Bio-activities of Powders of four plants against *Prostephanus truncatus* Horn. (Coleoptera: Bostrichidae) and *Tribolium Castaneum* Herbst (Coleoptera: Tenebrionidae)

T. Buxton[1], V. Y. Eziah[2] and E. O. Owusu[3]

[1] *African Regional Postgraduate Program in Insect Science (ARPPIS), University of Ghana, Legon, P. O. LG 59, Legon-Accra, Ghana*

E-mail: *buxton_thomas@yahoo.com*

[2] *Department of Crop Science, College of Agriculture and Consumer Sciences, University of Ghana, Legon-Accra, Ghana*

E-mail: *eziahvin@yahoo.com*

[3] *Department Of Animal Biology And Conservation Sciences, University Of Ghana, P. O. Box Lg 67 Legon-Accra, Ghana*

E-mail: *eoowusu@ug.edu.gh*

Abstract

The effect of the dry powders of the roots and leaves of *Ocimum canum*, *Zanthoxylum xanthoxyloides*, *Moringa oleifera* and *Securidaca longipedunculata* on the survival of *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) and *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae) was determined in the laboratory. Generally, all the plant materials exhibited various levels of bio efficacies, with Z. *xanthoxyloides* and *S. longipedunculata* exhibiting the highest potency. Percentage survivorship of 35% and 40% were recorded for the roots and leaves, respectively, of *Z. xanthoxyloides* against *T. casteeneum* while 20% and 30% were recorded for roots and leaves of S. *longipedunculata*, respectively, against *P. tuncatus*.

Introduction

Maize and groundnuts play a predominant role in diets of developing countries. Cereals and legumes are the cheapest sources of food energy and contribute a high percentage of calories and proteins in the diets of Ghanaian population (ISSER, 2011).

Prostephanus truncatus (Horn) (Coleoptera: Bostrichidae) and *Tribolium castaneum* (Herbst) (*Coleoptera*: *Tenebrionidae*) are two of the most important insect pests that attack stored maize and groundnuts. *Tribolium castaneum* is worldwide stored product pest which attacks stored grain products (flour, cereals, pasta, biscuits, beans, nuts, etc.) causing loss and damage. It may cause an allergic response but is not known to spread disease and cause any damage to structures or furniture (Obeng-Ofori, 2008). *Prostephanus tuncatus* has increased grains and dried cassava storage problems wherever the pest is found (Obeng-Ofori, 2008).

Several methods of control or management employed to minimize post harvest food loss include physical, chemical and biological control. Under many circumstances the easiest, most rapid and economical method of controlling insects is the use of insecticides.

However, most of the contact insecticides used in stored product insect pest management are lipophilic and accumulate in areas of high fat content such as the germ and bran of cereals (Mensah *et al.*, 1979). These toxic residues tend to persist in the treated products which may be detrimental to the consumer. The use of chemicals also affect non-target insect pests (natural enemies), leads to the development of insect resistance and may even have effect on the applicator (Obeng-Ofori, 2010). The use of natural products has been found to be very effective against stored product insect pests. Several plant products (leaves, ash, seed extracts, oil, roots, etc.) are processed and mixed with stored products or applied as insecticides to control these pests. These natural products are considered to be cheap, easily biodegradable and readily available for stored product production. The study aimed at comparing the insecticidal efficacies of the powdered form of *O. canum*, *M. oleifera* and *Z. xanthoxyloides* against the adult *P. truncatus* and *T. castaneum*, using *S. longepedunculata* as a reference.

Securidaca longepedunculata Frees belongs to the family Polyglaceae. It is a semi-deciduous shrub or small tree that grows to 12 m tall, with an often flattened or slightly fluted bole. It is spiny and much branched, with an open, rather straggly looking crown. Research shows that the bark contains methyl salicylate. The presence of saponins also in the bark and crushed seeds give a soapy solution in water and are used as soap for washing or bleaching clothes (Orwa *et al.*, 2009).

Zanthoxylum xanthoxyloides Lam belongs to the family Rutaceae. It is a shrub that can grow to a small tree of up to 1.25 m high and 0.13 m girth (Irvine, 1961). The plant has been found to be effective in controlling several stored products pests. (Udo, 2000, 2011).

