O$U TIP$ on STORED GRAIN

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Winter 2005

Welcome to the Winter Issue of the SPREC Newsletter, bringing you the latest in stored product management tips, research findings, and upcoming events.

SPREC News

- This summer, the Stored Products lab attended the International Conference on Controlled Atmosphere and Fumigation in Stored Products, held on the Gold Coast in Queensland, Australia. Included in this newsletter is one of the manuscripts they submitted as a part of their presentations.
- Jim Criswell, Tom Phillips, and Randy Beebe recently traveled to Columbia, MO, to participate in the Missouri Pesticide Certification Workshops, giving presentations on improving fumigation efficacy, the need for sealing structures, fumigation safety, and related information.
- Edmond Bonjour will be attending the 76th Annual International Technical Conference and Exposition of The Grain Elevator and Processing Society in Albuquerque, NM, February 26 - March 1. He will also attend a Pre-Conference Workshop entitled, "Grain Bin Safety and Rescue Training." The workshop will focus on the best ways to form rescue teams, as well as the best technical rescue techniques, and the types of equipment needed in most rescue situations. Edmond will share what he learns at GEAPS at upcoming workshops at SPREC.

- On February 1, Edmond Bonjour, Tom Phillips, and Mukti Ghimire gave a presentation entitled, "Stored product research and extension programs at Oklahoma State University" to the Lions Club in Marshall, Oklahoma.

Spinosad Registered for Stored Grain

Excerpt from a press release by Dow AgroSciences

In January 2005, the United States Environmental Protection Agency (EPA) issued a registration for the use of spinosad, a product developed and manufactured by Dow AgroSciences LLC, as a stored grain and seed protectant on commodities including wheat, corn, rice, oats, sorghum/milo, and barley. Spinosad provides excellent control of key grain and seed pests, including Indianmeal moth, lesser grain borer and other pests.

Dow AgroSciences will delay commercialization of products in the United States under this registration until key international trade standards or registrations have been obtained. This is based on a commitment to working with the stored grain industry to introduce spinosad-branded products while ensuring conformity with industry standards.

According to Tim Hassinger, global business leader, Dow AgroSciences, "When commercialized, this spinosad product will provide growers an excellent tool to control several hard-to-manage pests in stored grain. However, since the grains that will be treated with spinosad are traded on a global basis," Hassinger added, "it is in the best interest of everyone to delay its commercial launch until the appropriate standards or registrations are established in key countries where U.S. grain is exported."

A member of the Naturalyte® insect control class of insecticides, spinosad's combination of good performance characteristics with its favorable environmental profile has made it a leading insecticide product in the United States. Spinosad formulations, including one designated for use by organic farmers, are registered for use in over 200 row and specialty crops. Spinosad is one of the fastest growing crop protection products worldwide.

Dow AgroSciences, with support from U.S. commercial partners Gustafson and Agriliance, will be working closely with key industry trade associations and other stakeholders, such as CODEX, to establish and synchronize key international trade standards for this spinosad application as soon as possible.

Spinosad was awarded the 1999 Presidential Green Chemistry Challenge Award in the U.S. and spinosad products have been registered under the U.S. EPA reduced risk pesticide program due to their favorable environmental profiles.

Secure™ is the spinosad product from Dow AgroSciences. Gustafson will be marketing spinosad in several formulations, currently in development. New tolerances have just been approved by the EPA for direct application to grain. Although the performance is excellent, international approvals have not been implemented. Work is being done to help achieve CODEX approval and approval from other, non-CODEX countries. This process will take from 2-4 years to achieve. Therefore, at this time, Dow AgroSciences and Gustafson, have agreed to delay introduction until we can successfully secure international tolerances and be able to market a product readily accepted by the international grain trade. We will continue to provide product updates as they come available.

