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# Insecticide treated packaging for the control of stored product insects

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## Abstract

Improper or poor post-harvest handling and storage of stored grains contributes significantly to product loss, and bagged stored grain presents an option for safe storage and handling. Bagged grain is intended to maintain quality and safety, while protecting it from infestations. The objective of this research was to determine the effect of deltamethrin-treated packaging material on adults and larvae of common stored product pests. Adults or larvae of several species of stored product insects were exposed to deltamethrin-treated packaging for time intervals ranging from 1 h to 4 weeks. The percentage of affected*Prostephanus truncatus, Callosobruchus maculatus* and *Rhyzopertha dominica* adults was < 98% after 60 minutes of exposure to treated packaging. Mortality of adult *Trogoderma granarium* was about 33% after 1 day of exposure, and increased to 93% after 7 day of exposure. Direct mortality of *T. granarium* larvae exposed to the deltamethrin-treated packaging for 8 h was about 15%, but increased to 50% when larvae were exposed for 72 h.*Tribolium castaneum, Oryzaephilus surinamensis,* and *Trogoderma inclusum* larvae continually exposed to the deltamethrin-treated packaging resulted in > 96% larval death within 1-2 weeks.The major primary stored product insects were highly susceptible to the deltamethrin-treated storage bags, but there was variation in susceptibility between species and life stages tested. The deltamethrin-treated storage bags can offer protection of bagged grains and be used as a preventative measure to reduce infestations during storage.

**Keywords:** treated packaging, deltamethrin, stored product insects, affected adults

## 1. Introduction

Stored product insects are a common and persistent problem in grain storage, milling, and, warehouse facilities. *Rhyzopertha dominica* F., lesser grain borer, *Callosobruchus maculatus* F., cowpea weevil, *Tribolium castaneum* (Herbst), red flour beetle, *Prostephanus truncatus* (Horn), larger grain borer, and *Trogoderma spp.* are major stored product species found or associated with stored grains (Rees, 2004; Hagstrum et al., 2012). The improper handling and storage of grains impacts the quantitative and qualitative attributes of stored grain. Traditional integrated pest management (IPM) techniques depend on a series of management evaluations, decisions, and controls in order to provide the best control method (US-EPA, 2017). For IPM of food materials, prevention is one of the most important IPM strategies.

In recent years, use of insecticide-treated packaging has gained interest and proven effective against stored product insects. Use of insecticide-treated packaging can be easily incorporated into existing IPM programs and functions as aprevention techniquefor finished product. Previous research in the area of insecticide treated packaging has focused on the insect growth regulator methoprene and the contact insecticide deltamethrin. Both insecticide treated packaging materials are highly effective against a variety of stored product insects such as *T. castaneum, P. truncatus, Sitophilus* spp., and *R. dominica*. (Kavallieratos et al., 2017; Paudyal et al., 2017a, 2017b; Scheff et al., 2016, 2017). However, there is still a need for research examining the effects of treated packaging materials on more pest species, including evaluations against different life stages, and more information on the impact of exposure duration to better understand the effectiveness of this pest management tool. The objective of this research was to determine the effect of deltamethrin-treated packaging material on adultsand larvae of common stored product pests.

## 2. Materials and Methods

Experiments with larvae and adult*Trogoderma granarium*Everts, Khapra beetle, were conducted at the USDA-Animal and Plant Health Inspection Service (APHIS)-Center for Plant Health Science and Technology (CPHST), Otis Laboratory, in Buzzards Bay, MA, USA, in the insect quarantine facility. All other insect species were evaluated in experiments conducted at the USDA-Agricultural Research Service (ARS)-Center for Grain and Animal Health Research in Manhattan, Kansas, USA.

Deltamethrin-treated woven polypropylene storage bag material (ZeroFly® Storage bags) was used in the experiments (Vetergaard Frandsen, Lausanne, Switzerland). The deltamethrin concentration of the treated storage bags was 3g/kg or 3000 ppm (Vestergaard, 2015). Untreated control material consisted of a laminated woven packaging material containing no insecticide, as described by Scheff and Arthur (2017). Bioassay arenas used in all experiments were created as described by Kavallieratos et al. (2017) and Scheff and Arthur (2017). In brief, packaging material was cut into ~9 cm circles and affixed to thebottom of 100 x 20 mm plastic Petri dishesusing adhesive caulking. The interior sides of the Petri dishes were coated with Fluon® (polytetrafluoroethylene, Sigma-Aldrich Co., St. Louis, MO, USA) to confine insects to the bottom of the dish.

