₅₀ of the crude oil extract to *C. maculatus* and *C. chinensis* were 5,97 and 4.30µl/40g grain, whereas for anethole they were 0.37 and 0.65µl/40g grain respectively. Moreover essential oil and anethole produced a stronger repellent activity against the test insects. The results are discussed in terms of the efficacy of products derived from *C. anisata* for protection against insect infestation in traditional storage of legumes in Africa.

Key words : Essential oil, anethole, insects, bruchid, contact toxicity, repellent

Plants as insecticides for the protection of stored cowpea - Back to basics

S.J. Boeke.....165

Abstract The possibility of protecting stored cowpea seeds with local plant material is investigated. In rich countries of the developed world, plants as insecticides may seem dangerous and not very effective, although purified plant compounds are often used. For subsistence farmers in third world countries plants could be a cheap and relatively safe alternative for chemical insecticides.

Key words : Storage, bruchid, *Callosobruchus*, *Vigna unguiculata*, botanical insecticides.

Efficacy of burnt plant material smoke for protection of stored paddy against infestation of *Sitophilus oryzae* (L.)

R. Prasantha.....171

Abstract: In Sri Lanka, up to 60% of the total rice production is produced on the village level and 4% to 6% of paddy is lost during the storage. The treatment with smoke from burnt plant materials is used as a method of insect pest control by many rural farmers. Plant smoke was generated by flameless heating (about 300°C under controlled air supplement near to pyrolysis) of plant leaves. Four different plant species, *Azadirachta indica*, *Lantana camara*, *Ocimum sanctum* and *Oryza sativa* (paddy straw), were used to generate the smoke. Each generated smoke was conditioned to 75% rh by a saturated NaCl solution, and CO₂ was removed by KOH solution for 12 h before the testing. Rice weevils were reared on freshly harvested paddy and one week old adult insects were used for the experiment. Bioassays were carried out by 2 h intervals up to 48 h at 30-32°C. After 48 h of exposure time, 100% adult insect mortality was observed in *Azadirachta indica*, *Lantana camara*, *Ocimum*

sanctum except in the smoke generated by *Oryza sativa*. According to the results of LT₅₀ and LT₉₀, *Lantana camara* smoke showed highest efficacy among all plant species. Efficacy of smoke generated by *Azadirachta indica* and *Oryza sativa* did not show significant differences in LT₅₀ and LT₉₀ values. Effectiveness of smokes against adult rice weevils were observed in the following order: *Lantana camara* > *Ocimum sanctum* > *Azadirachta indica* and *Oryza sativa* (paddy straw).

Key words: burnt plant materials, flameless heating, smoke, *Azadirachta indica*, *Lantana camara*, *Ocimum sanctum*, *Oryza sativa*, rice weevils

Activity of chilli, *Capsicum annuum* L. var. *acuminatum*, on stored product insects *Oryzaephilus surinamensis* (L.), *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst)

P. Trematerra, A. Sciarretta177

Abstract: Fruits, extracts and metabolites of chilli, *Capsicum annuum* L. var. *acuminatum*, typical of the geographic area of the Molise region (Central Italy), were tested in an arena for their attractive/repellent activity against adults of saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.), rice weevil, *Sitophilus oryzae* (L.) and rust-red flour beetle, *Tribolium castaneum* (Herbst). The biological activity of chilli fruits were investigated comparing: whole fruits; cut fruits with seeds; cut fruits without seeds; whole seeds; split seeds. According to the results obtained in the arena tests, whole fruits were attractive for all three insect species; cut fruits with seeds, cut fruits without seeds and split seeds were attractive for *O. surinamensis* adults; cut fruits with seeds were repellent against *T. castaneum*; whole seeds and split seeds revealed a repellent activity against *S. oryzae* and *T. castaneum*. The extracts of chilli fruits, *n*-butanol, watery and *n*-hexane, were active in modifying the behaviour of *S. oryzae* and *T. castaneum* adults: a repellent effect against *S. oryzae* adults was showed by all extracts; watery extract was attractive for *T. castaneum*. In the tests with metabolites isolated from chilli fruits, capsaicin and dihydrocapsaicin were not active against *O. surinamensis* and *S. oryzae*, instead dihydrocapsaicin resulted repellent against *T. castaneum* adults.