Reldan Update

Excerpt from a letter released by Glen Karaffa of Gustafson/Bayer CropScience

Storcide™ II-The label for Storcide II was approved in November 2004 by the EPA. This is an exciting development for the industry, as we now have a true replacement product for Reldan. Storcide II will be registered on wheat, oats, barley, sorghum and rice. Storcide II will be accepted by CODEX for international export, and will offer excellent protection against the lesser grain borer, as well as the other important stored grain insects. Storcide II will be offered as a liquid-only formulation. It contains 3 ppm of chlorpyrifos-methyl (Reldan) and 0.5 ppm of deltamethrin. The formulation will be approved for use on seed, direct application to grain, for use as a top-dressing and for use as a grain bin and warehouse spray. We will be forwarding more information on this product in the near future.

Reldan® 4E-The last sale by Gustafson to our distribution partners must occur prior to December 31, 2004. Distribution must have Reldan 4E out of their possession prior to December 31, 2005. Product in the user's possession can be applied after this date and although there is not a set timeframe, the EPA will allow a "reasonable" amount of time for treated grain to clear the grain trade. They have provided us with a date of 2008 or 2009.

Gustafson has a small amount of product in our inventory. We do not want to flood the market with Reldan, but we understand that some of your customers may want to purchase a quantity for future use. We will work with interested distributors who would like to inventory a reasonable amount of product before the end of 2004. We will not authorize any Reldan 4E returns as inventory must be out of our possession by December 31, 2004.

Storcide-Some of our distributors have sold Storcide to their customers in the past two years. Although CODEX tolerances did not exist for the product, an extensive amount of product was applied and treated grain utilized domestically. Storcide, a combination of 3 ppm of chlorpyrifos-methyl and 2 ppm of cyfluthrin, has demonstrated that grain protectants can provide excellent activity against many insect pests and can be part of an effective grain management program. We only have a small amount of Storcide in our possession. We are planning on liquidating this inventory, prior to the end of 2004. We will keep state labels intact to allow continued sale and use of existing inventory.

In summary, Reldan and Storcide will be replaced by Storcide II in the Gustafson line. For those who may be interested in marketing Storcide II, your local Gustafson representative will be happy to provide additional information and discuss these options with you. We are planning on limiting availability to those customers who have provided past support of Reldan and/or Storcide and who are determined to provide the best representation for our stored grain market, which we believe can be significantly expanded due to the enhanced efficacy of the product. We are also planning on the elimination of the Storgard line of probes, traps and lures and will suggest direct purchase from Trece` in California.

Evaluating a Remote Monitoring Device for Stored Grain Insects in a Commercial Facility

Edmond L. Bonjour (OSU), Thomas W. Phillips (OSU), Ron Larson (OPIsystems, Calgary, Alberta, Canada), and Dennis Shuman (USDA-ARS)

Excerpted from a manuscript submitted as a part of a presentation at the International Conference on Controlled Atmosphere and Fumigation in Stored Products, held in Australia August 2004.

Abstract

The StorMax Insector is an electronic device for remotely monitoring insects in stored grain. Arthropods migrating within the grain mass encounter the probe trap body and are electronically counted by a computer as they fall through and interrupt infrared beams. A study in two large commercial steel bins containing stored wheat was conducted in Oklahoma to determine the accuracy of electronic counts recorded by Insector compared to actual counts of arthropods collected in the probe collecting tip. Electronic counts were approximately two times higher than actual counts over a range of counts. The probable cause of overestimation was the extremely high number of insects in the family Psocidae [editor's note: psocids can build up to high numbers in grain bins but do not cause damage to the grain]

that entered the traps. Refinement of the discriminating values entered into the software program will be able to filter out counts of these small insects and remove them from the reported counts to make the estimate more accurate for stored grain beetles counted. Insectors with collecting tips with holes near the bottom for insect release allowed insects to escape after passing through the sensor, including the high number of Psocidae. Using Insector technology to monitor insect activity will determine when treatment is necessary and improve safety by reducing the need for workers to enter grain bins.