Ocimum canum Sims belongs to the family Lamiaceae and is an annual plant native to Africa. Two important relatives of these with similar properties are the *Ocimum gratissum* (basil), and *Ocimum sanctum* (holy basil). It is used as an insect repellent during storage. It also works as a mosquito repellent to prevent malaria and dengue fever (Dokosi, 1998).

Moringa oleifera, Lam, also known as *Moringa pterygosperma* Gaertn, is a member of the Moringaceae family of perennial angiosperm plants, which includes 12 other species (Ramachandran *et al.*, 1980). *Moringa oleifera* is an edible plant. A wide variety of nutritional and medical virtues have been attributed to its roots, bark, leaves, flowers, fruits, and seeds.

Materials and methods

Culturing the Insects

Tribolium castaneum Hebst. The initial stock was obtained from infested flour purchased from the Makola market, Accra. The adult beetles were introduced into uninfested flour and allowed for oviposition after which the adults were sieved out 7 days later. The adults that emerged were transferred into another jar such that the F1 adults (which were used as the culturing stock for the experiments) were of uniform size and age. The set up was kept under a temperature of 32 2^{O}C, 70% relative humidity and 12 L: 12 D photo regime.

Prostephanus truncatus Horn

The adults *P. truncatus* used in the experiments were obtained from the Savannah Agricultural Research Institute, Nyankpala and were cultured in the laboratory in jars containg maize grains at 28 ± 2^{O}C and 70 ± 5% relative humidity and 12 L: 12 D photo regime. These were removed a week after oviposition to allow new progenies to emerge. This was to ensure that the insects that were used for the experiment were of the same age.

Collection of the plant samples

The plant species that were used were obtained from the following places: S. *longipedunculata*: Bawku, *Z. xanthoxyloides*: University farms, Legon, Accra. *M. oleifera*: Sowutuom, Accra and *O. canum*: La, Accra. The roots and leaves of *Securidaca longipedunculata*, *Zanthoxylum xanthoxyloides* and *Moringa oleifera* were used but for *Ocimum canum* only the leaves were used.

Preparation of plant powders

The leaves were removed from their branches and the roots cut into pieces and were air-dried under normal room temperature for 14 days to ensure that they were well dried. They were pounded using mortar and pestle and further ground and sieved to obtained fine powders.

Effect of the plant powders on adult insects

Two kilograms of uninfested whole maize and groundnut were weighed separately. (The maize for *P. truncatus* and the groundnut for *T. castaneum*). The seeds were sterilized in an oven to ensure that they were not infested. One hundred grams of the maize and groundnut was put into glass jars and the plant powders were admixed to it in the proportion 100 : 100 g (grains : plant powder) wt/wt.

The control had no plant powder added while the powder of *S. longipendunculata* was used as reference. After 1 h, 20 of the adult insects (of the same age) were introduced into the treatments. There were four replications per treatment and these were kept under a temperature of $28 \pm 2^{O}C$, 75% relative humidity and 12 L: 12 D photo regime. Live and dead insects were recorded daily for 1 week starting from 72 h (3 days) after treatment. An insect was considered dead if it did not respond to prodding using a blunt probe. Control mortalities were corrected for using Abbott's formula:

{Percent test mortality – Percent control mortality)/ 100 – Control mortality} X 100 (Abbott, 1925).

Data were then analyzed using Analysis of Vairance at 0.05 probability level using GenSat Statistical Package 9.2 (9th edition).

Results and discussion

All the plant parts used showed various levels of bioactivity against adult *P. truncatus* and *T. casteneum*. Comparing the bio-activities of the leaf treatment against the insects, *Z. xanthoxyloides* yielded the least percentage survivals of 35% against *T. castaneum* and 40% against *P. truncatus*. On the other hand, for the root treatments *S. longipedunculata* yielded the least percentage survival values of 30% against *T. castaneum* while *Z. xanthoxyloides* yielded the least percentage survival of 20% against *P. trancatus*. The powder preparation from the leaves of *M. oleifera*, *Z. xanthoxyloides* and *O. canum* reduced the survival rates of both pests faster than of *S. longipedunculata* (Fig. 4).