Key words: *Capsicum annuum*, stored products Coleoptera, attractive and repellent activity.

ThermoNox - Heat treatment as a non-toxic pest control

H. Hofmeir.....183

No abstract.

Efficacy of high temperatures to control *Lasioderma serricorne* and *Rhyzopertha dominica*

C. Adler.....187

Abstract The application of heat could be an alternative to fumigating premises of food industry like flour mills. High temperatures above 45°C are lethal to stored product arthropods and lethal exposure times decrease with increasing temperature. In literature, the tobacco beetle *Lasioderma serricorne* and the lesser grain borer *Rhyzopertha dominica* were reported more heat tolerant than other stored product pests, but there exist few sound data. In the laboratory, probes with *L. serricorne* in wheat bran and *R. dominica* in whole wheat grains were tested for their tolerance to heat. Probes consisted of 10 ml of substrate with one developmental stage (eggs, young larvae, old larvae, pupae) or 50 adults and were filled into glass tubes already preheated in a hot water bath at 45°C or 50±0.1°C for exposure periods between 2.5 h to 40 h at 45°C and for 20 min to 60 min at 50°C.

First results indicate that *L. serricorne* could be controlled at 45°C within 40 h but not *R. dominica*. At 50°C the longest exposure time tested (60 min) proved far too short, complete control may be achieved in the range of 3-4 h. Pupae and late larval stages were more heat tolerant in both species compared to adults, eggs and young larvae. The presence of substrate was essential for the survival of adults that were killed at 45°C in an empty glass tube within 10 h exposure but survived much longer exposure times when tested in 10g substrate.

Keywords : Heat, tobacco beetle, lesser grain borer, disinfestation.

Nitrogen as a major component of a controlled atmosphere to manage stored product insect pests in large vertical storage

B. Timlick, G. Dickie, D. McKinnon.....193

No abstract.

Controlling insect pests of stored medicinal plants by controlled atmospheres

M. Y. Hashem.....199

Abstract Various stages of *Trupanea stellata* and *Lasioderma serricorne* were exposed to four gas mixtures differing in their CO₂ content (20%, 40%, 60% and 80% CO₂). In general, increase in carbon dioxide combined with decrease in oxygen resulted in increasing mortality. The gas mixture containing 80% CO₂ was the most effective to control the different stages of *T. stellata* (more tolerant than the different stages of *L. serricorne* insects). The use of this gas mixture to disinfest chamomile for 7day exposure in 31.4 m³ PVC sheets (tunnel shape) and 30 m³ fumigation chamber under temperature range between 28 to 35°C, resulted in complete control. The use of CO₂ for creating an atmosphere lethal to stored-product insects in sealed container vans during shipment of medicinal plants was promising as a residue free control measure. Also studied was the rate of infestation of chamomile flowers by *T. stellata* under field conditions.

Key words: Carbon dioxide; medicinal plants; insect control, modified atmosphere; population dynamics, *Trupanea stellata*; *Lasioderma serricorne*, chamomile.

Integrated storage pest control methods using vacuum or CO₂ in transportable systems

S. Navarro, S. Finkelman, E. Donahaye, R. Dias, M. Rindner, A. Azrieli207

Abstract: The suggested potential alternatives to MB (methyl bromide) for disinfestation of durable commodities are likely to be costly compared to the use of MB. In addition, very few of the suggested treatments have the effectiveness of short exposure time comparable to MB. The objective of our investigation was to identify the combinations that enhance the effectiveness of the treatments based on vacuum or a combination of heat and CO₂.

Tests of the influence of CO₂ at 45°C on reducing the exposure time expressed as LT₉₉ values for diapausing larvae of *Trogoderma granarium* showed that by increasing the CO₂ concentration to 90% the exposure time decreased to about 10 h, whereas at 35°C the LT₉₉ value was 29 h. *Ephestia cautella* pupae were shown to be the most resistant stage to the same treatment with an LT₉₉ value of only 3 h. For *Oryzaephilus surinamensis* under the same conditions, it was 9 h for the most resistant egg stage.

In laboratory studies with *Lasioderma serricorne* exposed to low pressures at 30°C, LT₉₉ value for adults was 15 h when exposed to 25 mm Hg. *Trogoderma granarium* larvae were the most resistant species, whereby 172 h exposure was necessary under the same conditions.