Introduction

Stored grain pest management relies on effective sampling to determine the species present and the relative number of these species in a grain mass. Commercially available probe traps are used for detecting insect populations in stored grain (White et al., 1990) but these traps must be inspected periodically to determine the number and kinds of arthropods captured. Shuman et al. (1996) developed an electronic probe trap that generates an electronic count whenever an arthropod falls through a single infrared beam in the sensor head. The original Electronic Grain Probe Insect Counter (EGPIC) was a major improvement over other probe traps used to detect insect infestations in grain bins (Toews et al., 2003). The newest version of EGPIC, the StorMax Insector, incorporates two infrared beams and a microcontroller chip built into the new system's probe that analyze the signals from the beams to determine the relative size of counted insects and infer species identification (Shuman and Crompton, 2004).

Most of the preliminary Insector testing occurred in 10 cm diameter mini-silos in the laboratory. These laboratory tests were conducted in very clean grain with only one insect species per experiment. To be accepted for use by a variety of grain managers, Insector needed to be evaluated in field tests in different commodities and under different environmental conditions with various populations of insects. The objective of our research was to evaluate the performance of Insector in capturing stored grain insects in naturally infested commercial wheat bins in Oklahoma.

Materials and Methods

This field test was conducted from 25 Aug – 8 Oct 2003 in central Oklahoma. Eleven sampling periods varying from 2-5 days in length were evaluated. Initially, five probes were placed in each of two bins that each contained 6,804 metric tons of hard red winter wheat that had been harvested during June 2003. One probe was placed in the center of the bin and one probe was place in each cardinal direction approximately 3 m from the bin wall. Each probe was inserted vertically into the grain mass approximately 5 cm below the grain surface. The bins were naturally infested with insects. Bin 1 was fumigated on 15 Sept 2003 prior to selling the grain. The probes in Bin 1 were removed from the bin prior to fumigation and four of the probes were moved to an inner circle in Bin 2 and placed approximately 7.5 m from the bin wall in the four cardinal directions.

At the end of a sampling period, the contents of each Insector receptacle were removed and placed in a vial to take to the laboratory for processing, and samples of grain were collected using a spear-type grain trier. Three grain samples of approximately 1 kg each were collected near each Insector probe from the top 0.7 m of grain. Grain samples were sealed in plastic bags and taken to the laboratory where the grain weights and moisture contents were recorded. The samples were then sieved twice using an InsectoMat (Samplex Ltd., Norfolk, UK). Beetles and parasitic Hymenoptera captured in the traps were identified to species. Members in the family Psocidae and mites were not identified to species, but were categorized into the two respective groups and their numbers estimated.

Some Insector probes were also tested with probe tip receptacles that contained holes near the bottom of the tip. The purpose for this test was to determine if insects would leave the receptacle and return to the grain mass.

Data files generated by the Insector software were downloaded to disk after every sampling period. These data contained insect counts and species identification that were compared to actual counts of insects in the Insector collecting tip.

Results and Discussion

Several stored grain beetle species were captured in the Insector receptacles during this field study. The most common species were rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), red flour beetle, *Tribolium castaneum* (Herbst), lesser grain borer, *Rhyzopertha dominica* (Fabricius), and sawtoothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus). An example of the accuracy of actual insect counts compared to electronic counts is shown in Fig. 1 for rusty grain beetle during one sampling period. As the number of insects counted in the probe receptacles increased, the electronic counts also increased linearly with a very high R^2 value, indicating a high correlation. However, the electronic counts were overestimating the actual insect counts by a factor of approximately two. All sampling periods had a similar overestimation of actual counts.

The probable cause for the overestimation was because there was a very high population of Psocidae in the bins in comparison to the number of beetles. Thousands of electronic counts were recorded for each probe during the study. Accurate actual counts of Psocidae were difficult from the probe receptacles because so many were captured that the contents became a paste and the individuals were difficult to separate. Some of these Psocidae may have been mistakenly identified by size as rusty grain beetle, the smallest of the beetle species captured. It is also likely that the large number of Psocidae entering probes caused the passage of grain particles or other debris that were the same size as target insects, thus causing an increase in counts. Subsequent laboratory tests with Psocidae have been conducted to determine the size threshold value to set in the software to eliminate most Psocidae from being counted electronically.