There was significant ($P < 0.05$) difference between the leaf powders of the different plants against *T. castaneum*. However, there was no significant difference between the powder treatments of the plants against *P. truncatus* (Fig. 4). Comparing the bioactivities of only the roots against the

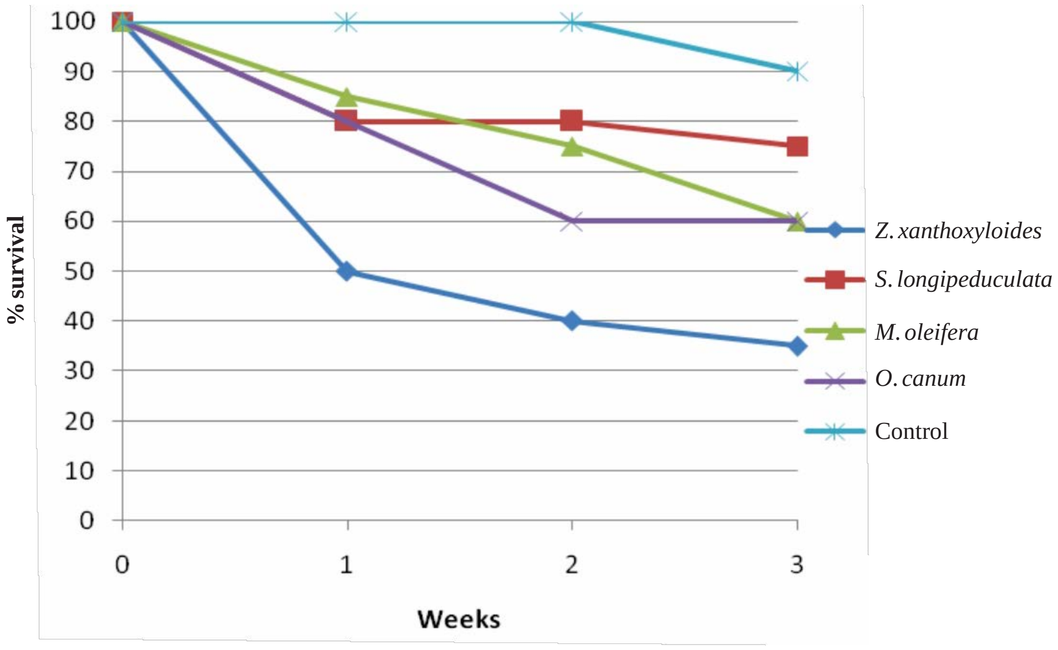

Fig.1. Effect of 100% wt/wt Powder treatment of the leaves of *Z. xanthoxyloides*, *O. canum M. oleifera* and *S. longipedunculata* on the survival of *T. castaneum*

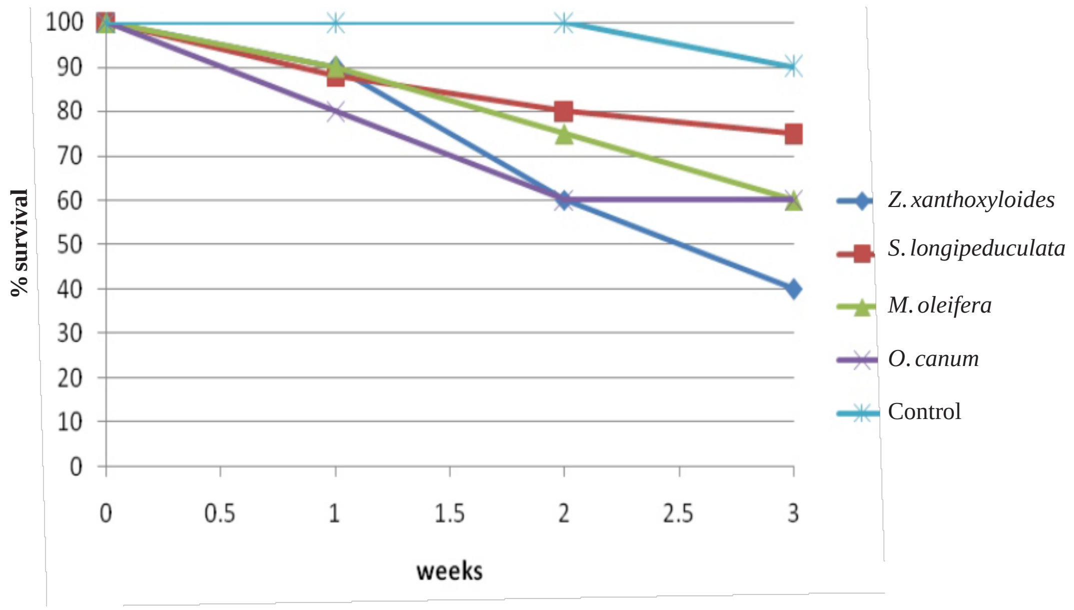

Fig. 2. Effect of 100% wt/wt treatment of the leaves of of *Z. xanthoxyloides*, *O. canum M. oleifera* and *S. longipedunculata* on the survival of *P. truncatus*.