These encouraging reports led to the idea of developing a transportable system to render the technology a practical tool for the control of insect pests. Experiments were carried out using a 15-m³ capacity plastic container termed the "Volcani Cube™" or "GrainPro Cocoon®". The pressure was maintained between 25 to 29 mm Hg for 17 days. Bioassay in field trials demonstrated that complete mortality of test insects composed of mixed ages of *E. cautella* *Plodia interpunctella*, and larvae of *T. castaneum* was observed on the 3-days exposure to vacuum.

Key words: IPM, storage pests control, vacuum, CO₂, transportable systems, methyl bromide alternatives, *Oryzaephilus surinamensis*, *Trogoderma granarium*, *Ephestia cautella*, *Plodia interpunctella*, *Tribolium castaneum*, *Lasioderma serricorne*

Control of *Sitophilus oryzae* (L.) and *Oryzaephilus surinamensis* (L.) in rice by CO₂ under increased pressure

J. Moreno-Marí, A. Meliá-Llácer, M.T. Oltra-Moscardó, J. García Reverter, R. Jiménez-Peydró.....215

Abstract: Cereals have an important nutritional value and they are one of the principal alimentary resources worldwide, among them rice has a remarkable position. During storage, products may be infested by microorganisms and/or arthropods causing deterioration of the grain. This makes a treatment necessary for their control. Carbon dioxide (CO₂) is an alternative treatment as effective as conventional chemical control but minimizing the contaminant effects. *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) is responsible for most of the insect-related damage of stored rice. This insect is called primary insect pest, or internal feeder, because the adults attack whole kernels and larvae feed and develop entirely within the kernels. *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae) is a secondary pest that feeds on damaged kernels. The aim of this paper is to establish the conditions and efficacy of control of *S. oryzae* and *O. surinamensis* in contaminated stored rice using CO₂ under increased pressure.

Key words: *Sitophilus oryzae*; *Oryzaephilus surinamensis*; pest control; stored product; rice; CO₂; high pressure.

Integrated pest management for stored grain in the U.K. incorporating diatomaceous earths to prevent surface infestations of insects and mites

D. A. Cook, D. M. Armitage.....221

Abstract Laboratory work recommended a dose of 3 g/kg diatomaceous earth (DE) as a top-dressing for prophylactic control of invertebrate pests, as part of a UK integrated grain storage strategy, based on cooling. Both this and a reduced dose of 1 g/kg were compared under field conditions. Two 20t bins of feed wheat were top-dressed with 3 g/kg “Protect-it”, two at 1 g/kg and two left untreated. The grain had initial moisture contents (MC) of 15-16% and had been infested with 1.2 insects /kg (*Oryzaephilus surinamensis* and *Sitophilus granarius*) and 3 mites /kg (*Acarus siro* and *Lepidoglyphus destructor*). The bins were cooled from 20-28°C to 5°C by winter using 6°C differential fan control. Mite numbers at the surface peaked after 12 weeks, coinciding with surface MCs of 18-19% when numbers of *A. siro* in the untreated bins were 2,600 and 19,000 / kg compared to less than 1 / kg in all the treated bins. Numbers of insects in the surface traps fell in all bins throughout the experiment but after 17 weeks both species were reduced by >90% for both doses compared to the untreated bins. These results validate the use of DEs as part of an IPM strategy and indicate that the lower dose could be commercially effective.

Key words: Diatomaceous earth, Inert dust, Grain storage, Integrated Pest Management, *Acarus siro*, *Lepidoglyphus destructor*, *Sitophilus granarius*, *Oryzaephilus surinamensis*

Can diatomaceous earths have an integrated role in small-scale tropical grain storage?