Insector probes tested with receptacles containing holes allowed all beetle species, mites, and members of the family Psocidae to return to the grain mass. Using the receptacles with holes would require less maintenance and fewer trips to the bin to service probes. Electronic data would still be collected from the probe to provide information needed to make management decisions. A study needs to be conducted to determine whether the insects that leave the receptacle will move up through the grain mass and reenter the probe. If insects reenter the probe and thus get counted again, the insect count data would be inflated compared to the actual number of insects. This could lead a manager to make management decisions before they were needed.

Our study contrasted with a concurrent field study in Montana, although similar high R^2 values were observed in both studies indicating a good statistical fit between actual and electronic counts (D.K. Weaver, personal communication). The actual counts were nearly in a 1:1 relationship with the electronic counts in the Montana study while we observed a nearly 2:1 overestimation in Oklahoma. Possible explanations may be differences in the types of insects found in the two locations, differences in the physical stored grain environment, and the total number of insects in the bin. Lower insect populations are usually observed in grain stored in Montana while insect populations can be very high in Oklahoma, mainly because of the warmer grain temperatures and the longer storage period when the grain is warm.

Data collected from grain trier samples along with the electronic data will be integrated into the Stored Grain Advisor (SGA), a decision support system for stored grain (Flinn, 1999). That system interprets information from standard sampling procedures, predicts the likelihood of insect infestation, and recommends appropriate preventative and remedial action. The electronic data, especially species identification, will be read and interpreted by SGA, which will then make recommendations to the grain manager.

The interpretation of electronic counts has to be carefully evaluated before developing a management strategy to control pests. Refinement of the discriminating values for the software will filter out electronic counts of small insects and provide more accurate estimates of stored grain beetles. The

StorMax Insector should be a useful tool for accurately estimating insect populations to help grain managers make the best decisions for when treatment is necessary. Using this technology will also improve safety at grain storage facilities by reducing the need for workers to enter grain bins. Ultimately, this technology will also improve the quality of stored grain by treating grain only when necessary, by lowering pest populations, by decreasing pest control costs, and by reducing pesticide residues.

References

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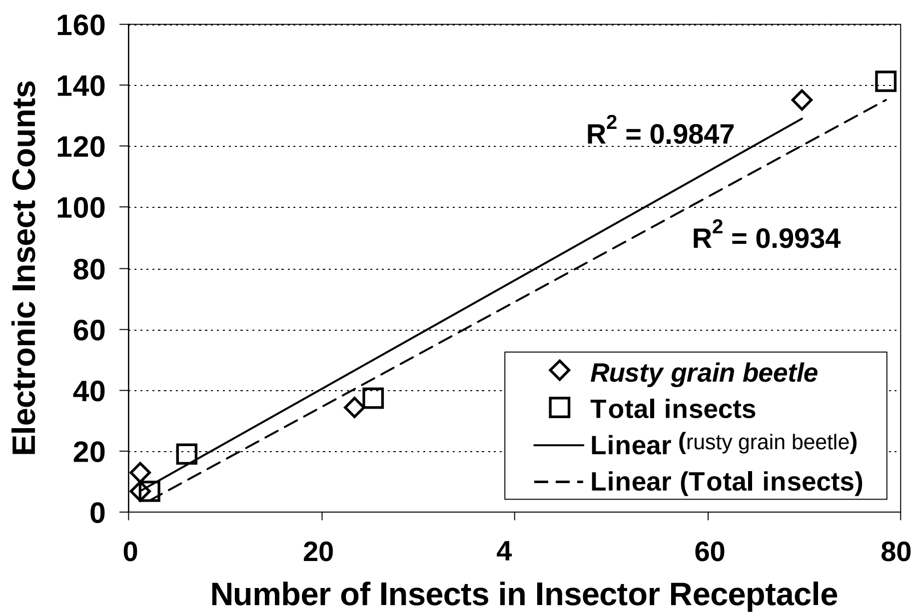
Fig. 1. Insector Performance, 10-12 September 2003