### 2.1 Adults

Cohorts of 10 adults of *P. truncatus, C. maculatus*, and *R. dominica* were exposed to treated packaging and monitored every 15 minutes for up to 4 h, and the time until 100% of adults were observed as being affected was determined. Affected insects were those where the adults could not remain upright and exhibited uncoordinated movement for five or more seconds, were turned on their backs and displayed loss of appendage control and tremors, or only exhibited movement in legs, antennae or mouthparts when probed by a fine-hair brush. Additional testing on mortality of adults exposed to deltamethrin-treated material is currently being conducted. Adults of *T.*

*granarium* were continually exposed to treated or untreated packaging materialas described for *P. truncatus, C. maculatus,* and *R. dominica*, and observed after 1, 2, 5 and 7 daysof exposure on the packaging material to determine the percentage of affected and dead adults at each time. The time to 100% of adults that were affected in 15 minute increments is currently being conducted.

2.2. Larvae

The effects of deltamethrin-treated packaging material on larvae was conducted as either continually exposing larvae on treated or untreated surface (continual exposure assay) or a short term exposure period of ≤4 days on treated or untreated material (short-term assay).

The continual exposure assays were conducted for *T. granarium, Trogoderma inclusum* LeConte, larger cabinet beetle, *T. castaneum* and *Oryzaephilus surinamensis* (L.), sawtoothed grain beetle. Ten individual larvae were added to deltamethrin-treated or untreated arenas along with ~1 g of diet and continually held on each area and monitored for adult emergence, up to 8 weeks. Six replicates were used. Short-term exposures were conducted for *T. castaneum, T. granarium,* and*T. inclusum* as described by Scheff et al. (2017). Briefly, 50 larvae of each species, six replicates, were exposed to deltamethrin-treated or untreated packaging material, and ten larvae were removed from the arenas after 0.3, 1, 2, 3, and 4 days and placed onto an untreated plastic Petri dish along with ~1 g of diet and held for adult emergence for 8 weeks. Two larval sizes for *T. granarium* and *T. inclusum* were used. Small larvae were <3 mm and largelarvae were >4 mm (Anthanassiou et al., 2015).

**3. Results**

3.1 Adults

The time requiredfor 100% adults tobe affected varied among species tested. The order of susceptibility was *P. truncatus* >*R. dominica* >*C. maculatus.* All adult*P. truncatus* were affected after 30 m of exposure to the deltamethrin-treated packaging material, while only 83% of*R. dominica* and 30 % of *C. maculatus* were affected.*R. dominica* needed 45 minutes of exposure for 100% of adults to be affected and 75 minutes of exposure was needed for*C. maculatus.*
There was 100% affected or dead adult *T. granarium* after 1 day of exposure to deltamethrin-treated packaging and the percentage of mortality increased with longer exposure periods as the affected adult *T. granarium* succumbed to the effects of the deltamethrin. After 7 dayd of continual exposure, 93% of adults were dead.

3.2 Larvae

Continual exposure of *T. granarium* larvae to treated packaging material resulted in approximately95 and 97% mortality for small (<3 mm) and large (> 4mm) larvae, respectively, while on untreated material mortality was <4% for both larvae sizes. Likewise, *T. castaneum* had <7% adult emergence and *O. surinamensis*had 0% adult emergence when continually exposed at two different temperatures, 27 or 32°C, and all the larvae died. Continual exposure of *T. inclusum* larvae to treated packaging material resulted in 10% adult emergence for large larvae held at 32°C, and <3% for small larvae at 27 or 32°C and large larvae at 27°C. Larval death ranged from 65-100% among small and large larvae held at 27 or 32°C. However, roughly 25% of large *T. inclusum*larvae held at 32°C were alive after 8 weeks of continual exposure and 22% of small larvae at 27°C were still alive.
Short-term exposure of large*T. granarium* larvae, > 4mm, resulted in adult emergence ranging from 61-34% among the exposure periods. Larval death ranged from 15-50% depending on exposure time. As exposure time to deltamethrin-treated packaging material increased, the percentage of emerged adults decreased and the most effective exposure period was 3 days. We observed a significant reduction in adult emergence for *T. castaneum* larvae exposed to the deltamethrin-treated material for >3 days at 32°C. Adult emergence was 62% after 3 days of exposure and 50% after 4 days of exposure to treated material. Similar to *T. granarium,* the precentage of small *T. inclusum* larvae, < 3 mm, exposed to deltamethin-treated material at 32°C that emerged as adults

was reduced as exposure time increased. After 0.33 days of exposure, 72% of larvae emerged as adults but only 42% of larvae emerged as adults after 4 days of expsoure to treated material.

