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Modern perspectives on stored-product insect pest management

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Introduction

Modern perspectives of stored-product insect pest management are represented here by nine topics which fall into three broad categories: sampling, insecticide resistance and management practices. The three insect sampling papers cover techniques for detecting insects and estimating insect population densities to decide whether pest management is needed. The first of the resistance papers covers the sub-lethal effects of insecticides and behavioural resistance, areas that are often overlooked when evaluating effectiveness of insecticides against insect pests associated with stored commodities. The other resistance paper describes the historical background and current perspectives on the only national resistance surveillance and management programs in the world. Three of the four pest management papers cover specialised pest management methods such as use of semiochemicals, insect-resistant packaging or treatment of packaged products with modified atmospheres, and use of elevated temperatures. The last paper gives a current overview of the status of stored-product insect pest management in Africa using biological, chemical and physical methods, and sheds light on challenges and current needs for improved pest management.

Sampling

In introducing these topics, we would like to emphasise certain aspects covered in a few papers in this volume. Sampling is most cost-effective when the sampling program is designed to determine whether insects have reached an economically-damaging density rather than estimating actual insect density. Estimating actual insect density when it is below a threshold or close to zero will require too many samples, which drives up the cost of sampling. When the density is found to be low after taking adequate number of samples (30 or less), it is best to quit sampling and resample after a month. If the density is high, a few samples will indicate whether or not it is above a threshold that warrants an intervention. However, resampling is still essential to ensure the degree and duration of suppression obtained post-intervention. This approach was well illustrated by the monitoring-based management of insect populations at grain elevators in the USA [1]. Since 2002, this sampling and decision-making program has been used effectively by a private consultant at 70 elevators in Kansas, Oklahoma and Nebraska. In addition to insect pest management information, this sampling program has provided grain quality information useful in grain marketing.

A tool not mentioned in any of the papers, that is available for developing sampling programs, is the generic variance-mean equation [2]. This generic equation is often better than an equation fit to a small preliminary data set covering only a narrow range of insect densities. Acoustic detection of insects provides a method for continuous monitoring of insects, and continuous monitoring can provide advanced warning of insect problems, so one can manage insect populations before they reach an economic injury level.

Insecticide resistance

Resistance development, surveillance, and management are important aspects to consider, especially when using chemical management methods, because few chemical insecti-

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cides or fumigants are available for use in stored commodities or food storage and processing facilities. Reasons for the limited number of chemicals available include the following: (a) stored-products are a minor market for pesticides compared to field crops or disease vectors; and (b) fewer chemicals qualify for use around stored raw or processed commodities. The number of chemicals may be further reduced when they are used as trade barriers.

Resistance has developed in every major stored-product insect species and these resistant insects are moved around the world by international trade. Behavioural and sub-lethal effects are often ignored when detecting and monitoring resistance in stored-product insects to pesticides. The label rates are designed for commercial kill of insects and do not consider behavioural and sub-lethal effects. More research on these two aspects should be part of evaluating existing and candidate chemicals for use in stored-product protection.

The best way to manage insecticide resistance is to kill resistant insects by another pest management method with entirely different mode of action such as natural enemies, impact mortality (by grain handling or through impact machines in food-processing facilities), ionizing radiation, and heat or cold. There have been numerous reports published in literature on stored-product insect resistance to various classes of pesticides. Many countries do not have a concerted program to track resistance in stored-product insects to chemicals. Australia is the only country that has a national infrastructure to monitor and manage phosphine resistance in stored-product insects. Similar surveillance and management programs should be implemented for other pesticides used in stored-product protection.

Management practices

Insect pheromones have been successfully and widely used to detect and monitor stored-product insect populations in grain stores, warehouses, food-processing facilities, and retail stores. In addition to monitoring, pheromones can be used to manage stored-product insect populations in closed environments. The article on pheromones highlighted several methods for managing stored-product insect populations, and also alluded to some challenges in accurately making inferences about the degree of suppression obtained. For example, the absolute density of insects in a given environment is unknown, and trying to have a “control” facility or a room is difficult, as are the effects of environmental variables on insect populations. Therefore, the authors of the mass-trapping, mating-disruption, and attracticide article suggest directly examining the female insects for sperm transfer to validate mating disruption. One study [3] observed male flight to determine whether males were able to find females in a sex pheromone permeated atmosphere. This study also investigated two insect densities and two pheromone release rates. More studies are needed that quantify the potential effectiveness of pheromone-based pest management methods in a pest management program.

Beyond the up-to-date discussion of insect-resistant packaging technology, Brody [4] provides an industry perspective of packaging requirements and development process, and Karitas [5] provides a survey on the prevalence of packaging damage and the recovery of commodities from damaged packages. Packaging is designed to protect the quality and integrity of the product within, and therefore, making it insect resistant is just a part of the equation. Products to be packaged should be processed in a facility that is relatively insect-free, and every effort should be made to make sure that the product is insect-free prior to packaging. Some companies use modified atmospheres (<2% oxygen) to manage insects and mites in packages. In addition to packaging, care must be exercised to ensure that packages are transported, stored, or finally displayed in insect-free carriers, warehouses and retail stores.

The use of high temperatures is a 100-year old technology and the phase out of methyl bromide has generated a renewed interest in using this technology for disinfesting food-processing structures [6]. Many food companies in the USA have been using heat treatments for nearly 50 years, and many more in the USA and Europe started using heat treatments as a methyl bromide alternative. The article on heat treatments provides a historical overview and sheds light on recent advances made through research and education.

The last chapter presented biological, chemical, and physical control methods prevalent in sub-Saharan Africa, and mentioned challenges and opportunities for stored-product insect management. In Africa pesticides are available, but it is unclear if pesticide laws and regulations result in their proper use. Therefore, grain with smallholder farmers is best managed using non-chemical methods. The author discussed triple bagging grain to preserve quality and the use of hermetic metal bins for insect management as successful examples in Africa. Biological control was considered to be a valuable part of insect pest management in Africa. However, a full discussion of the potential effectiveness of natural enemies as part of a pest management program was beyond the scope of this paper. Interested readers are referred to the book by Hagstrum and Subramanyam [7] for a review. The author stressed the need to re-evaluate storage losses in Africa and develop customised stored-product insect management practices suitable for different agro-climatic and geographic regions of sub-Saharan Africa.

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Dedication

We would like to dedicate this special issue to the memory of

Mr. Jan van Someren Graver, a retired CSIRO stored-product entomologist and fumigation expert, who was a great scientist, friend, and an outstanding humanist.

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