Research Briefs

- The Stored Products Entomology laboratory recently published six papers. Titles and abstracts are included here. For the full papers, go to http://ipm.okstate.edu/ipm/sprec/publications.htm
    - **Relationship Between Flight Activity Outside Grain Bins and Probe Trap Catches Inside Grain Bins of Rusty Grain Beetle, *Cryptolestes ferrugineus***. Environ. Entomol. 33: 1465-1470. Abstract: Insect sampling/monitoring inside grain bins is time consuming, cumbersome during the summer heat in the headspace of grain bins, may require investment in costly sampling devices for sampling of grain, and involves a certain risk to employees. Thus, it is important to explore unbaited sticky traps on the outside of grain elevators as decision support tools for improved management of stored grain. In this study, we analyzed seven trap catch data sets of unbaited sticky trap catches on the outside of grain bins and corresponding probe trap catches in the upper level of the grain mass at three farm bins in 1991, with capacities ranging from 68 to 141 metric tons, and at two commercial steel bins in 1993 and 1994, with capacities of 5,400 and 6,800 metric tons. We used response surface regression analysis to analyze standardized trap catches of the rusty grain beetle, *Cryptolestes ferrugineus*, and showed that (1) from late June to late July, catches on unbaited sticky traps placed on the outside of grain bins preceded probe traps inside the bins by 3 d, which suggested immigration into bins; and (2) in late August, unbaited sticky trap catches on the outside of bins started to decrease, while probe trap catches inside the bins continued to increase until mid-September. We concluded that,

from late June to mid-August, immigration of rusty grain beetles into grain bins influences abundance in the upper grain layer, whereas later in the season, the two types of trap catches were only loosely associated. This study is consistent with results published elsewhere that immigration of rusty grain beetles into grain bins initiated shortly after wheat was loaded into the bins.