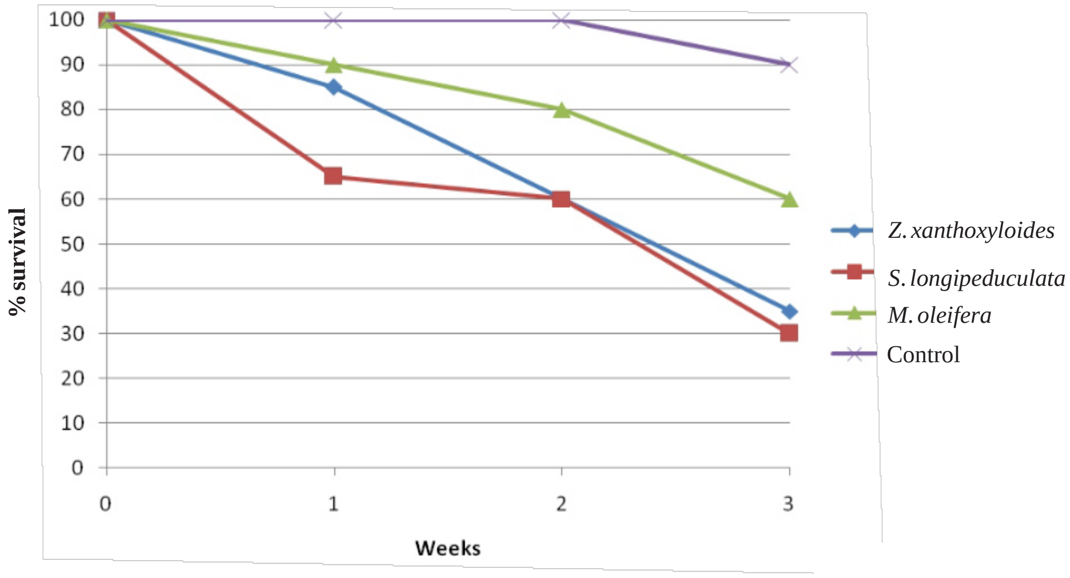

Fig. 3. Effect of 100% wt/wt Powder treatment of the roots of *Z. xanthoxyloides*, *M. oleifera* and *S. longepedunculata* on the survival of *T. castaneum*

