Research Application Summary

Ecology and safer management of storage insect pests in sorghum smallholder farming systems

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Abstract

This study seeks to develop safe, effective and environmentally friendly alternatives to the conventional organophosphate-based insecticides and generate better understanding of storage insect pest population dynamics so as to identify appropriate measures for controlling the pests. Three experiments will be carried out; laboratory bioassays, field efficacy studies and ecological studies. Insect mortality, grain damage, grain moisture content, insect species and spectrum will be assessed to determine efficacy and persistence of the protectants. In the ecology studies; population dynamics and the effectiveness of insect exclusion on grain damage will be determined and these will give a guide as to when grain protectants can be applied.

Keywords: Ecology, storage insects, sorghum grain damage, safer pest management, population dynamics

Résumé

Cette étude vise à développer des alternatives sûres, efficaces et respectueuses de l'environnement aux insecticides conventionnels à base d'organophosphates et à générer une meilleure compréhension de la dynamique des populations d'insectes ravageurs des greniers afin d'identifier les mesures appropriées pour lutter contre ces ravageurs. Trois expériences seront réalisées:les bio-essais en laboratoire, les études d'efficacité sur le terrain et les études écologiques. La mortalité des insectes, les dommages du grain et la teneur en eau des grains, les espèces d'insectes et leur spectre seront évalués afin de déterminer l'efficacité et la persistance des protecteurs. Concernant les études sur l'écologie, la dynamique des populations et l'efficacité de l'exclusion des insectes sur les dommages du grain seront déterminées et celles-ci donneront un guide pour savoir quand les protecteurs des céréales peuvent être appliqués.

Mots clés: Ecologie, insectes des greniers, dommages des grains de sorgho, gestion sûre des ravageurs, la dynamique des populations

Background

Smallholder farmers in Zimbabwe practice postharvest grain retention as a food security strategy. However, substantial amount of the grain is lost to storage insect pests because the structures used are not insect proof (Nyagwaya *et al.*, 2010). Due to climate variability, there is a strong drive by development agencies in Zimbabwe to encourage farmers to produce sorghum which is a more drought tolerant crop compared to maize as an adaptation strategy in the drier areas of the country as a complementary food security strategy. Unfortunately, little attention has been paid to postharvest aspects of sorghum in comparison to maize and wheat. Grain protection is currently based on the use of organophosphate-based grain protectants. These however, pose challenges due to their environmental impacts, insect resistance development and safety concerns. Therefore safer alternative control options are needed in order to ensure that grain is safely stored. Therefore, safer grain protectants need to be tested under real-life conditions for protracted periods to determine their persistence. This study therefore was carried out to develop safe, effective and environmentally friendly alternatives to the conventional organophosphate-based insecticides for managing sorghum storage insect pests.

Literature Summary

Sorghum is a major crop in Zimbabwe which is adapted to a wide range of rainfall patterns and temperature (Lauschner and Manthe, 1996). It is even becoming more important as the chances of staple maize crop failure are increasing. The most important insect pests of stored sorghum in Zimbabwe are *Sitophilus oryzae*, *Rhyzopertha dominica*, *Tribolium castaneum* and *Sitotroga cerealella* (Mvumi *et al.*, 2003) (Fig. 1).

Insect resistance to organophosphates has been reported (Giga and Mazarura, 1990). This could partly be due to misuse and use of adulterated chemicals (Nyagwaya *et al.*, 2010). Diatomaceous earths (DEs) have also been demonstrated to be potential control alternatives to organophosphate based protectants against sorghum storage pests (Stathers *et al.*,

Figure 1. Common sorghum storage pests. Left, *Rhyzopertha dominica; middle, Sitotroga cerealella;* right, *Sitophilus* spp.

2002). However effective control against *R. dominica* a major sorghum storage pest is attained at high rates. This gives an opportunity to combine DEs with other chemicals with a knockdown effect so as to reduce DEs application rates. The DEs work by desiccation (Ebeling, 1971) which makes them ideal in areas with high temperatures and low humidity, where sorghum is a major crop. More potential of DEs can be realized when they are combined with other chemicals such as bio-pesticides and pyrethroids. Spinosad (bio-pesticide) which is environmentally benign with low mammalian toxicity (Thompson *et al*., 2000) was found to be effective against several grain pests under laboratory conditions (Huang and Subramanyam, 2007). However, research on spinosad effectiveness has mainly been on maize and wheat. There is a need to test its efficacy on sorghum and also under field conditions.