T. Stathers, B. Mvumi, P. Golob.....231

Abstract: During needs assessment studies in sub-Saharan Africa, farmers repeatedly prioritised the need for improved methods of storage pest control. Reduction of storage losses will help to reduce the vulnerability of small-scale producers by improving household food security and by improving income-generating opportunities. If synthetic chemical pesticides are available in rural areas they are often adulterated, past their expiry dates and expensive, many farmers are fearful of mixing these synthetic chemical pesticides with their food. Inert dusts particularly diatomaceous earths (DE) offer a safer alternative to synthetic chemicals, but information on their efficacy under small-scale farming conditions is limited. Field trials during two storage seasons in Zimbabwe demonstrated that DEs are extremely effective and persistent grain protectants against the major insect pests attacking sorghum, maize and cowpeas in storage. DE treatments outscored the existing grain protection practices during farmer-managed trials. However DE application rates as high as 2 g/kg were needed to reduce bostrichid beetle damage. Further studies in the laboratory found the combination of DEs and very low doses of pyrethroids resulted in high mortality of the bostrichid, *Prostephanus truncatus*. The effect of DEs on natural enemies and their combination with other biological and chemical control options is discussed.

Stored product protection with amorphous silica dust (SilicoSec®) in Germany – practical experiences and laboratory trials

M. Erb-Brinkmann, B. Straube.....239

Abstract SilicoSec is a natural silica powder based on fossilized diatom algae (diatomaceous earth, DE). It contains > 90% amorphous SiO₂ and controls all arthropod pests including weevils, moths, mites etc.. The sharp-edged silica particles destroy the wax layers of the arthropod cuticle and quickly absorb lipids and body fluids, leading to desiccation and death. Amorphous silica is completely harmless for all vertebrates and humans. SilicoSec is a registered pesticide for stored grain protection in Germany since 1997.

Cereal grain treated with DE looks different to untreated grain and shows changes in physical behaviour. Flow rate through handling equipment is reduced, bulk volume and the angle of repose are increased. These side effects may limit the use of DE. In order to minimize side effects, it would be necessary to reduce the concentration of SilicoSec within the grain.

In order to check the efficacy of the natural product under field conditions, farmers were asked about their experiences with SilicoSec.

In a laboratory trial it was investigated to what extent either a superficial SilicoSec-covering on grain or a treatment of the upper 30 cm layer of the grain guarantees full protection. Trials were carried out in tubes of 46 cm high with a diameter of 10 cm. The grain was covered with 0.2, 1, or 2 kg SilicoSec/m² or the upper 30 cm of the grain were treated with 1.5, 3 or 5 kg SilicoSec/t (each n=5). 20 *Sitophilus granarius* were put on each tube and kept in a warm, dry room for 21 days. Grain was sieved in 6 cm layers, active and dead individuals of *S. granarius* were counted out.

65 % of farmers replied to the survey. Four farms treated the empty store, 19 farms the stored product and 3 farms treated both, store and product. The three types of application resulted in successful protection against

insect pests in 75, 95 and 100% of the farms. Treatment of the store is useful only in combination with treatment of the stored product or in infested stores which will stay empty for a longer period of time. In order to ensure full protection of the grain SilicoSec should not be applied at less than 1 kg/t.

Results of the laboratory trial showed that a 0.2 kg/m² superficial covering does not prevent *S. granarius* from entering the untreated grain. With 1 kg/m² only a single weevil survived the penetration of the SilicoSec layer, at 2 kg/m² no weevils survived. Increasing the dosage for treatment of the upper 30 cm resulted in a decreased penetration depth of *S. granarius*. Whereas one individual was able to reach the untreated grain through a 1 kg/t treated 30 cm layer, all weevils died within the treated area by the application of 3 or 5 kg/t. Tube trials suggest that >1 kg SilicoSec/m² or ≥3 kg/t should be applied to protect the stored product. Calculating for the protected amount of grain, treating the upper 30 cm layer needs less SilicoSec than a superficial covering.

It can be concluded that SilicoSec ensures a long-term, complete protection of stored products when the whole grain is treated. For superficial treatment and treatment of the upper 30 cm only, more extensive studies are necessary to produce general recommendations.

Keywords : stored product protection, diatomaceous earth, inert dusts

Control of the Mediterranean flour moth (<i>Ephestia kuehniella</i> [Zeller]) in an automated pig-fattening enterprise <i>H. Klupal</i>	241
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Potential of combining silica aerogels with IGRs as protectants of stored rice (paddy) against <i>Sitophilus oryzae</i> (L.) (Coleoptera: Curculionidae) <i>O. Casaco, A. Barbosa, A. Mexia</i>	243
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Abstract The efficacy of silica aerogels (Gasil 23D and Neosyl TS) used alone and in combination with IGRs (diflubenzuron and fenoxycarb) was evaluated under laboratory conditions against adults of the rice weevil *Sitophilus oryzae* (L.) on stored paddy.