## 4. Discussion

Results of this study show there is variationin the susceptibility among life stages andstored product insectspecies, and a strong effect of exposure duration on susceptibility and lethality. We first observed that exposure to the deltamethrin-treated packaging material yielded affected adult stored product insects within 60 minutes. The exposure time required to yield affected adults reported here was similar to previous research by Kavallieratos et al. (2017), in which the order of susceptibility based on knockdown and mortality during 5 dayexposures to deltamethrin-treated material was*T. variabile* >*P. truncatus* > *R. dominica* >*T. castaneum*. Kavallieratos et al. (2017) found out that all *P. truncatus* and *R. dominica*were knocked down after 60 minutes of exposure. In our experiements, we were able to deterime time to knockdown or affected, was less than 60 minutes for both species.

Larvae of several different stored product insects showed susceptibility to treated packaging. Among all species tested, adult emergence was <10% and larval death was 100% for *O. surinamensis* and large *T. inclusum* larvae at 32°C. Scheff et al. (2016, 2017) observed differences in susceptibility to methoprene-treated packagaing between *T. castaneum* and *T. variabile* aftercontinual exposure for egg-to-adult development. The differences observed in the previous studies and the current study could be due to physiological differences between species and pubescenceof larvae. *T. inclusum* and *T. granarium* larvae are covered in fine hairs, which could reduce the precentage of body surface exposed to the treated packaging. Scheff et al. (2017) also observed longer exposure periods to methoprene-treated packaging material, decreased the percentage of normal adult emergence from exposed larvae of*T. castaneum* and *T. variabile*. We observed similar results for *T. granarium, T. castaneum,* and *T. inclusum* when exposed to deltamethrin.

Our study demonstrated that some major primary stored product insects were highly susceptible to the deltamethrin-treated storage bags among various life stages. The use of these deltamethrin-treated storage bags can offer protection of bagged grains and be used as a tool in the integrated pest management approach to stored grains.

## Acknowledgement

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture. The US Department of Agriculture is an equal opportunity provider and employer.

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## Field studies with insecticide treated packaging for the control of stored product insects

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### Abstract

Food Security is an issue that will impact everyone by 2050 it is projected there will be a global crisis unless action is taken. The ZeroFly® Storage Bag is a new combination of key technologies developed to reduce post-harvest losses. It contains an insecticide, Deltamethrin that is incorporated within the polypropylene yarns woven into a storage bag. The level of insecticide residue found on grains stored for up to two years in ZeroFly® Storage Bag are below CODEX & EPA maximum residue levels. This technology can be combined with natural rodent repellent compounds and the multilayer hermetic liners, meaning these bags can adhere to and improve on currently accepted practices and requires limited behavior change for the user. Studies show that the ZeroFly® Storage Bag can effectively control key stored product insects. The presentation will explore the current scale-up efforts and strategies of distribution planned throughout Africa and Asia, this would also include an assessment of the broader impact of ensuring the most appropriate combinations of technologies reach the most vulnerable groups.

## On-Farm Comparison of Different Postharvest Storage Technologies for effectiveness in pest management in a Maize Farming System of Tanzania Central Corridor

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### Abstract

Seven methods for storing maize were compared with traditional practice of storing maize in polypropylene bags. Twenty farmers managed the experiment under their prevailing conditions for 30 weeks. Stored grain was assessed for damage every six weeks. The dominant storage insect pests identified were the Maize weevil (*Sitophilus zeamais*) and the Red flour beetle (*Tribolium castaneum*). There was no significant difference ($F = 87.09$; $P < 0.0001$) in insect control and grain damage between hermetic storage and fumigation with insecticides. However, the insecticide treated polypropylene yarn (ZeroFly®) did not control insect infestation of grain for the experimental period under farmers' management. Grain damage was significantly lower in hermetic storage and fumigated grain than ZeroFly® and polypropylene bags without fumigation. No significant difference in grain damage was found between airtight treatment alone and when combined with the use of