Study Description

Studies will be carried out at three sites: University of Zimbabwe's Department of Biological Sciences (CTH room, 27±2°C and 65±5% R.H.), Harare; Matopos Research Station (MRS) (20°23È latitude & 28°30È longitude, average annual rainfall of 585mm and average annual temperature of 20.9 °C) and Uzumba Maramba Pfungwe (UMP), located in natural region (NR) IV (rainfall 450-650mm per annum). MRS and UMP are semi-arid areas where sorghum is a major crop.

Laboratory bioassays: Two laboratory bioassays will be carried out in CTH room: *(a)* to determine the efficacy of new DE (MN51) and compare it with Protect-It, a commercial DE; *(b)* to evaluate the synergistic effects of combining DEs, pyrethroids and bio-pesticides against key storage pests of sorghum. Experiment 1(a) will have treatments that comprise of the MN51 at 200, 400, 600, 800, 1000ppm compared to Protect-It at 600 and 1000ppm. Experiment 1(b) will be comprised of untreated control; Spinosad 1mg/kgw/w; Spinosad1mg/kg+Protect-It 0.1%w/w; Spinosad 0.5mg/kg+Local DE 0.1%w/w; Protect-It 0.1%+ Permethrin 0.5% and Actellic Gold Chirindamatura Dust (Primiphos-methyl 16g/kg mass/mass and Thiamexotham 3.6g/kg mass/mass).

Sterilized undamaged sorghum grain (var: Marcia) (100g) treated or untreated in 375ml jars will be used for bioassays. Fifty unsexed 7-21 day old adult insects (*R. dominica*, *S. oryzae* and *T. castaneum*) and 2-4 day old *S. cerealella* larvae will be added to the grain. The experiments will be arranged in a completely randomised design (CRD) with treatments replicated 4 times. Insect mortality assessments will be conducted at 7 and 14 days after introducing insects into jars. Progeny survival test will be conducted after 6 weeks for *S. cerealella*, 7 weeks for *S. oryzae* and *R. dominica* and 10 weeks for *T. castaneum* (Fields *et al*., 2002). Data for toxicity will be corrected for control mortality according to Abbott's formula (Abbott, 1925). Analysis of data will be done by species using ANOVA.

Field efficacy studies: On-farm, researcher-managed experiments will be conducted in UMP in farmers' stores on bagged sorghum grain. The experiment will be arranged in RCBD where each farmer will have a complete set of treatments and taken as a block. Treatments will be comprised of four most efficacious candidates from bioassays and Actellic Gold Chirindamatura dust®. The treatments will be replicated at least four times i.e., at least four farmers will be chosen. The trial will be conducted for 40 weeks in each of 2012/13 and 2013/2014 storage seasons. Grain sampling will be done at 8 week intervals without replacement using probes. Samples will be collected from the bottom, middle and top positions of the bags to form a composite sample of about 1 kg which will be brought to the UZ laboratory for analysis. The samples will be assessed for percentage insect damaged grain; arthropod population and species; and F1 emergence upon incubation of the samples in CTH room for 5 weeks.

Ecology studies: On-station studies will be set up at MRS: *(a)* To determine population dynamics and interactions of sorghum storage pests; and *(b)* To evaluate the importance of resident infestation vis a vis re-infestation on grain damage. The experiments will run concurrently for two storage seasons (2012/13 and 2013/14). Insect population dynamics will be monitored using pheromone traps, and arranged in an RCBD with two factors (direction and distance) for outside storage dynamics. In-store population dynamics will be monitored using baited crawling traps placed at different grain layers. Each grain layer will be taken as a treatment; the treatments will be replicated four times and RCBD will be the design for in-store dynamics. Insect counts will be done every 4 weeks. Population peaks will be determined by comparing number of insect against time.

Experiment for the significance of resident *vis a vis* re-infestation will be arranged in an RCBD with four treatments replicated four times. Hundred liter plastic drums will be used for the experiment. Treatments will comprise of sealed pesticide free clean and fumigated grain; clean fumigated left open; infested sealed grain and infested grain left open. Temperature and humidity of the grain will be measured using data loggers. Sampling and measurements will be carried out as for the field efficacy studies.

Research Application

The results will be used for developing safer, efficacious and appropriate pest management strategies for smallholder sorghum farmers. The safer protectants will be used to complement and gradually replace the organophosphate-based grain protectants. Knowledge of the pests ecology generated will help in the devising of sound integrated pest management programs for stored sorghum insect pests.

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