Gasil 23D and Neosyl TS revealed some differences and the LC50s were 0.03% and 0.02% w/w, respectively. The combinations of each of these materials with IGRs also revealed slight differences of effectiveness. However, the joint action of IGRs and Gasil 23D seems to be more synergistic than IGRs with Neosyl TS.

Key words : *Sitophilus oryzae*, activated silicates, insect growth regulators.

Effect of time of exposure on the effectiveness of silica dusts and mixtures with IGRs against <i>Sitophilus zeamais</i> Motschulsky (Coleoptera: Curculionidae) <i>C. Conceição, A. Barbosa, A. Mexia</i>	247
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Abstract The effectiveness of two precipitated silica dusts (Gasil 23D and Neosyl TS) used either alone or in combinations with fenoxycarb and diflubenzuron against *Sitophilus zeamais* Motsch. were evaluated under laboratory conditions with different times of exposure.

The data showed differences between the silica dusts. Gasil 23D (LC=0.037% w/w) was more effective than Neosyl TS (LC50=0.113% w/w) when the insects were exposed for 5 hours. Neosyl TS (LC50=0.028% w/w) was more effective than Gasil 23D (LC50=0.037% w/w) at a period of fifteen days of exposure. All the combinations revealed differences in the effectiveness for each time of exposure and the LC50 values decreased significantly (2-3 times) when the insects were exposed during fifteen days. The experiments suggested that the efficacy of some of the treatments increased significantly after a longer exposure of fifteen days.

Key words : *Sitophilus zeamais*, silica dusts, Gasil 23D; Neosyl TS; mixtures

Phosphine combined with low level carbon dioxide for the control of <i>Tribolium castaneum</i> (Herbst) at different temperatures <i>A. P. Ramos de Almeida-e-Silva, L. R. D'Antonino Faroni, R. N. Carvalho Guedes, A. G. da Silva Júnior</i>	253
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Abstract Pest control in stored grain and in processing/manufacturing units is going through great difficulties. The need of rapid, low cost and environmentally safe ways of controlling pests requires the generation of new technologies and a better handling of the existing ones. The phasing out of methyl bromide is prompting the search for possible alternatives for effective pest control within a 24 hours period, especially for grain processing

units. The reported work assessed the combination of phosphine (PH₃) with carbon dioxide (CO₂) at different temperatures for the control of *Tribolium castaneum* (Herbst). Modified atmospheres with 1g m⁻³ of PH₃ combined with 5% of CO₂ were tested at 20, 25, 30, 35 and 40°C. Five exposure periods for each temperature were used, according to results obtained in preliminary tests. Experiments were carried out in metallic chambers placed inside a climatic chamber with air temperature and relative humidity control. Mortality with time was assessed for each treatment, and the LT₅₀ and LT₉₅ values determined for each temperature. Increasing temperatures reduced the time to kill the beetles and at 40°C, it was possible to control 95% of the insect population with the proposed treatment in 23.2 hours.

Key words: modified atmosphere, storage pest control, stored products, grain processing units.

The erosion of local practices of post-harvest management in times of war – A case study from the North of Mozambique)

M. P. Temudo.....259

Abstract: War can affect African rural societies in many more ways than causing death: it can disrupt entire societies that are forced to displace from their lands to other regions or to neighbouring countries; it can isolate them from the markets preventing people from selling their surplus and buying basic needs like medicines and agricultural instruments; it can spread fear and mistrust breaking sustainable livelihoods. In any case both the productive and the reproductive potential of the societies are affected. Although seed supply and support to crop genetic resources management is now considered an important component of relief and rehabilitation aid to rural communities recovering from war, civil strife and natural disasters, support to post-harvest management is still a frequently forgotten intervention. In this paper, based on field study in the Niassa province of Mozambique, we describe traditional post-harvest management practices of the main agricultural products, how they were affected by war and recent external development interventions in rural societies.

Key words: Gender; participatory R&D; ethno-agronomic approach.