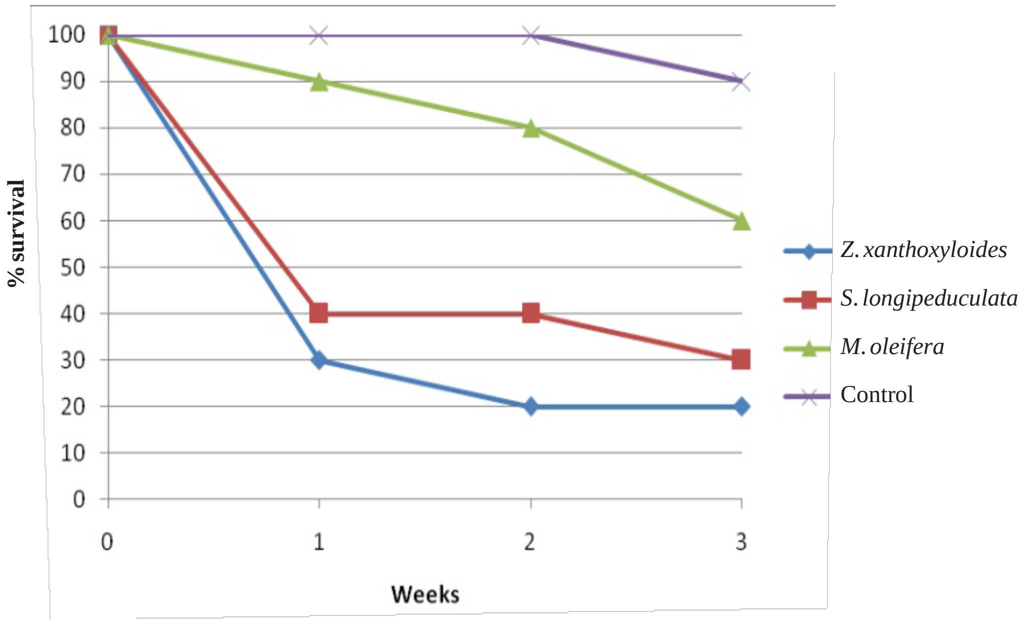

Fig. 4. Effect of 100% wt/wt Powder treatment of the roots of *Z. xanthoxyloides*, *M. oleifera* and *S. longipedunculata* on the survival of *P. truncatus*

insects, there was a significant difference (*P* < 0.05) between the powder treatments of the different plants against *P. truncatus* but no significant difference between the powder treatments of the plants against *T. castaneum*.

Toxicity of powders

The powder forms of all the four plants, i.e. *O. canum, M. oleifera, Z. xanthoxyloides* and S. *longipedunculata* exhibited various levels of bioactivities against the adult P. *truncatus* and *T. castaneum.* In a similar study by Udo (2011), it was reported that the roots, bark and leaves of *Z. xanthoxyloides* were very effective against *C. maculatus* and *S. zeamais*. This phenomenon suggests the presence of highly pungent secondary metabolites found in the roots of *Z. xanthoxyloides* (Adesina, 1986). One of the constituent secondary metabolites, Zanthoxylol, has been identified as a phenolic compound reputed for insecticidal activity (Elujoba & Nagels, 1985; Wongo, 1998). A study by Belmain *et al*. (2001) indicated that the powder of *S . longipeduculata* was very effective against *R. dominica* and *P. truncatus*. The presence of eugenol, which is a major essential oil in the plant, as established by the above studies may account for these physiological effects exhibited against the insects (Obeng-Ofori *et al.*, 1997).

Prabhu *et al*. (2011) reported the larvicidal potential of *M. oleifera* against malarial vector, *Anopheles stephensi* Liston. Kamel (2010) also showed that *M. oleifera* was effective in the control of *Spodoptera frugiperda* (J.E. Smith) as it yielded antifeedant and toxic effect against the target insect. These authors indicated the presence of fatty acids and sterols in *M. oleifera* which played a synergistic effect as antifeedants against the insects (Kamel, 2010). Quercetin and Kaempferal are also found in the *M. oleifera* (Prabhu *et al*., 2011). These are flavinoids and phenol oxidase inhibitors which interfere with the biochemical processes involved in B-sclerotization, quinone tanning and melanin biosynthesis, which occupies a major role in insect development and immunity, such as cuticle sclerotization, wound healing, and defense against foreign pathogens (Kubo, 2001).

Under the same wt/wt powder treatment of the plants there were different levels of survivorship between the two insects. There was higher rate of survival of *T. castaneum* than *P. truncatus* in the powdered treatment and this could be attributed to the surface area of the powder form in which the plant parts were administered.

Hodges (1986) indicates that *T. csateneum* is a secondary pest which feeds on powdered stored product like flour (hence their name, Red flour beetle) where as *P. truncatus* is a primary stored product pest of grains, hence, the powdered conditions of the plant material rather may hve provided a better medium for the survival of *T. csataneum* than *P. truncatus*.

Conclusion

The study has shown the bio-efficacies of *O. canum, M. oleifera, Z. xanthoxyloides* and *S. longipedunculata* against P. *truncatus* and T. *castaneum*. The roots and leaves powder of *M. oleifera, Z. xanthoxyloides* and *S. longipedunculata* and leaf powder of *O. canum* used in the ratio 100% wt/wt reduced the survival of *P. truncatus* and *T. castaneum* in stored grains.

Acknowledgment

The authors extend their sincere gratitude to the Carnegie Corporation through The University of Ghana (UG-CCNY 'Next Generation Project'), Office of Research, Innovation and Devleopment (ORID) for funding the study.

References

Adesina S. K. (1986). Further novel constituents of *Zanthoxylum xanthoxyloides* roots and pericarp. *J. Nat. Prod.* **49:** 715–716.

