Research Application Summary

Temporal population dynamics of storage insect pests and their management using safer grain protectants in maize smallholder systems of Zimbabwe

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Abstract

The study aims to determine peak flight activity periods and develop a safer and more efficacious grain protection strategies using different combinations of new and commercial diatomaceous earths (DEs), biopesticides and minimal pyrethroids against the major pests of stored maize over two storage seasons (2011/12 and 2012/13). The study also seeks to assess grain damage by resident versus incoming infestations. The treatment materials will initially be tested in the laboratory, and the best candidates will be further tested on-farm and on-station at the Institute of Agricultural Engineering (IAE) in Harare. Storage insect population dynamics through pheromone trap catches will also be conducted on-station at IAE.

Key words: Farmers, maize, safer grain protectants, storage insect pests, storage insect population dynamics

Résumé

L'étude vise à déterminer les périodes de pointe d'activité de vol et à développer des stratégies de protection des graines, plus sûres et plus efficaces, au moyen de différentes combinaisons de nouveaux insecticides et des insecticides diatomites commerciaux (DEs), les biopesticides et les pyréthroïdes minimales contre les principaux ravageurs du maïs stocké pendant deux saisons de stockage (2011 / 12 et 2012/ 13). L'étude vise également à évaluer les dommages des graines causés par des infestations résidantes par rapport aux infestations entrantes. Les matériaux de traitement seront d'abord testés dans le laboratoire, et les meilleurs candidats seront en outre testés à la ferme et à la station de l'Institut de génie agricole (IAE) à Harare. La dynamique des populations d'insectes ravageurs de stockage à travers les captures par piège en phéromone sera également menée à la station de l'IAE.

Mots clés: Agriculteurs, maïs, protecteurs des semences plus sûrs, insectes ravageurs de stockage, dynamique des populations d'insectes de stockage

Background

Maize is the staple cereal for Zimbabwe whose production is seasonal (summer Nov-March) yet it is demanded throughout the year (Nukenine, 2010). Often, yearlong supply of maize is not possible due to grain loss in storage. There is therefore need for safe and effective storage of maize throughout the year to guarantee food security. The control of insect pests in stored maize grain has largely been based on curative chemical methods (Mvumi and Stathers, 2003). Maize storage systems need to minimise dependence on these synthetic pesticides as they pose health and environmental concerns in addition to development of resistant insect pest populations (Fields *et al*., 2002). Diatomaceous earths treatments have also been used to manage insect pests. These however need field tests based on a spectrum of pest species (Stathers *et al*., 2004). The broad objective of the study is to develop grain damage preventive techniques and materials that are safer and can fit into existing IPM strategies so that production investments are not lost to insect pest damage.

Literature Summary

The global shortage of food has greatly increased the necessity for effective grain preservation methods. Many methods of processing and handling maize grain to minimise infestation have been developed (Bond, 1974) but grain losses to storage pests continue to be incurred (Hodges *et al*., 2010). Since yields recorded after harvest represent the maximum value in terms of expended human effort (Bond, 1974), it is imperative that more effort and resources be directed towards post-harvest handling and stored product protection to prevent damage by insect pests.

In Zimbabwe, maize is shelled and stored in traditional granaries or bagged and stored in living quarters or storerooms. These storage methods are not effective against maize storage pests as they are not pest proof (Nyagwaya *et al*., 2010), and predispose maize grain to pest infestations. Damaged grain has reduced weight, market value, nutritional value, and low percentage germination (Tefera *et al*., 2011).

The pest complex of stored maize in Zimbabwe (and most countries in sub Saharan Africa) comprises of the maize weevil, *Sitophilus zeamais* Motsch, larger grain borer, *Prostephanus truncatus* Horn, Angoumois grain moth *Sitotroga cerealella* Olivier and the rust red flour beetle *Tribolium castaneum* Herbst (Meikle *et al*., 2002; Mvumi *et al*., 2003; Tefera *et al*., 2011). *P. truncatus* is the most destructive pest and in Zimbabwe the pest is relatively new (Rwegasira *et al*., 2003) and was officially declared in the country in March 2010 (Nyagwaya *et al*., 2010). Stathers *et al*. (2004) and Arthur (2010) reported that Diatomaceous earths (Des) are very effective against most Coleopteran storage pests. Huang and Subramanyam (2007) reported 98% mortality of seven storage pests (including *P. truncatus*) on spinosad treated maize at rates 1-2mg/kg of DE.