- **Model of Rusty Grain Beetle, *Cryptolestes ferrugineus*, Flight Activity Outside Commercial Steel Grain Bins in Central Oklahoma.** Environ. Entomol. 33: 426-434. Abstract**:** Unbaited sticky traps were placed on ropes in the four cardinal directions and at different heights on the outside of commercial steel bins containing stored wheat. Weekly trap catches of the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), were examined. The number of traps per steel bin varied due to differences in dimensions, and three height classes were established, but there was no significant difference in trap catches of rusty grain beetles among height classes. Significant yearly and between-steel bin variation was found, and these effects were removed before using a response surface regression analysis to determine how well two time variables (daylength and day number) and three weather variables (minimum and maximum temperature and precipitation) could explain the seasonal variation in rusty grain beetle flight activity. These variables were used in separate analyses of rusty grain beetle trap catches in the four cardinal directions and from the three height classes (12 separate analyses). The most robust model fit was obtained when using a subset representing 208 rusty grain beetle trap catches from the northern side at height class 3 (traps s placed at least three-quarters of bin height). The full model of the two time variables and three weather variables explained 48% of the variance in this subset of trap catches, whereas a model based on weekly means of daylength and minimum and maximum air temperatures explained 40% of the total variance in rusty grain beetle trap catches. The relative trap catch response to daylength and minimum and maximum air temperatures was evaluated. High beetle flight activity around grain bins may indicate a high risk of insect infestation of stored wheat, and the presented model can therefore be used to determine time periods with high risk of beetle immigration into commercial steel bins.
- **Effects of Height and Adjacent Surfaces on Captures of Indianmeal Moth in Pheromone-Baited Traps**, J. Econ. Entomol. 97(4): 1284-1290. Abstract: Diamond-shaped pheromone-baited traps are used widely in food storage and food processing facilities for monitoring of Indianmeal moth, *Plodia interpunctella* (Hübner), and here we evaluated to what extent trap captures were affected by 1) vertical placement of traps, 2) deployment of a horizontal landing platform to the diamond-shaped pheromone trap, and 3) placement of traps either freely exposed or along a sidewall. In the small sheds (height 1.8 m), traps were placed in three heights and significantly highest trap captures were obtained near the ceiling. When the same experiment was conducted in a larger room (height 6 m) with traps at seven heights, highest captures were obtained at both the lowest and highest traps. In a subsequent experiment, we deployed a horizontal platform to traps at seven heights and found that the importance of vertical placement became less important. Thus, it seemed that male moths preferred to orient to a pheromone source associated with a physical surface, such as the door, ceiling, or landing platform. In a comparison of Indianmeal moth male trap captures in a completely dark room (no visual cues), traps with a landing platform caught significantly more than traps without the platform. In a final experiment, we evaluated the effect of hanging traps either freely or adjacent to sidewalls, and significantly highest trap captures were obtained along side-walls. The results presented here suggest that deployment of a horizontal platform reduces the importance of the vertical placement of traps and seems to increase the trap efficiency, and we recommend placement of traps along sidewalls and/or near the ground.
- **Analysis of the Insect Community in a Stored-Maize Facility**, Ecological Research 19: 197-207. Abstract: Maize samples were obtained at two depths [0–30 cm (top sample) and 30–60 cm (bottom sample) from the maize surface] at 19–28 locations from a naturally infested maize storage facility in Wisconsin, USA. Based on identification of insects in stored-maize samples from 13 weekly sampling events, four topics were addressed: (i) the seasonal fluctuation in the insect community; (ii) ordination analysis was conducted to examine the association among insect taxa and to determine their distribution along abiotic and geographic gradients; (iii) the demographic characteristics of insect communities in maize samples with high abundance of either Indianmeal moth, *Plodia interpunctella* (moth samples), or maize weevil, *Sitophilus zeamais* (weevil samples); and (iv) to what extent natural enemies were spatially associated with their prey species. We identified a total of 18 different taxa, composed of adults and larvae of 14 determined species, and others identified to genus, family or order. Insect density was significantly higher in top samples compared to bottom samples, and the insect taxa occurred more frequently in top samples compared to bottom samples. In the ordination analysis, the three explanatory variables accounting for eastern, northern and vertical position of maize samples explained the largest part of the total variance. There was a gradual time trend with some of the insect species mainly occurring early or late in the monitoring period. Moisture content of the maize was the weakest of the significant explanatory variables, while temperature in the grain mass did not explain a significant part of the total variance. Moth samples and weevil samples had significantly different spatial distribution patterns and had markedly different insect species composition. Moth samples were characterized by low abundance of all grain feeders and fungus feeders, except Indianmeal moth. Conversely, weevil samples had high abundance of red flour beetle, foreign grain beetle, and rusty grain beetle. Consequently, weevil samples seemed to comprise more diverse insect communities than moth samples. Natural enemies were not significantly associated with their most common hosts. In a highly homogeneous habitat (stored maize), we demonstrated that stored-product insect species had significantly different distribution patterns mainly along geographic gradients. Stochasticity of the initial infestation process or interspecific competition are two of the possible explanations for the spatial segregation of stored-product insects, and the spatial segregation of insects on the same trophic level may have profound implications for the understanding of how these ecosystems develop over time and thereby how integrated pest management strategies are implemented to control insect pest populations.
- **The Impact of Spatial Structure on the Accuracy of Contour Maps of Small Data Sets**, J. Econ. Entomol. 96(6): 1617-1625 (2003). Abstract: Spatial analysis of insect counts provides important information about how insect species respond to the heterogeneity of a given sampling space. Contour mapping is widely used to visualize spatial pest distribution patterns in anthropogenic environments, and in this study we outlined recommendations regarding semivariogram analysis of small data sets (N = 50). Second, we examined how contour maps based upon linear kriging were affected by the spatial structure of the