Belman S. R., Neal G. E., Ray D. E. and **Golob P.** (2001). Insecticidal and vertebrate toxicity associated with ethnobotanicals used as post-harvest protectants in Ghana. *Fd Chem. Toxicol.* **39**: 287–291.

Belmain S. R. (2002). *Optimising the Indigenous Use of Botanicals in Ghana*. Final Technical Report 1st April 1999–31st March 2002. Natural Research Institute, Chatham Kent, UK.

Dokosi O. B. (1998). *Herbs of Ghana*. Ghana Universities Press, Accra. 746 pp.

Elujoba A. A. and Nagels. L. (1985). Chromatographic isolation and estimation of Zanthxylol: An antisickling agent from the roots of *Zanthoxyum xanthxyloides. Journal Pharmaceutical and Biomedical Analysis* **3**: 447–451.

Hodges R. J. (1986). The biology and control of Prostephanus truncatus (Horn) (Coleoptera: Bostrichidae) – A destructive storage pest with an increasing range. *J. Stor. Prod. Res*. **22**: 1–14.

Institute of Statistical, Social and Economic Research (2006). *The State of The Ghanaian Economy in 2006*. ISSER, Uiversity of Ghana, Legon.

Irvine G. R. (1961). *Woody plants of Ghana with special reference to their uses*. Oxford University Press, London. 868 pp.

Kamel A. M. (2010). Can we use the Moringa oil as Botanical Insecticide Against Spodoptera frugiperda. *Academic Journal of Entomology*. **3**: 59–64.

Kubo I. (2001). Insect Phenol oxidase inhibition from plants. National *Natural Science Foundation of China*. 73: 18–23.

Mensah G. W. K., Watters F. L. and **Webster G. R. B.** (1979). Insecticide recidues in milled fractions of dry or tough wheat treated with malathion, bromophos, isodofenphos and pirimiphos-methyl. *J. Econ. Entomol.* **72**: 728–731.

Obeng-Ofori D. (2008). Major Stored Product Arthropod Pests In *Post Harvest Science and Technology*. (E. W Cornelius, and. D. Obeng-Ofori., eds), pp. 67–91. Smartline Publishing Limited, Accra.

Obeng-Ofori D., Reichmuth C. H., Bekele J. and **Hassanali A.** (1997). Biological activity of 1,8 cineole, a major component of essential oil of Ocimum kenyense (Ayobangira) against stored product pests. *J. appl. Entomol.* **121**: 237–243.

Orwa C., Mutua A., Kindt R., Jamnadas R. and **Anthony S.** (2009). Agroforestree Database: a tree reference and selection guide. Version 4.0 (*http://www.worldagroforestry.or/sites/treesdbs/treesdatabases.asp*) Accessed on 04/07/2012.

P**rabhu K., Murugen K., Nareshkumar A., Ramasubramanian N.** and **Bragadeeswaran S.** (2011). Larvicidal and Repellence Potential of Moringa oleifera against malarial vector Anopheles stephensi Liston (Diptera: Culicidae) *Elsevier Science* **8**: 183–194.

Ramachandran C., Peter K. V. and **Gopalakrishnan** (1980). Drumstick (Moringa oleifera): a multipurpose Indian vegetable. *Ecological Botany* **34**: 276–283.

Stevenson P. C., Dayaratha T. K., Belmain S. R and **Veitech N. C.** (2009). Bisdesmosidic Saponins from *Securidaca longepedunculata* Roots: Evaluation of Deterrency and Toxicity to Coleopteran Storage Pests. *J. Agric Fd Chem.* **57**(19): 8860–8867.

Udo I. O. (2000). Efficacy of Candlewood *Zanthoxylum xanthoxyloides* (Lam) for the control of Three Stored Product Pest. (MPhil Thesis,) University of Ghana, Legon, 79 pp.

Udo I. O. (2011). Potential of *Zanthoxylum xanthoxyloides* (Lam) for the control of stored product insect pests. *Journal of Stored Product and Post Harvest Research*. **2(**3): 40–44.

Wongo L. E. (1998). Biological activity of Sorghum tanning extracts on the stored grain pests, *Sitophilus aryzea* (L). *Sitotroga cereallela* (Oliver) and Tribolium castaneum (Hebst). *Insecticide Science Application* **11**: 17–32.