Study Description

Study sites. Laboratory studies are being conducted at the University of Zimbabwe, located in Harare, Zimbabwe. In addition there will be on-station trials at the Institute of Agricultural Engineering (IAE) located at Hatcliffe farm (17°45[1] latitude and 31°10È longitude with 750-1000mm annual rainfall). Researcher managed on-farm trials and farmer managed trials will be conducted in agro-ecologically different areas: Murehwa district (17°65[1] latitude and 31°77[1] longitude, agro-ecological region IIa, 750 – 1000mm annual rainfall) and Uzumba Maramba Pfungwe (UMP) district (16°83[1] and 32°33[1], agro-ecological region IV, 450-650mm annual rainfall) under Mashonaland East province. IAE was chosen based on the availability of grain storage research structures. UMP and Murehwa districts were chosen for their being maize producing areas, contrasting agro-ecological conditions (to observe effects of climate), presence of field partners for farmer mobilisation and presence of storage pests in the area.

Insect rearing. All the insects are being reared in 1L and 2L glass jars on sterilised maize grain in the controlled temperature and humidity room (C.T.H) maintained at 27±1°C and 60%±5 RH (Tefera *et al*., 2011). Emerged progeny is sieved off 14 days from day of emergence and introduced into fresh clean sterilised maize grain. *S.cerealella* adults are provided with sterile pleated filter papers for oviposition.

Experiment 1. Pest ecology studies

(**A) Population dynamics.** Three insect flight traps are going to be set in all four directions East, West, North and South of each of three stores at 15m, 30m and 45m points. Baited crawling traps will be placed at the top, middle and bottom layers of the grain. Four pheromone flight traps will be placed at each point, specific one for each insect species. Trap counts will be conducted at six week intervals. RCBD with two factors (trap distance and trap direction) will be used.

(B) Resident versus incoming infestation trials. Freshly harvested grain will be divided into fumigated and not-fumigated. Each of the lots will be further divided into 4 sub-lots and randomly allocated to well cleaned storage bins as follows: Fumigated-open replicated three times, non-fumigated-closed replicated three and non-fumigated-open and fumigated closed also replicated three times. ANOVA in an RCBD will be used to analyse data from both experiments.

Experiment 2. Laboratory bioassays

(A) New and registered DEs. One hundred grammes of clean untreated maize will be admixed with MN51 in glass jars at 200ppm, 400ppm, 600ppm, 800ppm, 1000ppm (Fields *et al*., 2002). Protect-It® will be mixed with 100g of maize grain at 600ppm and 1000ppm while jars with untreated grain will act as a control. Twenty 7-21day-old unsexed adult beetles (Fields *et al*., 2002) and 2-5day old *S. cerealella* larvae will be introduced into each jar.

(B) DEs and Biopesticides. Fifty (7-21 day-old) unsexed adult insects and 2-5day old *S. cerealella* are going to be introduced to 100g of insecticide treated grain in 375ml jam jars replicated 3 times. The treatments are going to be Untreated control, Spinosad 1mg/kg, Spinosad 0.5mg/kg + Protect-It® 0.1%w/w, 100ppm, Spinosad 0.5mg/kg + Chemutsi (Local DE) 0.1% w/w, Protect-It 0.1%w/w + Permethrin, and Super Shumba® dust 0.5g/kg. Completely Randomised Design (CRD) will be used for both A and B. Mortality assessment will be done day 7 and 14 (Fields *et al*., 2002) and the grain will be weighed. Adults will be sieved off on day 14 and grain returned to jars and incubated at 25±1°C and 60% ± 10% temperature and relative humidity respectively (Fields *et al*., 2002). Progeny survival data will be collected after 7 weeks for *S.zeamais* and

10 weeks for *T.castaneum* (Fields *et al*., 2002), then 6 weeks for *S.cerealella* and 8 weeks for *P.truncatus*. Product persistence data will be collected 3 and 6 months later (Stathers *et al*., 2004). One way ANOVA to separate significantly different mortality means (at $P<0.05$) and Repeated Measurements will be carried out in Genstat to analyse the data.