given data set, as error estimation of contour maps appears to have received little attention in the entomological domain. We used weekly trap catches of the warehouse beetle, *Trogoderma variabile*, and the accuracy assessment was based upon data sets that had either a random spatial structure or were characterized by asymptotic spatial dependence. Asymptotic spatial dependence (typically described with a semivariogram analysis) means that trap catches at locations close to each other are more similar than trap catches at locations further apart. Trap catches were poorly predicted for data sets with a random spatial structure, while there was a significant correlation between observed and predicted trap catches for the spatially rearranged data sets. Therefore, for data sets with a random spatial structure we recommend visualization of the insect counts as scale-sized dots rather than as contour maps.

- **Attractancy and Toxicity of an Attracticide for Indianmeal Moth, *Plodia interpunctella***, J. Econ. Entomol. 97(2): 703-710 (2004). Abstract: Indianmeal moth, *Plodia interpunctella* (Hübner), is a serious and widespread postharvest pest on cereal products, dried fruits, candy, and pet food. Due to the strong positive anemotactic flight response of Indianmeal moth males to the main component of the female-produced pheromone [(*Z*,*E*)-9,12-tetradecadienyl acetate, herein referred to as ZETA], we evaluated the potential of an attracticide for this pest, in which ZETA as attractant was combined with permethrin as the killing agent. Two concentrations of ZETA [0.16 and 0.32% (wt:wt)] and five concentrations of permethrin [0, 3, 6, 12, and 18% (wt:wt)] were incorporated into Last Call gel (10 different permethrin:ZETA combinations). All attracticide gels were evaluated in a toxicity test, in which either the tip of a leg or an antenna of a virgin Indianmeal moth male was touched <3 s into a dot of attracticide gel. These males were subsequently transferred to jars with virgin females. The toxicity test showed that a brief and gentle contact of Indianmeal moth males with attracticide gel containing 3-18% permethrin caused a significant reduction in mating and killed males moths within 24 h. A wind tunnel test was conducted to evaluate the flight responses of Indianmeal moth males to the same 10 attracticide gels. Male moths displayed significantly higher levels of positive anemotactic flight and more males made contact with the attracticide gel when the ZETA concentration was 0.16% compared with 0.32%. Indianmeal moth males showed no signs of repellency to permethrin concentrations within a range of 0 -18% in the attracticide gel. Three densities of Indianmeal moth pairs were released into small warehouse rooms, and we found that the attracticide gel suppressed oviposition when the moth density was at a low level, but it was ineffective when the moth density exceeded one male-female pair per 11.3 m^3.

Upcoming Workshops

- Fumigation Practical at SPREC, Stillwater, OK, March 22, 2005. Contact Jim Criswell, 405-744-5531, for more information (or visit the SPREC Web site, http://ipm.okstate.edu/ipm/sprec/calendar.htm.
- GEAPS (Grain Elevator and Processing Society) Exchange 2005, the annual technical conference and trade show, will be Feb. 26 – Mar. 1 in Albuquerque, NM. For more information, including registration details, see http://www.geaps.com/exchange2005/index.cfm.

Stored Product IPM Team

Brian Adam, Agricultural Economist, 405-744-6854, badam@okstate.edu
Kim Anderson, Extension Economist, 405-744-9817, anderso@okstate.edu
Pat Bolin, IPM Coordinator, 405-744-9420, bolinp@okstate.edu
Edmond Bonjour, SPREC Manager, 405-744-5099, elb4119@okstate.edu
Jim Criswell, Pesticide Education Coordinator, 405-744-5531, jtc@okstate.edu
Tom Phillips, Stored Products Entomologist, 405-744-9408, tomp@okstate.edu

Pat Bolin
IPM Coordinator

Edmond Bonjour
SPREC Manager