Experiment 3. On-station and on-farm trials

(A) On-station. The most efficacious treatments from Experiment 2, a commercial synthetic chemical grain protectant and untreated control are going to be further tested at IAE using shelled maize. Grain will be treated separately and randomly allocated to storage granaries replicated three times. RCBD will be used with store houses as blocks. Sampling will be done 8 week intervals (Stathers *et al*., 2002). Insect population, species, grain moisture content and grain damage will be recorded.

(B) On-farm. On-farm trials will be conducted as follows: 5 farmers are selected by judgemental sampling for researcher-managed trials and another 5 farmers for farmer-managed trials through farmer field schools (FFSs). Existing farmer field schools will be used. Each of both the selected (researcher-managed) and volunteer (farmer-managed) farmers will have a full set of treatments. Grain will be contained in 25 or 50kg polypropylene bags instead of jars. Each farmer will act as a block with a complete set of treatments in a RCBD design. Samples of about 1kg of grain will be collected and grain damage, insect population and spectrum recorded at 8 week intervals for a period of 36 weeks.

One way ANOVA in Genstat version 14 will be carried out for each pest species against each of the treatments. Grain damage will be assessed using the count and weigh method. Multiple comparison tests are going to be carried out to compare insect mortalities for all the treatments.

The effective grain protectants are expected to replace or complement currently registered organophosphates and pyrethroid based protectants which are potential health (livestock and human) hazards, and environmental contaminants. Knowledge of pest population dynamics in store will result in accurate and precise pesticides application resulting in less

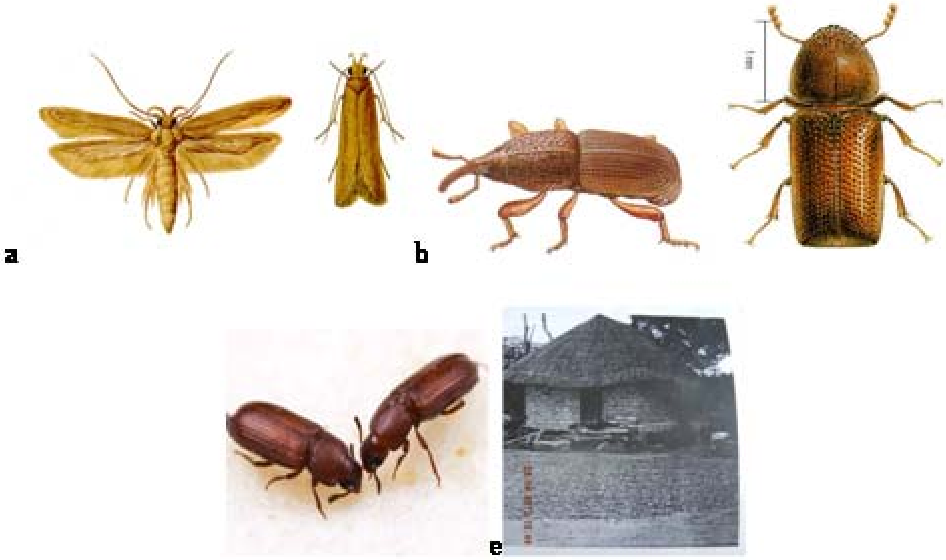

Figure 1. The notorious pest complex of stored maize in Zimbabwe (a) *Sitotroga cerealella* (USDA), (b) *Sitophilus zeamais* (CIMMYT, Zimbabwe), (c) *Prostephanus truncatus* (CIMMYT, Zimbabwe), (d), *Tribolium castaneum* (Alex Wild, USA) and (e) Traditional maize store-houses in Zimbabwe (NRI).

volume of pesticides used per volume of grain; this does not only save costs but also reduces the level of exposure to grain handlers. The results of these ecological studies will provide grain protection tactics that will be integrated into existing IPM programs in stored product protection. The knowledge of peak flight activities in relation to environmental factors will be used to synchronise synergistic post-harvest handling activities with certain window periods to reduce the susceptibility of stored maize to pest infestations.

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